Environmental, economic and social impacts of the use of sewage sludge on land

Final Report

Part III: Project Interim Reports

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This report has been prepared by Milieu Ltd, WRc and RPA for the European Commission, DG Environment under Study Contract DG ENV.G.4/ETU/2008/0076r.

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Part III of the final report consists of the project's interim reports:

1. The Assessment of Existing Knowledge
2. The Baseline Scenario and Analysis of Risk and Opportunities
3. Interim report describing the first consultation

Delivered on the 10th of February 2010

List of abbreviations

AD	Anaerobic digestion
AOX	Total adsorbable organo-halogen
APD	Acid phase digestion processes
BAT	Best available techniques
BOD, BOD5	Biochemical oxygen demand
CBA	Cost-benefit analysis
CEN	Comité Européen de Normalisation
CHP	Combined heat and power plant
COD	Chemical oxygen demand
CoGP	Code of good practice
DEHP	Bis(2-ethylhexyl)phthalate
DG ENV	Directorate General Environment of the European Commission
DM	Dry matter, or dry solids, or total solids
DS	Dry solids, dry matter, total solids
ECJ	European Court of Justice
EEA	European Environment Agency
EoW	End-of-waste
EPA	Environmental Protection Agency
EQS	environmental quality standards
EU 12	The 12 Member States that joined the EU in 2004 and 2008
EU 15	The 15 Member States that joined the EU before 2004
EU 27	All 27 Member States since 2008
FAO	Food and Agriculture Organization
FWD	Food waste disposal
GHG	Green house gas
GWP	Global warming potential
HACCP	Hazard analysis and critical control point
IA	Impact Assessment
IPPC	Integrated pollution prevention and control
LAS	Linear alkylbenzene sulfonate
LCA	Life-cycle analysis
MAD	Mesophilic anaerobic digestion
MBT	Mechanical biological treatment
MS	Member State of the European Union
MSW	Municipal solid waste
Mt	Million tonnes
ND	Nitrate Directive
NP/NPE	Nonylphenol/Nonylphenol ethoxylate
NP/NPE	Nonylphenol/Nonylphenol ethoxylate
OC	Organic compounds / Organic contaminants
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PCDD/F	Polychlorinated dibenzodioxins and polychlorinated dibenzofurans
pe	population equivalent
PPP	Public private partnerships
PTE	Potentially toxic elements; refers to heavy metals
QA	Quality assurance
QMRA	Quantitative microbial risk assessment
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RED	Renewable Energy Directive
SEPA	Scottish Environmental Protection Agency

SSM	Safe sludge matrix
TD	Thermal Destruction
tDS	Tonnes of dry solids
THP	Thermal hydrolysis process
TOC	Total organic content/carbon
TRF	Toxicological reference value
TS	Total Solids, dry matter, dry solids
TSP	Total sludge production
UBA	Umweltbundesamt
UWWTD	Urban waste-water treatment
VOSL	Value of statistical life
WFD	Water Framework Directive
WI	Waste incineration
WWTP	Wastewater treatment plant

Environmental, economic and social impacts of the use of sewage sludge on land

Summary Report 1

Assessment of Existing Knowledge

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This report has been prepared by Milieu Ltd, WRc and RPA for the European Commission, DG Environment under Study Contract DG ENV.G.4/ETU/2008/0076r. The primary author was Anne Gendebien. Additional expertise was provided by Bob Davis, John Hobson, Rod Palfrey, Robert Pitchers, Paul Rumsby, Colin Carlton-Smith and Judith Middleton.

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EXECUTIVE SUMMARY

Milieu Ltd is, together with partners WRc and Risk & Policy Analysts Ltd (RPA), working on a contract for the European Commission's Directorate General Environment, entitled *Study on the environmental, economic and social impacts of the use of sewage sludge on land* (DG ENV.G.4/ETU/2008/0076r).

The aim of the study is to provide the Commission with the necessary elements for assessing the environmental, economic and social impacts, including health impacts, of present practices of sewage sludge use on land and prospective risks/opportunities and policy options related to the use of sewage sludge on land. This could lay the basis for the possible revision of Community legislation. This report summarises information on sludge recycling to land. It is the first deliverable of the study on "Environmental, economic and social impacts of the use of sewage sludge on land" for the European Commission (DG Environment). The report focuses on work reported since 2000 but taking account of important earlier studies. The aim of the report is to identify key information that would be relevant for updating the Directive 86/278/EEC (hereinafter, the "Sewage Sludge Directive") which is the principal legislation underpinning the control of sludge recycling to land in the EU.

Topics covered in this report include: sludge production, legislation, economics and some social considerations but the emphasis is on environmental factors. In this way, the report has identified, from the very extensive literature on sludge recycling to land, the key factors on which the review of Directive 86/278/EEC needs to focus. The topics covered are:

- Current sludge Production and Disposal in the EU
- EU and Related Legislation on the Use of Sludge on Land
- Economics of sludge Treatment and Disposal
- Agricultural Value
- Contaminants and Pathogens
- Water and Air Pollution
- Greenhouse Gas Emissions and Carbon Footprint
- Stakeholder Interests and Public Perception
- Future Trends
- Monitoring, Record Keeping and Reporting
- Summary of Areas of Uncertainty and Knowledge Gaps

1 Introduction

The Sewage Sludge Directive 86/278/EEC was set up to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. To this end, it prohibited the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. The Directive also required that sludge should be used in such a way that account is taken of the nutrient requirements of plants and that the quality of the soil and of the surface and groundwater is not impaired.

Directive 86/278/EC on sewage sludge was based on the knowledge available at the time, including the evaluation of the risks provided by the COST 68 programme during the early 1980's. Since its adoption, many Member States have, on the basis of new scientific insight in the effects of sludge use on land, enacted and implemented stricter limit values for heavy metals as well as for contaminants which are not addressed in the Directive.

The most recent estimates reported to the Commission by the Member States suggest that more than 10 million tons DS were produced in 26 EU Member States (no estimate for Malta), of which approximately 36%, almost 3.7 million tons DS, was recycled in agriculture. In the last 10 years, the total amount of sludge produced has increased in most of the 15 EU Member States, due primarily to the implementation of the Urban Waste Water Treatment Directive 91/271/EEC. The quality of the sludge has also improved quite substantially in the EU 15. The proportion of waste recycled to land has also changed dramatically. For example, in Finland, Slovenia and Flanders quantities going to land has decreased significantly in recent years while they have increased in countries like Bulgaria.

2 Current Sludge Production and Management in the EU

This section reviews recent information on the production and disposal of sewage sludge in the EU. In particular, it presents information that can be used in the next stage of the study to develop a baseline scenario for future production and disposal.

2.1 Sludge quantity and disposal

According to the figures provided to the European Commission for the period 2003-2006 (personal communication, 2009) (Table 1), about 10 million tons DM of sewage sludge were produced in the EU; 8.7 million t DM in the EU-15 and an additional 1.2 million t DM for the 12 new Member States. This is probably underestimating the total quantities produced as not all of the Member States had provided up to date figures for the latest Commission survey (2003-2006) and figures from the previous survey (1999-2002) (EC, 2006) or from other sources were included in the Table. No data was reported for Malta.

According to the same sources of information, 37%, about 3.6 million t DM, was recycled in agriculture (Table 1). However, the proportion of sludge recycled in agriculture varies widely between different Member States and regions. In the Walloon Region (Belgium), Denmark, Spain, France, Ireland, and the UK, 50% or more of the sludge generated is applied to agricultural land while in other Member states there is less than 5% (i.e. Finland, Flemish Region of Belgium) or no application (Greece, Netherlands, Romania, Slovenia, Slovakia) of sewage sludge to land (EC, 2006; Alabaster and LeBlanc, 2008).

Compared with figures (Table 2) provided in the previous Commission surveys for 1995-1997 and 1998-2000 (EC, 2006), sludge production has steadily increased between 1995 and 2006 in most Member States. This can be attributed mainly to the implementation of the Urban Waste Water Treatment Directive 91/271/EEC (CEC, 1991) and also, in some cases (i.e. Italy and Portugal), to better reporting. However, in some Member States (i.e. Germany, Denmark, Finland, Sweden), although sludge quantities had increased since the 1980's, sludge production appears to have stabilised or even slightly decreased over the last 5 years. This has been attributed to a reduced consumption of water and an increased treatment of sludge (Jensen 2008). In 2004 and 2007, there was also the enlargement of the EU with the accession of 10, then 2, more new Member States, which added another 12% to the total sludge production in the EU. For the next 5 years this trend should continue with further investment in sewer connection and wastewater treatment capacity, especially in the new Member States.

The proportion of waste recycled to land has also changed dramatically in recent years (Tables 1 and 2). While in some Member States, such as France, Portugal, Spain and the UK, quantities recycled to agriculture have continued to increase, agricultural application has effectively been banned in some countries, e.g. the Netherlands and some regions of Belgium (Flanders), of Austria and of Germany, due to growing public concerns about the safety of the outlet and competition with other organic materials going to land such as animal manure. The Global Atlas (Alabaster and LeGrand 2008), however, estimates that there is more than a 50% chance that the benchmark sludge in a European city would be treated and recycled to land.

Incineration and landfilling are the main alternative methods to agricultural recycling for sludge management. Most Member States treat a proportion of their sludge by incineration and the residual ash is usually disposed of to landfill. The amount of sludge that is incinerated significantly increases when recycling is discouraged or banned. In Flanders (Belgium), for instance, more than 70 % of sludge production is now incinerated (Table 3). In the Netherlands, about 60% of sewage sludge is incinerated (Smith 2008) and in Austria, Denmark and Germany approximately 40 % of sludge is incinerated. Slovenia dries and then sends 50% out of the country to be incinerated.

The total amount of sludge destined for landfills is relatively small overall, and as the Landfill Directive 99/31/EC (CEC, 1999) sets mandatory targets for the reduction of biodegradable waste to landfill, landfilling of sewage sludge will be effectively banned. Some countries (mainly in the new Member States), however, still depend heavily, or entirely on this outlet as a means of sludge disposal (e.g. Greece, Hungary, Poland – see Table 3).

Table 1 Recent sewage sludge production and quantities recycled to agriculture in the 27 EU Member States (Doujak 2007, EC, 2006, EC, personal communication, 2009, IRGT 2005)

Member State	**Year**	**Sludge production**	**Agriculture**	
		(t DS)	**(t DS)**	**(%)**
Austria (a)	2005	266,100	47,190	18
Belgium				
• Flemish region	2006	76,254 (b)	1,981	3
• Walloon region	2003	23,520	11,787	50
• Brussels region (c)	2002	2,792	878	31
Denmark	2002	140,021	82,029	59
Finland	2005	147,000	4,200	3
France	2002	910,255	524,290	58
Germany	2006	2,059,351	613,476	30
Greece	2006	125,977	56.4	0
Ireland	2003	42,147	26,743	63
Italy	2006	1,070,080	189,554	18

Luxembourg	2003	7,750	3,300	43
Netherlands	2003	550,000	34	<0
Portugal	2002	408,710	189,758	46
Spain	2006	1,064,972	687,037	65
Sweden (e)	2006	210,000	30,000	14
United Kingdom	2006	1,544,919	1,050,526	68
Sub-total EU 15		***8,649,848***	***3,462,839***	***40***
Bulgaria	2006	29,987	11,856	40
Cyprus	2006	7,586	3,116	41
Czech republic	2006	22,0700	8,300- 25,400	4- 12
Estonia (d)	2005	nd	3,316	?
Hungary	2006	128,380	32,813	26
Latvia	2006	23,942	8,936	37
Lithuania	2006	71,252	16,376	23
Malta		nd	nd	nd
Poland	2006	523,674	88,501	17
Romania	2006	137,145	0	0
Slovakia	2006	54,780	0	0
Slovenia	2006	19,434	27	< 0
Sub-total for EU 12		***1,216,880***	***190,341(f)***	***17***
Total		**9,866,728**	**3,653,180**	**37**

a) Austria has not submitted figures to the Commission for the last two surveys. Figures presented above are from Doujak (2007) from UBA: total sludge production amounts to 420,000 t DM in 2005. This includes 238,100 t DM municipal sewage sludge + 28,000 t DM exported and 155,000 t DM of industrial sludge (mainly from cellulose and paper industry.
b) Figure for previous year (2005) as for total sludge produced no figure was provided for 2006.
c) No figures submitted to the Commission. Figures from IRGT 2005. In the Brussels Region, there are now 2 STEs; wastewater treatment started in one STW in 2000 for 360,000 pe and a second STW was commissioned for 1.1 M pe and started operating in 2008. In 2002, sludge production in the Brussels Region amounted to 2800 t DM.; 66% was incinerated, 32% recycled to agriculture and 2% was sent to landfill.
d) No figures reported for total sludge production.
e) Estimates
f) Taking into account the highest figure for the Czech Republic.

Table 2 Past (1995 and 2000) Sludge production in the EU-15 (EC 2006)

Year	**1995**		**2000**	
Member State	**Sludge production (t DS)**	**Sludge used in agriculture (%)**	**Sludge production (t DS)**	**Sludge used in agriculture (%)**
Austria (a)	390,000	12	401,867	10
Belgium				
• Flemish region	73,325	13	80,708	0 (b)
• Walloon region	14,311	75	18,228	59
Denmark (c)	166,584	67	155,621 (1999)	61 (1999)
Finland	141,000	33	160,000	12
France	750,000	66	855,000 (1999)	65 (1999)
Germany	2,248,647	42	2,297,460	37
Greece	51,624	0	66,335	0
Ireland	38,290 (1997)	11 (1997)	35,039	40
Italy	609,256	26	850,504 (d)	26
Luxembourg	nd	nd	7,000 (1999)	80 (1999)
Netherlands (f)	nd	0	nd	0

Portugal (e)	145,855	30	238,680	16
Spain	685,669 (1997)	46 (1997)	853,482	53
Sweden (e)	230,000	29	220,000	16
United Kingdom	1,120,00 (e)	49	1,066,176	55
Total EU-15	**6,664,781**	**42**	**7,306,342**	**40**

a) Includes sludge from municipal treatment plants (60%) and commercial/industrial treatment plants (40%) (especially from cellulose and paper industry)
b) Since December 1999, municipal sewage sludge is no longer used in agriculture.
c) Since 1994, annual sludge production in Denmark has been between 150,000 – 160,000 t DM with a drop to 140,000 t DM in 2002.
d) Data not complete for all regions
e) Estimates
f) Figures reported to the Commission in 1995 and 1999 only covered sludge produced by private treatment plants (220 t DM and 242 t DM respectively as since 1995), as since 1995 municipal sewage sludge was no longer used in agriculture in the Netherlands

Nd no data

Table 3 Disposal methods for sewage sludge in EU Member States as percentage (AMF 2007, Doujak 2007, Eureau 2006 reported by Smith 2008, IRGT 2005, Leonard 2008, COM personal communication, 2009)

Member State	**Year of data**	**Agriculture**	**Landfill**	**Incineration**	**Other**
Austria (a)	2005	18	1	47	34
Belgium					
• Flemish Region (b)	2005	9		76	14
• Walloon Region (c)	2005	32	6	62	
• Brussels region (d)	2002	32	2	66	
Denmark (e)	2002	55	2	43	
Finland	2000	12	6		80 (f)
France (g)	2002	62	16	20	3
Germany (h)	2003	30	3	38	29 (i)
Greece (j)			>90%		
Ireland	2003	63	35		3
Italy		32	37	8	22 (k)
Luxembourg	2004	47		20	33 (l)
Netherlands (m)	2006	0		60	40
Sweden		10-15		2	90-85 (n)
UK	2004	64	1	19.5	15.5 (o)
Bulgaria (p)	2006	40	60		
Czech republic (q)	2004	45	28		26
Hungary (r)	2006	26	74		
Poland (s)	2000	14	87		7
Romania (t)		0			
Slovenia (u)	2006	>1	50		49
Slovakia (v)	2006		17		83

a Figures from Doujak (2007) from UBA. In 2005, municipal sewage sludge production amounted to 238,100 t DM + 28,000 t DM exported. Sludge used in agriculture has to meet specific legal requirements which differ from federal state to federal state. In several federal states, there is a ban on sewage sludge application in agriculture. The legal prescriptions and the restrictions for use of sludge and compost for land reclamation or landscaping are much less stringent; therefore an increasing part of sewage sludge is used for this purpose. Since 2001, thermal treatment has increased from about 30% to nearly 50% . While in 2001, 11% of municipal sewage sludge was sent to landfill, by 2005, this outlet represented only 1%. Sludge disposal to landfill was basically banned in 2004 as new legislation required that only material meeting the following criteria be allowed for landfill disposal: ≤ 5 % TOC related to total dry solids and ≤6000 MJ/kg dry solids. These criteria cannot be met by conventional sludge treatment. Only the ashes after incineration are meeting these requirements. Out of 91,700 t DM disposed of by others routes - 77% are composted, 12.3% used in landscaping, 2.4% in temporary storage and 8.2% in unknown outlets.

b The Flemish Region has discouraged the recycling of sewage sludge to land through stricter limit values due to the large volume of animal manure produced in the region. While in 2005, 31% of 76,250 t DS were still used in agriculture, land spreading of sludge in agriculture was stopped in 2006 due to increasing costs of complying with the recent regional restrictions. Other means landfill cover.

c While landspreading in agriculture (82% in 1998, 56% in 2001) and landfilling (18% in 1998 and 37% in 2001) have been the preferred options for years, these outlets have now been supplanted by incineration which was first used in 1999 (2% , 7% in 2001) (IRGT 2005, Leonard 2008).

d According to IRGT (2005), in 2002, 66% of sludge in the Brussels region was incinerated, 32% recycled to agriculture and 2% was sent to landfill.

e Denmark has a target for 2008 to sent 50% of sewage sludge to agriculture, 45% to incineration corresponding to 25% incineration with recycling of ashes in industrial processes and 20% “normal” incineration. Agriculture includes sludge mineralisation plants, composting, long time-storage. Incineration includes recovery, e.g. cement or sand blasting agents (58% of incinerated sludge is recovered by alternative methods). Sludge recycling to agricultural land has been encouraged as a way of recycling nutrients. From 1995 to 2002, however, the relative fraction of sludge recycled to land has decreased from 70% down to 60%. Since 1994, the relative proportion of sludge incinerated has stayed fairly constant at around 20%, while landfilling has decreased to less than 5% (Jensen, 2004).

f While in 2004, there was still 9% of sludge recycled to agriculture, it was down to 3% in 2005. In 2000, other outlets include 27% as landfill cover and 53% for landscaping

g From AMF 2007 (Data from Agences de l’Eau for 2002/2003)

h Three of 16 federal states intend to stop agricultural sludge use.

i 26% as landscaping and 3 % as other

j No recycled to agriculture. Stated that most goes to landfill due to joint ownership of WWTP and landfills by municipalities.

k Includes 19% as composting, no final outlet given.

l As composting no final outlet given

m Since 1995, in the Netherlands, municipal sewage sludge is no longer used in agriculture. In 1996, the majority of municipal sewage sludge was sent to landfill (82%). Now, most sewage sludge goes to incineration in the Netherlands or in Germany, some of it after composting or heat drying.

n Including 60-65% as construction soil and 10% as vegetation material.

o Including 11% for land reclamation and 4% as compost and industrial crops

p While there was no recycling to agriculture in previous years (in 2004 and 2005), 40% of sludge was reported to be used in agriculture in 2006.

q In the Czech Republic, in 2001, 42-48% of sludge was recycled to agriculture, in 2002 and 2003, there was no sludge sent to agriculture and in 2004, 16% of 206,000 t DM was again recycled to land.

r Recent legislation regarding maximum water content of landfilled sludge (at least 25% DM) could limit this outlet. No incineration of sludge.

s Data from Twardowska 2005

t From the literature review (Crac 2004) although Romania does not yet recycled sludge to agriculture, is intending to do so in the near future as well as other recovery methods such as co-incineration in cement kilns

u In the past, the majority of sewage sludge was disposed of in landfills; however, following the adoption of a Decree on landfilling of waste, the volume should slowly be reduced as the landfilling of sludge from 2008 is only authorised for waste with TOC < 18% d.m. and calorific value < 6 MJ/kg d.m. In 2001, 2002 and 2003, Slovenia recycled 6%, 16% and 9% respectively to agriculture. Since 2003, the quantities of sludge recycled into compost and on agricultural land have been reduced down to about one per cent due to concerns about the content in hazardous substances when produced from combined wastewater treatment plants in urban and industrial areas. The remaining sludge is exported for the preparation of artificial soil and other recovery methods (not specified but could include co-incineration).

- v Figures reported are estimates. In Slovakia, in 2004, 23% of sludge was directly spread on land, 54% was composted and another 3% was used in land reclamation, 9% was landfilled and 11% were placed in temporary storage. In 2006 there was no direct land spreading in agriculture but 61% was composted (no final outlet mentioned) and 10% was used in land reclamation, 17% landfilled and 11% placed in temporary storage. No suitable incineration capacity for sewage sludge, but potential co-incineration in cement plants.

2.2 Sludge quality

Member States have to provide information to the Commission on the average quality of sludge recycled to agriculture regarding PTEs (Potentially Toxic Elements) and nutrients (Total nitrogen and total phosphorus). The information submitted during the latest survey for period 2004- 2006 is presented in the Table 4 below. The following comments can be made:

- The three highest values for each metallic elements have been highlighted;
- There are some large differences in quality between 18 Member States which have provided information depending on the elements;
- Cyprus, Italy, Latvia, Poland have the sludge containing the highest concentrations for at least 3 elements.

Sewage sludge contains potentially toxic elements (PTEs), including heavy metals, which are from domestic (i.e. plumbing, body care products, etc.), surface run-off and/or commercial and industrial origins (see chapter 6 below). It has been confirmed by several studies (Smith 2008) that since the mid 80's concentrations of heavy metals in sewage sludge has steadily declined in the EU due to regulatory controls on the use and discharge of dangerous substances, voluntary agreements and improved industrial practices; all measures leading to the cessation or phasing out of discharges, emissions and losses of these PTEs to the environment.

Table 4 Quality of sewage sludge (on dry solids) recycled to agriculture (2006) (CEC, personnel communication 2009)

Parameter	**BE a,b)**	**DE**	**ES**	**FI b)**	**IT**	**PT a)**	**SE**	**UK**	**BG**	**CY**	**CZ**	**EE b)**	**HU**	**LT**	**LV**	**PT**	**SI**	**SK b)**
Zinc	337	713	744	332	879	341	481	574	465	**1188**	809	783	824	534	**1232**	996	410	**1235**
Copper	72	**300**	252	244	283	12	**349**	295	136	180	173	127	185	204	**356**	153	190	221
Lead	93	37	68	8.9	**101**	27	24	**112**	55	23	40	41	36	21	**114**	51	29	57
Nickel	11	25	30	30	**66**	15	15	30	13	21	29	19	26	25	**47**	**32**	29	26
Chromium	20	37	72	18	**86**	20	26	61	20	37	53	14	57	34	**105**	**127**	37	73
Mercury	0.2	0.4	0.8	0.4	1.4	<1	0.6	1.2	1.2	**3.1**	1.7	0.6	1.7	0.5	**4.2**	**4.6**	0.8	2.7
Cadmium	1	1	2.1	0.6	1.3	<0.4	0.9	1.3	1.6	**6.9**	1.5	2.8	1.4	1.3	**3.6**	**4**	0.7	2.5
Total Nitrogen	3.9	4.3	4.5	3.4	4.1	1.7	4.5	2.8	7.2	4.1	3.6	4.9	3	2.3	3.9	0.9	3.2	3.8
Total Phosphorus	6.7	3.7	3.6	2.4	2.1	2	2.7	2.2	4.3	4.9	1.9	3.4	1.4	0.9	1.3	0.6	3.9	1.8

a) Data from the Flemish Region
b) data for 2005 as no values available for 2006

2.3 Sludge Treatment and current practice in EU Member States

Directive 86/278/EEC requires that sewage sludge be treated before it is used in agriculture (Member States may authorise the injection or working of untreated sludge in soil in certain conditions, including that human and animal health are not at risk). The Directive specifies that for sludge to be defined as treated it should have undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as to significantly reduce its fermentability and the health hazards associated with its use.

These overall requirements have been interpreted and implemented within individual Member States differently, in part based on specific local conditions and circumstances. Detailed descriptions of sewage sludge management for each Member States can be found in the latest available Commission's implementation report (EC 2006). In general, untreated sludge is no longer applied. In the Czech Republic, Denmark, Spain, Finland, Germany, Hungary, Italy, Luxembourg, the Netherlands, Slovakia, Slovenia, and in the UK it is prohibited to spread any untreated sludge on land (EC 2006).

Where sludge is to be used on land, it is usually stabilised by mesophilic anaerobic digestion, or aerobic digestion and then treated with polymers and mechanically dewatered using filter presses, vacuum filters or centrifuges. Other treatment processes for sludge going to land include long-term storage, conditioning with lime, thermal drying and composting.

In the UK, land spreading of raw, untreated sludge to food crops was banned by the Safe Sludge Matrix from December 1999, and on land used to grow non-food crops from December 2005 (ADAS, 2001).

In the UK, most sludge is stabilised by anaerobic digestion and must meet other management restrictions. A site permit is not required but regulations, notably the Code of Good Practices (CoGP) and Safe Sludge Matrix (SSM), must be followed. Treatment processes for sludge in the UK are managed according to the principles of HACCP (Hazard Analysis and Critical Control Point management) (Water UK, 2004). HACCP applies risk management and control procedures to manage and reduce potential risks to human health and the environment. The approach has been adopted and applied to sludge treatment for agricultural application to provide assurance that the microbiological requirements set out in the Safe Sludge Matrix are met and that risk management and reduction combined with appropriate quality assurance procedures are in place, thus preventing the use on farmland of sludge that does not comply with the microbiological standards.

The periods of prohibition between sludge spreading and grazing or harvesting vary according to the Member State (EC 2006). In Ireland, Spain, Luxembourg, the Netherlands, Portugal and the United Kingdom, the provisions of the Directive apply: i.e. sludge must be spread at least three weeks before grazing or harvesting and on soil in which fruit and vegetable crops are growing, or at least ten months for soils where fruit and vegetable crops that are eaten raw are cultivated in direct contact with soil. In the other Member States the rules are generally stricter than those provided for by the Directive. For more detailed information, please refer to the Commission report (EC 2006).

3 EU Legislation, other EU Acquis and Member State Controls on the Use of Sludge on Land

3.1 EC legislation

The recycling of sewage sludge in agriculture has been regulated by Directive 86/278/EEC since 1986. The Directive both addresses pathogen reduction and the potential for accumulation of persistent pollutants in soils. The Directive sets maximum limit values for Potentially Toxic Elements (PTEs) in sludge (Table 6) or sludge-treated soil (Table 5) and specifies general land use, harvesting, and grazing restrictions, to provide protection against health risks from residual pathogens. The Directive allows untreated sludge to be used on agricultural land if it is injected or worked into the soil. Otherwise sludge shall be treated before being used in agriculture; however, the Directive does not specify treatment processes but rather defines "treated sludge" as "sludge which has undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use" (Art. 2(b)).

The Commission now plans to undertake a comprehensive review of the provisions contained in the Directive. There have been previous reviews of this Directive, which produced draft proposals that included limit values for Organic Compounds (OCs) (Table 8).

When considering a review of the Directive 86/278/EEC, it is also necessary to consider other (especially more recent) directives and how they might regulate or otherwise affect the production and use of sludge on land as well as restrict other outlets for sludge.

- **Directive 91/271/EEC Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment**

The Urban Waste Water Treatment Directive 91/271/EEC concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. The Urban Waste Water Treatment Directive 91/271/EEC sets the following targets for secondary treatment of waste waters coming from agglomerations:

- at the latest by 31 December 2000 for agglomerations of more than 15,000 p.e. (population equivalent);
- at the latest by 31 December 2005 for agglomerations between 10,000 and 15,000 p.e.;
- at the latest by 31 December 2005 for agglomerations of between 2,000 and 10,000 p.e. discharging to fresh waters and estuaries.

Since the implementation of these requirements quantities of sewage sludge requiring disposal have increased dramatically in Member States. Foreseeing such issue, the Urban Waste Water Treatment Directive 91/271/EEC encourages the recycling of sludge arising from waste water treatment. It states that sludge arising from waste water treatment shall be re-used whenever appropriate. Under the Directive, Member States authorities must also publish situation reports on the disposal of urban waste water and sludge in their areas.

- **Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources**

This Directive has the objective of reducing water pollution caused or induced by nitrates from agricultural sources and preventing such pollution. To that aim the Directive requires Member States to designate vulnerable zones that contribute to the pollution of water by nitrates. Within these vulnerable zones, a code of good agricultural practice should be applied by farmers. Such a code could for example provide periods when the land application of fertilizer is inappropriate ban the land application of fertilizer to steeply sloping ground or to water-saturated, flooded, frozen or snow-covered ground. Since the Directive considers that sewage sludge falls within the definition of fertilizers, such code of agricultural practice should also apply to the spreading of sewage sludge.

- **Directive 99/31/EC Council Directive 99/31/EC pf 26 April 1999 on the landfill of waste (Landfill Directive)**

EU policy for waste management (CEC 1999) aims to encourage the recovery of value from waste products and to reduce the disposal of biodegradable wastes in landfill. The Landfill Directive (99/31/EC) implements by obliging Member States to reduce the amount of biodegradable waste that they send to landfills to 35% of 1995 levels by 2016. This implies that land filling is not considered a sustainable approach to sludge management in the long-term.

- **Directive 2000/76/EC of the European Parliament and the Council of 4 December 2000 on the incineration of waste**

Dry sewage sludge can be incinerated to produce energy. Sewage sludge falls within the category of waste and thus falls under the scope of Directive 2000/76/EC on the incineration of waste. This Directive sets several standards and technical requirements (air emissions, water discharges contamination, plant designs) that have to be respected by the operators of the plants which incinerate dry sewage sludge.

- **Directive 2000/60/EC of the European Parliament and the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive (WFD))**

Cadmium, lead and mercury are designated Priority Hazardous Substances under the Water Framework Directive 2000/60/EC, and thus are subject to further measures leading to the cessation or phasing out of discharges, emissions and losses of these substances to the environment as far as possible. Directive 2008/105/EC implements these provisions in the Water Framework Directive. The Water Framework Directive is discussed further in section 9.

- **Directive 2008/105 on environmental quality standards in the field of water policy**

This Directive lays down environmental quality standards (EQS) for priority substances and certain other pollutants with the aim of achieving good surface water chemical status and in accordance with the provisions and objectives of Article 4 of Directive 2000/60/EC. The environmental quality standards set in Annex I, part A, of Directive 2008/105 are to be applied by Member States for bodies of surface water. Member States have also the option to apply environmental quality standards for sediment and/or biota. Member States might thus apply stricter measures to sewage sludge in order to respect these environmental quality standards.

- **Directive 2006/118/EC on the protection of groundwater against pollution and deterioration**

This directive complements the Water Framework Directive with additional rules to protect groundwater. It establishes a regime which sets underground water quality standards and introduces measures to prevent or limit inputs of pollutants into groundwater. It establishes quality criteria that take into account local characteristics and allows for further improvements to be made based on monitoring data and new scientific knowledge. This Directive might have an impact on the practise of the spreading of sludge since it provides that the protection of groundwater may in some areas require a change in farming or forestry practices. Annex 1 of the Directive sets some groundwater quality standards; the spreading of sewage sludge will need to ensure that contaminants do not contaminate groundwater.

- **Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives**

Directive 2008/98/EC[1] is the new Waste framework Directive that lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing the overall impacts of resource use and improving the efficiency of such use. Directive 2008/98/EC does not mention sewage sludge. However, it provides that waste waters are excluded from its scope to the extent that they are covered by other Community legislation (Article 2(2(a).).

Since Directive 2008/98/EC entered into force recently, the ECJ has not yet ruled whether sewage sludge falls within the scope of this Directive as waste or was excluded from it as waste waters. However, the Directives that refer to "sewage sludge" as well as the commission working papers it is not mentioned that "sewage sludge" is defined as waste waters. For example the report from the commission on the implementation of the "community waste legislation", which dates back to the 19th of July 2006, only provides that waste oils, sewage sludge, and packaging waste are specific waste streams each with different characteristics and management issues.

Furthermore the European Court of Justice in the "Lahti Energia"[2] judgment, defined sewage sludge as a "residue" from the treatment of waste water, thus making a distinction between waste waters and the products that are generated from its treatment.

Finally, in case sewage sludge is considered as waste waters, a preliminary ruling of the ECJ[3] mentioned that waste waters were to be excluded from Directive 75/442/EC (the former waste framework Directive) only if such waste waters were covered by other legislation (national or European) that guarantee at least the same level of environmental protection as Directive 75/442/EC. For example, the Court mentioned that the Urban Waste Water Treatment Directive did not say anything about disposal of waste or decontamination of soils and therefore couldn't guarantee a level of environmental protection as high as Directive 75/442/EC. This interpretation of the ECJ was partially taken into consideration by Directive 2008/98/EC which provides that waste waters are excluded from its scope to the extent that they are covered by other Community legislation.

Thus, it is probable that sewage sludge when discarded or intended to be discarded is waste that falls within the scope of the Directive 2008/98/EC because as the ECJ stressed, it is not waste water but a residue of it. In case sewage sludge is included into the definition of waste waters it might anyway be covered by the new framework Directive if other Community legislation dealing with waste waters do not guarantee at least the same level of environmental protection as this Directive.

Requirements that must be applied to sewage sludge if sewage sludge falls within the scope of Directive 2008/98/EC as waste:

First of all, under Article 6 of Directive 2008/98/EC certain specified waste shall cease to be waste when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions: the substance or object is commonly used for specific purposes; a market or demand exists for such a substance or object; the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and the use of the substance or object will not lead to overall adverse environmental or human health impacts. The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the

[1] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)

[2] http://eur-lex.europa.eu/Result.do?arg0=Lahti+Energia&arg1=&arg2=&titre=titre&chlang=en&RechType=RECH_mot&idRoot=10&refinecode=JUR*T1%3DV100%3BT2%3D%3BT3%3DV1&Submit=Search

[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:62005J0252:EN:HTML

substance or object. Thus, sewage sludge that fulfils these criteria might not be considered waste anymore under Directive 2008/98/EC.

Secondly, under articles 10 and 11 Member States shall take the necessary measures as to ensure that waste is recycled or re-used. When it is not possible to do so, under article 12, waste must undergo safe disposal operations, which meet a certain number of conditions regarding human health and the environment (article 13). These disposal operations must occur without risk to water, soil, plants or animals, must not cause noise or odour nuisances, and must not adversely affect the countryside or places of special interest. Their costs lie with the producer of the waste. Under Article 16, disposal of waste must answer to the principles of self-sufficiency and proximity, meaning that MS shall cooperate to set up a network of waste disposal installations. If sewage sludge falls within the scope of this directive, all these measures will have to be taken into account when dealing with its disposal.

Thirdly, article 15 deals with management responsibility. Member States must ensure that any original waste producer or other holder carries out the treatment of waste himself or has the treatment handled by a dealer or an establishment. Member states may specify the conditions of responsibility for the whole treatment chain and decide that it is to be borne partly or wholly by the producer of the product.

Fourthly, Member States must require any establishment intending to carry out waste treatment to obtain a permit from the competent authority, which shall specify the types and quantities of waste that may be treated, the technical requirements relevant to the site concerned, the safety and precautionary measures to be taken, etc. MS may exempt from these requirements establishments intending to carry out recovery of waste. Under article 34, establishments which carry out waste treatment operations, or collect or transport waste on a professional basis or produce hazardous waste, shall be subject to appropriate periodic inspections by the competent authorities. Establishments that treat sewage sludge will have to fulfil these requirements if sewage sludge falls into the scope of the directive.

Finally it is worth mentioning that Directive 2008/98/EC defines ‘bio-waste’ as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants. Thus, sewage sludge cannot fall within the definition of bio-waste. Under Article 22 of Directive 2008/98/EC, member States shall take measures to encourage, the separate collection of bio-waste with a view to the composting and digestion of bio-waste, the treatment of bio-waste in a way that fulfils a high level of environmental protection; the use of environmentally safe materials produced from bio-waste. The Commission shall also carry out an assessment on the management of bio-waste with a view to submitting a proposal if appropriate. The Commission has come up with a Green paper on the management of bio-waste in the European Union[4].

The current measures on bio-waste under Directive 2008/98/EC and the probable future EC legislation on bio-waste will increase the treatment of bio-waste into compost that can be spread on agricultural fields. Compost from bio-waste might conflict with sewage sludge since compost from bio-waste might have a better environmental reputation. Indeed there are fewer probabilities that it contains hazardous substances compared to sewage sludge.

[4] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0811:FIN:EN:PDF

- **EC Regulation 1907/2006, concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)**

The purpose of REACH is to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of chemical substances, as well as the free circulation of the substances on the internal market while enhancing competitiveness and innovation. The Regulation applies to the manufacture, placing on the market or use of such substances on their own, in preparations or in articles and to the placing on the market of preparations.

Under the REACH Regulation, waste does not fall within the definition of a chemical substance, preparation or article. Thus, sludge sewages producers are not directly affected by the REACH Regulation. However REACH will have an indirect impact on the sewage sludge composition, as it may lead to a reduction in the levels of chemicals contained.

- **Commission Regulation (EC) No 466/2001**

This regulation sets maximum levels for certain contaminants in foodstuffs set limits for Cadmium in foodstuffs 'as low as reasonably achievable' following the precautionary principle. The limits are close to background levels which occur naturally in foodstuffs from uncontaminated sources. The spreading of sewage sludge thus needs to respect these requirements (see section 6).

- **Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No2092/91**

Regulation No 834/2007 provides the basis for the sustainable development of organic production while ensuring the effective functioning of the internal market, guaranteeing fair competition, ensuring consumer confidence and protecting consumer interests. It establishes common objectives and principles concerning all stages of production, preparation and distribution of organic products and their control, and the use of indications referring to organic production in labelling and advertising.

This Regulation does not directly refer to sewage sludge. However, on the requirements for soil, article 12 of this Regulation provides that 'the fertility and biological activity of the soil shall be maintained and increased by multiannual crop rotation including legumes and other green manure crops, and by the application of livestock manure or organic material, both preferably composted, from organic production.' It is clear from this provision that the application of material coming from non-organic production, including sewage sludge, is not allowed for organic production.

- **Decision 2006/799 establishing revised ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to soil improvers**

Decision 2006/799 defines soil improvers as 'materials to be added to the soil in situ primarily to maintain or improve its physical properties, and which may improve its chemical and/or biological properties or activity.' In order to be awarded the Community Eco label, soil improvers shall comply with the criteria set in out in the Annex to Decision 2000/799.
1.1 of the Annex mentions that soils improvers containing sewage sludge shall not be awarded an eco-label.

- **Decision 2007/64 establishing revised ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to growing media**

Decision 2007/799 defines growing media as 'material other than soils in situ, in which plants are grown.' In order to be awarded the Community Eco label, growing media shall comply with the criteria set in out in the Annex of this Decision. 1.2 of the Annex mentions that growing media containing sewage sludge shall not be awarded an eco-label.

- **Proposal for a Directive establishing a framework for the protection of soil and amending Directive 2004/35/EC** [5]

The Commission adopted a Soil Thematic Strategy (COM(2006) 231) and a proposal for a Soil Framework Directive (COM(2006) 232) on 22 September 2006 with the objective to protect soils across the EU. Sewage sludge contains organic matters which reduce soil degradation but can also contain pollutants that affect the quality of the soil.

Article 3 of the proposed directive provides that in the development of sectoral policies likely to exacerbate or reduce soil degradation processes, Member States shall identify, describe and assess the impacts of such policies on these processes, in particular in the areas of regional and urban spatial planning, transport, energy, agriculture, rural development, forestry, raw material extraction, trade and industry, product policy, tourism, climate change, environment, nature and landscape. Thus, under this proposal Member States would have to identify, describe and assess the impacts of sewage sludge spreading in agricultural fields on the exacerbation or reduction of soil degradation.

- **Proposal for a Directive on the promotion of renewable energy sources.**[6]

Biogas can be produced from sewage sludge treatment, via a process called anaerobic digestion. Article 2 of the proposed directive on the promotion of renewable energy considers that sewage treatment plant gas is energy from renewable energy sources.

The proposed directive sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport. Overall, in 2020 there shall be at least a 20% share of energy from renewable sources in the Community's gross final energy consumption. Such targets are likely to create incentives for the use of renewable energy sources of biogas from sewage sludge. An increase in the production of biogas from sewage sludge is expected to contribute to a reduction in greenhouses gas emissions.

3.2 Member State legislation and policy

The development of guidelines, codes of practice and statutory controls has been an ongoing process at national level since the 1986 Directive was implemented. In some Member States (i.e. Sweden and UK), voluntary agreements set more stringent requirements than those in the Directive or in national regulations. Other initiatives have been the development of quality assurance systems, such as in Germany and Sweden. (This section also provides some information from non-EU Members, notably Switzerland and the US.)

A comprehensive review of national regulatory frameworks has been carried out for the European Commission by Sede and Andersen (2002). This study reported that most EU15 had adopted more stringent limits and management practices than were originally specified by the Directive, either through binding rules or via codes or practice and other voluntary agreements (Sede and Andersen, 2002).

For example, the standards for PTEs adopted in different countries vary considerably (Tables 5 and 6). In addition, standards for compounds not included in the Directive (i.e. pathogens and organics) have been set by some national regulations (Tables 7 and 8).

For the limit values of contaminants in soil-treated sludge (Table 5), most national requirements are similar to the ones specified in the Directive, apart from Denmark, Finland and the Netherlands which

[5] http://ec.europa.eu/environment/soil/pdf/com_2006_0232_en.pdf

[6] European Parliament legislative resolution of 17 December 2008 on the proposal for a directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (COM(2008)0019 – C6-0046/2008 – 2008/0016(COD))

have more stringent limits. Some Member States (Spain, Portugal and the UK) have defined limit values for different categories of soil pH, while the regulations set by Latvia and Poland and the new proposed standards in Germany have defined different categories of soil based on their granulometry (Table 5). In addition, several Member States (Finland, France, Hungary, Luxembourg, Netherlands, Sweden, Belgium (Flanders) and three Lander in Austria) have introduce limitations in terms of maximum annual load of heavy metals on a ten year basis.

A comparison of heavy metal concentrations in sewage sludge (Table 6) between Member States shows that most Member States have more stringent limits than the ones in the Directive.

Agricultural application has been effectively prevented in some countries due to prohibitively stringent national limit values for heavy metals (e.g. the Netherlands, Belgium (Flemish region)). Concerns about the potential consequences for human health and the environment of potentially toxic substances and harmful microorganisms in sludge have even led to the banning of the use of sludge in agriculture in some countries, including Switzerland, despite the recognition that there is no conclusive scientific evidence that the practice is harmful. (FOEN, 2003).

Table 5 Maximum permissible concentrations of potentially toxic elements in sludge-treated soils (mg kg^{-1} dry soil) in EC Member States and US, (SEDE and Andersen, 2002)

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Directive 86/278/EEC	1-3	100-150(4)	50-140	1-1.5	30-75	50-300	150-300
Austria							
Lower Austria	1.5/1h)	100	60	1	50	100	200
Upper Austria	1	100	100	1	60	100	300/150(9)
Burgenland	2	100	100	1.5	60	100	300
Vorarlberg	2	100	100	1	60	100	300
Steiermark	2	100	100	1	60	100	300
Carinthia if 5<pH<5.5	0.5	50	40	0.2	30	50	100
if 5.5<pH<6.5	1	75	50	0.5	50	70	150
if pH>6.5	1.5	100	100	1	70	100	200
Belgium, Flanders	0.9	46	49	1.3	18	56	170
Belgium, Walloon	2	100	50	1	50	100	200
Bulgaria							
pH=6-7.4	2	200	100	1	60	80	250
pH>7.4	3	200	140	1	75	100	300
Cyprus	1-3	100-150	50-140	1-1.5	30-75	50-300	150-300
Denmark	0.5	30	40	0.5	15	40	100
Finland	0.5	200	100	0.2	60	60	150
France	2	150	100	1	50	100	300
Germany (6)	1.5	100	60	1	50	100	200
Germany (7)							
Clay	1.5	100	60	1	70	100	200
Loam/silt	1	60	40	0.5	50	70	150
Sand	0.4	30	20	0.1	15	40	60
Greece	3	-	140	1.5	75	300	300
Ireland	1	-	50	1	30	50	150
Italy	1.5	-	100	1	75	100	300
Luxembourg	1-3	100-200	50-140	1-1.5	30-75	50-300	150-300
Estonia (10)	3	100	50	1.5	50	100	300
Hungary	1	75/1 (8)	75	0.5	40	100	200
Latvia	0.5-0.9	40-90	15-70	0.1-0.5	15-70	20-40	50-100
Lithuania	1.5	80	80	1	60	80	260
Malta							
pH 5<6	0.5	30	20	0.1	15	70	60
pH 6-7	1	60	50	0.5	50	70	150
pH >7	1.5	100	100	1	70	100	200
Netherland	0.8	10	36	0.3	30	35	140
Portugal							
Soil ph<5.5	1	50	50	1	30	50	150

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
5.5<soil<7	3	200	100	1.5	75	300	300
Soil ph>7	4	300	200	2	110	450	450
Poland							
Light soil	1	50	25	0.8	20	40	80
Medium soil	2	75	50	1.2	35	60	120
Heavy soil	3	100	75	1.5	50	80	180
Romania	3	100	100	1	50	50	300
Slovakia	1	60	50	0.5	50	70	150
Slovenia	1	100	60	0.8	50	85	200
Spain							
Soil ph<7	1	100	50	1	30	50	150
Soil ph>7	3	150	210	1.5	112	300	450
Sweden	0.4	60	40	0.3	30	40	100
UK(1)	3	400 (5)	135	1	75	300 (3)	20
USA (2)	20	1450	775	9	230	190	1500

(1) For soil of pH ≥5.0, except Cu and Ni are for pH range 6.0 – 7.0; above pH 7.0 Zn = 300 mg kg^{-1} ds (DoE, 1996);
(2) Approximate values calculated from the cumulative pollutant loading rates from Final Part 503 Rule (US, EPA 1993);
(3) Reduction to 200 mg kg^{-1} proposed as a precautionary measure;
(4) EC (1990) – proposed but not adopted;
(5) Provisional value (DoE,1989).
(6) Regulatory limits as presented in the German 1992 Sewage Sludge Ordinance (BMU, 2002)
(7) Proposed new German limits (BMU, 2007)
(8) Chromium VI
(9) For ph<6
(10) In soils where 5<ph<6 it is permitted to use lime-sterilised sludge

Other elements only restricted in some countries or regions:

	Arsenic	Molybdenum	Cobalt
Steiermark		10	50
Belgium (Flanders)	22		
Hungary	15	7	30

Table 6 Maximum level of heavy metals (mg per kg of dry substance) in sewage sludge used for agricultural purposes. (SEDE and Andersen, 2002, Alabaster and LeBlanc, 2008)

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Directive 86/278/EEC	20-40	-	1000-1750	16-25	300-400	750-1200	2500-4000
Austria							
Lower Austria	2	50	300	2	25	100	1500
Upper Austria	10	500	500	10	100	400	2000
Burgenland	10	500	500	10	100	500	2000
Voralberg	4	300	500	4	100	150	1800
Steiermark	10	500	500	10	100	500	2000
Carinthia	2.5	100	300	2.5	80	150	1800
Belgium (Flanders)	6	250	375	5	100	300	900
Belgium (Walloon)	10	500	600	10	100	500	2000
Bulgaria	30	500	1600	16	350	800	3000
Cyprus	20-40	-	1000-1750	16-25	300-400	750-1200	2500-4000
Czech republic	5	200	500	4	100	200	2500
Denmark	0.8	100	1000	0.8	30	120	4000
Estonia	15	1200	800	16	400	900	2900
Finland	3	300	600	2	100	150	1500
France	20	1000	1000	10	200	800	3000
Germany (1)	10	900	800	8	200	900	2500
Germany (2)	2	80	(600)	1.4	60	100	(1500)
Greece	20-40	500	1000-1750	16-25	300-400	750-1200	2500-4000
Hungary	10	1000/1(3)	1000	10	200	750	2500
Ireland	20		1000	16	300	750	2500
Italy	20		1000	10	300	750	2500
Latvia	20	2000	1000	16	300	750	2500
Lithuania	-	-	-	-	-	-	-
Luxembourg	20-40	1000-1750	1000-1750	16-25	300-400	750-1200	2500-4000
Malta	5	800	800	5	200	500	2000
Netherlands	1.25	75	75	0.75	30	100	300
Poland	10	500	800	5	100	500	2500
Portugal	20	1000	1000	16	300	750	2500
Romania	10	500	500	5	100	300	2000
Slovakia	10	1000	1000	10	300	750	2500
Slovenia	0.5	40	30	0.2	30	40	100
Spain	20	1000	1000	16	300	750	2500
Spain	40	1750	1750	25	400	1200	4000
Sweden	2	100	600	2.5	50	100	800
United Kingdom	PTE regulated through limits in soil						

(1) Regulatory limits as presented in the German 1992 Sewage Sludge Ordinance (BMU, 2002)
(2) Proposed new limits (BMU, 2007)
(3) Chromium VI

Other elements only restricted in some countries or regions:

	Arsenic	**Molybdenum**	**Cobalt**
Lower Austria			10
Steiermark	20	20	100
Belgium (Flanders)	150		
Denmark	25		
Netherlands	15		
Czech republic	30		
Hungary	75	20	50
Slovakia	20		

For organic contaminants (OCs), there is no consistent approach in setting limit values in sludge between different countries (Table 8) (Smith 2008). Some countries, such as the UK, US and Canada, have argued that there is no technical justification for setting limits on OCs in sludge, on the basis that research has shown that the concentrations present are not hazardous to soil quality, human health or the environment (US Environmental Protection Agency, 1992b,c; WEAO, 2001; Blackmore et al., 2006). However, other countries have established limits for different groups of OCs. For example, in Germany, limits are set for the persistent compounds, AOX (total adsorbable organo-halogen), PCBs (polychlorinated biphenyls) and PCDD/Fs (polychlorinated dibenzodioxins and Polychlorinated dibenzofurans), but not PAHs (polycyclic aromatic hydrocarbons). However, Germany's proposed revised regulation (BMU, 2007) includes a limit for one PAH, benzo(a)pyrene, and France regulates PAHs and PCBs, but not PCDD/Fs. Denmark, on the other hand, has established controls for \ bulk volume chemicals including DEHP (Bis(2-ethylhexyl)phthalate), LAS (Linear Alkylbenzene Sulfonate) and NP/NPE (Nonylphenol/Nonylphenol ethoxylate).

Table 7 Standards for maximum concentrations of pathogens in sewage sludge (Sede and Andersen, 2002; Alabaster and LeBlanc, 2008)

	Salmonella	**Other pathogens**
Denmark a)	No occurrence	Faecal streptococci:< 100/g
France	8 MPN/10 g DM	Enterovirus: 3 MPCN/10 g of DM Helminths eggs: 3/10 g of DM
Finland (539/2006)	Not detected in 25 g	Escherichia coli <1000 cfu
Italy	1000 MPN/g DM	
Luxembourg		Enterobacteria: 100/g no eggs of worm likely to be contagious
Poland	Sludge cannot be used in agriculture if it contains salmonella	

a) applies to advanced treated sludge only
b) tbc – need to be checked

Table 8 Standards for maximum concentrations of organic contaminants in sewage sludge (mg kg-1 DS except PCDD/F: ng TEQ kg-1 DS) (CEC 1986, EC, 2000 and 2003; SEDE and Andersen, 2002; Alabaster and LeBlanc, 2008; and Smith, 2008;)

	Absorbable organic halides (AOX)	Bis(2-ethylhexyl) phthalate (DEHP)	Linear Alkylbenzene Sulfonate (LAS)	Nonylphenol/ Nonylphenol ethoxylate (NP/NPE)	Polycyclic aromatic hydrocarbon (PAH)	Polychlorinated biphenyls (PCB)	Dioxins/Furans (PCDD/F)	others
Directive 86/278/EEC	-	-	-	-	-	-	-	
EC (2000)a)	500	100	2600	50	6b	0.8c	100	
EC (2003)a)			5000	450	6b	0.8c	100	
Austria								
Lower Austria	500	-	-	-	-	0.2 d)	100	
Upper Austria	500					0.2 d)	100	
Vorarlberg	-					0.2 d)	100	
Carinthia	500				6	1	50	
Denmark (2002)		50	1300	10	3b			
France					Fluoranthene: 4 Benzo(b)fluoranthene: 2.5 Benzo(a)pyrene: 1.5	0.8c)		
Germany (BMU 2002)	500					0.2 e)	100	
Germany (BMU 2007) f)	400				Benzo(a)pyrene: 1	0.1 e)	30	MBT+OBT:0.6 Tonalid: 15 Glalaxolide:10
Sweden	-	-	-	50	3b)	0.4c)	-	
Czech Republic	500					0.6		

a proposed but withdrawn
b sum of 9 congeners: acenapthene, fluorene, phenanthrene, fluoranthene, pyrene, benzo(b+j+k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3-c,d)pyrene
c sum of 7 congeners: PCB 28, 52, 101, 118, 138, 153, 180
d sum of 6 congeners:PCB28,52,101,138,153,180
e Per congener
f Proposed new limits in Germany (BMU 2007)

The remainder of this section reviews the rules and requirements in selected Member States.

In **Sweden** the Swedish Environmental Protection Agency (Naturvårdsverket) (SEPA) by mandate from the Government has implemented the Directive through the *Regulation regarding protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture* (Kungörelse SNFS (1994:2) med föreskrifter om skydd för miljön, särskilt marken, när avloppsslam används i jordbruket). The Regulation is more stringent than the Directive in that it bans the usage of sewage sludge on pastureland and it regulates the necessary analyses for toxins in soil and sludge. Besides the Regulation, Sweden has adopted legislation on several other aspects of sewage sludge such as maximum permissible concentrations of potentially toxic elements in sewage sludge for commercial use, management of fertilizers (including sludge) in agriculture, requirements and permissions for sewage water treatment plants, deposit of sludge etc. In 1994, SEPA, the Federation of Swedish Farmers (LRF) and the Swedish Water and Waste Water Association (VAV) signed a voluntary agreement regarding quality assurance. This has primarily led to additional requirements for organics and the creation of a consultative group. In Sweden a quality assurance system (ReVAQ) has been designed in concert by the concerned parties, water companies, farmers, nature conservation and the food industry. These stakeholders studied the risks and then agreed the standards that they would endorse for using treated sludge on land. Aspects of the DIN ISO certification are included in the system. A pilot implementation has been successful and the next phase is to develop it as a national scheme. Two main drivers have been the need to heighten acceptance of and trust in the use of sludge in agriculture and to aid the achieving of national environmental targets (EWA 2008).

In the **UK**, a voluntary code was agreed in 2001 between the UK Water Industry and British Retail Consortium, known as the Safe Sludge Matrix (ADAS, 2001), that requires more rigorous control over sludge treatment, pathogen removal and use on land than was previously required by the guidelines in the *Code of Practice for Agricultural Use of Sewage Sludge* and the Statutory Instrument (DoE, 1989; UK SI, 1989) implementing the Directive. Importantly, the Matrix also introduced a two tier system of treatment for sludge with regard to the extent of pathogen removal, and strict land use controls that were analogous to the US EPA's Class A and B pathogen reduction requirements in the Part 503 Standards for the Use or Disposal of Sewage Sludge for agricultural use of sludge (US EPA, 1993).

In **France**, agricultural use of sludge is regulated by the Decree No. 1133 of December 8, 1997 and by the Enforcement Order dated January 8, 1998. This recent legislation was implemented in the broader context of the 1992 Water Act, the 1975 and 1992 Waste Acts and the Health Code. In particular, the 1992 Waste Act restricts the landfilling of sewage sludge from 2002 onwards: from this date, landfilling is limited to waste that cannot be recovered at reasonable cost (defined as "ultimate waste").

France's 97/1133 Decree establishes that before any spreading of sludge on land, a preliminary study must be carried out by the sludge producer identifying the sludge treatment and quality as well as the soil quality. In addition, a land spreading forecast must be established each year, specifying the quantities of sludge to be spread on land, the scheduling of each spreading operation as well as the parcels which will receive sludge. A report on the sludge spread on land and on the resulting impacts on soil qualities must be prepared at the end of the year (defined as the end of the "agricultural campaign"). Both the land spreading forecast and annual report must be transmitted to the local authorities by the sludge producer.

The spreading on land of more than 800 tonnes of sludge (DM) per year is subject to authorisation. For industrial sludge a preliminary study is required for such a permit and must include an evaluation of health risks. The French association of land spreading operators have developed a methodology to evaluate health risks of spreading operations (SYPREA 2007). Since March 2004 there are standards of quality regarding composted sludge approved by national authorities. The compost which reaches this quality standard is being considered as a product. Moreover a quality assurance scheme regarding the beneficial reuse of sludge in agriculture has been set out by the SYPREA. Thirty-seven criteria, which are controlled every year by an independent body, guarantee the respect of the best practices of sludge land spreading.

The French legislation on the spreading of sewage sludge is globally more stringent than Directive 86/278/CEE. For example, it provides that minimal distances should be respected between housings, river banks, bathing places, water wells, shellfish zones and the place where sewage sludge is spread. Furthermore, unlike Directive 86/278/CEE, the French legislation bans the spreading of sewage sludge when the soil is covered by snow or frost or during periods of strong rainfall, and it bans application on slopes.

In **Germany** the application of sewage sludge on land is regulated by the *Sewage Sludge regulation of 15 April 1992 (Klärschlammverordnung, AbfKlärV, last amended 20.10.2006) (BMU, 1992)*. This 1992 regulation strengthened an earlier (1982) version, introducing more stringent limit values for heavy metals. The use of untreated sludge is generally forbidden, as is the use of sludge on horticultural, grassland, forestry land, on land in protected areas, on land in water protection areas, and on river banks. Field vegetables may not be grown on land if sludge has been applied that year or the year before. If crops are used as fodder, sludge can only be applied before seeding and has to be incorporated into the soil. Although there are a number of restrictions governing the spreading of sewage sludge in agriculture, there are still concerns in some parts of Germany that the law governing this outlet is not strict enough.

In 2007, a draft for a new ordinance for sewage sludge (BMU, 2007) was issued by the Ministry of Environment (BMU), following an expert seminar held in December 2006 at the BMU in Bonn (www.bmu.de/abfallwirtschaft/fb/klaerschlamm). Delegates from some Federal States wanted to ban the agricultural use of sewage sludge, mainly because of concerns over the accumulation of organic contaminants in the soil (e.g. Baden-Württemberg (Kaimer (2006)), but recognised that this would not be possible under existing EU and German national legislation. Although the Federal Ministry for the Environment (BMU) as well as most Länder do not support a total ban of the use of sludge on land, some of the Länder think that the currently discussed revision of the German sewage sludge regulation does not go far enough and a total ban should be made possible. In June 2008 the Bavarian Minister for the Environment requested an EU wide ban of the use of sewage sludge on land or a provision in the directive for Member States to allow a ban. Bavaria has already reduced the amount of sludge used from 55% in 1997 to 20% in 2008. The Land wants to further reduce this amount by building several incineration plants at waste water treatment plants. Baden –Württemberg also has proposed an end to the use of sludge on agricultural land and has already initiated a "de facto" ban by restricting certain agricultural subsidies to farmers that do not use sewage sludge on their fields.

The main issues of the 2007 draft revision are a significant reduction of existing limit values for heavy metals and new limit values for organic substances (lower limits for dioxins/dibenzofurans, and some PCB congeners, and the introduction of a limit for benzo(a)pyrene). It was envisaged that the process of adopting the revised ordinance would be initiated in autumn 2008.

In the **Netherlands,** Directive 86/278 has been transposed into national legislation mainly through the "Decree on the quality and use of other organic fertilisers" (Besluit kwaliteit en gebruik overige organische meststoffen), abbreviated as "Boom" (BOOM 1991) The decree entered into force on the 1st of January 1993 – after the Commission concluded on the failure of a timely transposition of the directive in 1990. In 1998, the original decree was replaced by a new "Decree on the quality and use of other organic fertilisers" (BOOM 1998).
In sum, the provisions of Chapter II of the Decree concern the quality of organic fertilizers other than of animal origin such as compost, mud and other sediments, compost, etc. Article 8 includes measures for analysing and certifying these substances. The producers of the fertilizing substances are obliged to keep a register in which the information specified in Article 9 is inserted. Chapter III establishes rules with respect to the use of the fertilizing substances concerned. The use of fertilizing substances other than those which are in conformity with requirements laid down in the attachments is prohibited by Article 12. Articles 28 – 36 contain rules respecting the distribution on the land of fertilizing substances concerned. The 1998 Boom Decree sets more stringent limit values for heavy metals in sludge and in soil than the Directive. This has essentially ended the spreading of sewage sludge on agricultural land in the Netherlands. In principle, the use of sewage sludge is not allowed on land that is not used for agricultural purposes (Article 14 of the Decree). The requirements of quality are based on the Fertilisers Law (Meststoffenwet, 1986), whereas the norms of use are based in the Law on soil protection of the (Wet bodembescherming, 1986 and amendments). The 1998 Decree has been amended in 1996, 2001 and 2005 (amending the Decree use of Fertilizers of Animal Origin 1998, the Decree Quality and Use of Remaining Organic Fertilising Substances, and the Decree Discharge Open Cultivation and Livestock Breeding). Strengthening of norms regarding the use of nitrogen in the Netherlands is mainly based on laws transposing both the Nitrates and Water Framework Directive.

4 Economics of Sludge Treatment and Disposal

Agriculture application, incineration or landfilling are the main routes for sludge management across Europe. The amount of sludge that is incinerated significantly increases when agricultural recycling is discouraged or banned. Increasingly, the landfill option is becoming restricted to the disposal of ash from the incineration of sludge. Minor routes include land reclamation and incorporation, usually of ash, into building materials. The incorporation of whole sludge into bricks has also been tried. These minor routes will not be considered further at this point.

Of the developing processes, pyrolysis is probably the most significant. This can be viewed as an alternative to incineration and may prove to be of lower cost. The solid char that is produced may, however, not prove that easy to dispose of. Sometimes the char is incinerated which would appear to remove much of the advantage claimed for pyrolysis. Pyrolysis will not be considered further in this section but new technology options will be considered in the next stage of reporting (Task 3). Dried sludge can be used as a fuel in e.g. power stations. This could be viewed as incineration in stages, though in this case the ultimate disposal route may not be to landfill. In the UK, power stations are not allowed to burn waste material without meeting the stricter flue gas requirements applicable to waste incinerators, which makes this option unattractive to the electricity generators. No costs are given for this route.

Any disposal option/route requires the sludge to be treated in a range of unit processes which contribute to the overall cost. These include:

- Mechanical thickening and dewatering with the aid of polyelectrolytes for sludge conditioning.
- Anaerobic digestion.
- Drying.
- Lime treatment.
- Heating for pasteurisation.
- Incineration.
- Composting.
- Landfilling. Also land reclamation.
- Use in agriculture. A variant is silviculture where sludge is used in a fast rotation coppice.
- Transport.
- Storage.
- Many sludge treatment processes require odour control plant.

As well as the capital costs, there are operating costs which include:

- Labour.
- Energy. Drying in particular is a major user of energy and composting is a moderate user. Anaerobic digestion produces methane which is usually used in combined heat and power engines to produce a significant surplus of electricity, which can be sold. Incineration also generates electricity but less than used within the process.
- Transport fuel.
- Chemicals such as polyelectrolyte and lime. Lime is used for lime treatment and also to treat incinerator flue gas.
- When a sludge product is used in agriculture, the farmer requires less chemical fertiliser. This is a monetary benefit, whether it accrues to the farmer as is usually the case or to the operator responsible for the sludge.

- Even when the use of chemical nitrogen and phosphorus is reduced according to the levels of available nitrogen and phosphorus in sludge, crop yields can be higher. This could be due to a portion of the N or P in the sludge classed as unavailable, actually having some availability, or to other nutrients in the sludge or to the organic matter acting as a beneficial soil conditioner. The extra crop yield can be given a value.
- Instrumentation and analysis associated with regulatory requirements.
- Landfill tax and landfill gate fees.

A costing exercise for the European Commission was reported in 'Disposal and recycling routes for sewage sludge' (Sede and Andersen, 2002). Where costs have been obtained by WRc, these have been in broad agreement.

These costs are shown in Figure 1, in 2002 Euros.

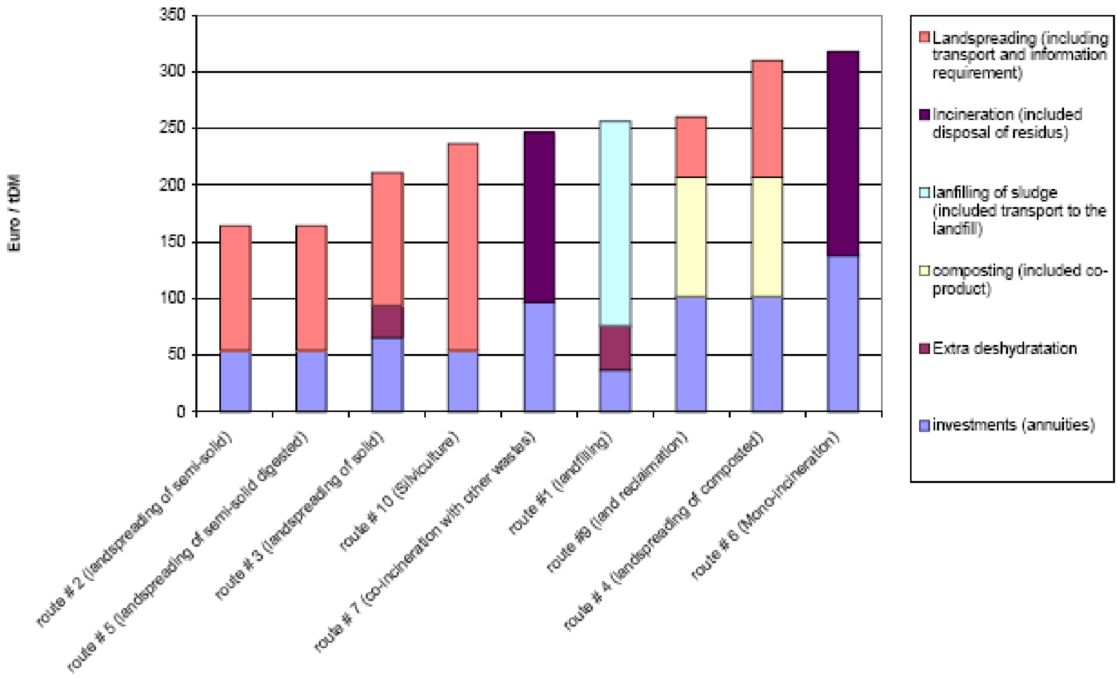

Figure 1 Average internal costs of sludge disposal and recycling in Europe (Euro/ tonne dry matter)

(From SEDE AND ARTHUR ANDERSEN (2002) *Disposal and Recycling Routes for Sewage Sludge*, European Commission, DG Environment – B2, 2002. Available at: http://ec.europa.eu/environment/waste/sludge/sludge_disposal.htm)

The costs in Figure 1 include operating costs and annualised investment costs for capital items. Two of the most commonly employed options are Route #3, the use of sludge cake, usually digested, in agriculture at €210/t DM, and Route #6, incineration in a dedicated incinerator at €320/t DM. Routes that were not costed included lime treatment and any that involved drying. The use of limed raw sludge cake in agriculture in the UK, is cheaper than the use of digested sludge cake (Route #3). Drying is very energy intensive and any route that involves drying would be at least as expensive as dedicated incineration. Despite its expense, drying is used quite frequently since it offers great flexibility to the operator in terms of storage and final destination.

Costs for routes based on use in agriculture assumed that extended storage periods of up to 9 months were required. If these were not required, costs would reduce by €50/t DM. This matches very well with the situation in the UK, where with 3 months storage, the costs for using digested sludge cake in agriculture are around 50% those of dedicated incineration. If additional storage is required this is assumed to be carried out by the farmer at the field-side at no extra cost.

Incinerators require extensive maintenance. If full throughput is required at all times, extra standby capacity is required, increasing costs by 50%.

The costs in Figure 1 include any benefits from energy recovery but not the value of displaced chemical fertiliser, which was costed separately. The value of displaced chemical fertiliser plus additional crop yield for a range of sludge products is shown in Figure 2.

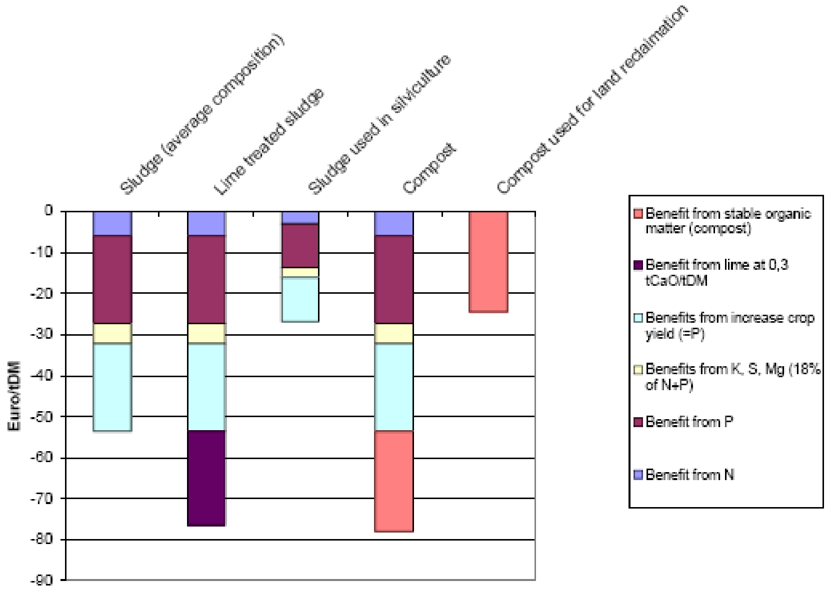

Figure 2 Internal benefits of sludge recycled to land (€/tDM)
(From SEDE AND ARTHUR ANDERSEN (2002) *Disposal and Recycling Routes for Sewage Sludge*, European Commission, DG Environment – B2, 2002. Available at: http://ec.europa.eu/environment/waste/sludge/sludge_disposal.htm)

When comparing routes, the appropriate benefits from Figure 2 should be added to the costs in Figure 1. As an example, to the cost of €210/t DM for the use of sludge cake in agriculture, Route #3, should be added €-53/t DM for the benefit of reduced fertiliser requirement and increased crop yield resulting in just under €160/t DM, which could reduce further given the low storage assumption. This is very much less than the €320/t DM for dedicated incineration.

In the Sede and Andersen (2002) study a range of external impacts was quantified. Some of the impacts from airborne pollutants are quantified in monetary terms but this goes beyond the scope of this section.

Current estimates are that 45% of the EU15 total of 9 million tDM of sewage sludge are used in agriculture (CEC 2006b, Alabaster and LeBlanc, 2008). If this route was lost, to be replaced by incineration, the cost would be of the order of €650 million per year. Andersen suggested a policy of pollution prevention, needed to maintain the agricultural route in the light of the draft revisions to the regulations regarding the use of sewage sludge in agriculture, would cost a similar amount.

5 Agricultural Value of Sewage Sludge

Application of sewage sludge to land recycles nitrogen (N), phosphorus (P), other macronutrients (such as calcium, potassium and sulphur), micronutrients (such as copper and zinc) and organic matter and so confers very positive agricultural benefits. Sewage sludge has also been used successfully in land reclamation, on forest land and in other land applications.

The focus of investigations into the agricultural value of sewage sludge has been on the availability to crops of the N and P it contains and the soil conditioning capability of its organic matter content. The availability factor is the key to determining the fertiliser replacement value of sludge and thereby quantifying its agricultural benefit to farmers.

The availability of sludge N to crops is broadly in the range 15-85% compared with the availability of N in inorganic fertiliser. The availability of N in sludge is largely determined by the treatment process given to the sludge before application to the land. Selection of sludge treatment process is concerned principally with factors such as stabilisation, sanitisation and volume control but it is also important, if the sludge is for agricultural use, to have a sludge product which farmers will want to apply to their land. In general terms the N in anaerobically digested, dewatered sludge cake (20-30% dry solids content) will be at the low end of the scale (15-20% available) whilst liquid digested sludge (3-8% dry solids content), which contains readily plant-available ammonia, will be at the high end of the scale (up to 85% available). Dewatered sludge cake has logistical advantages over liquid sludge and is the sludge product most widely used in agriculture. Sludge cake has the positive attribute that much of its N content is combined with organic matter and will be slowly released to the growing crop roots in the soil as the organic matter decays. Also, the dry solids: N content of sludge cake is comparatively high so an application of sludge cake will add more organic matter to the land before the N limit is reached.

P availability is less influenced by sludge treatment process is likely to be about 50% available in most sludge products. In the case of advanced-treated thermally dried sludge products nutrient availability may be influenced by the physical properties of the dried material. Hard dry sludge pellets of 90%+ dry solids content will break down only gradually in the soil causing very slow release of nutrients.

Thus the agricultural benefit of sludge products has been defined as effectively as is possible for an organic material and many farmers use sludge products, recognising their value and economic benefit. Sludge may be supplied free to the farmer or there may be a charge for a service which would include derivation of rate of application (usually based on the N requirement of the crop and often in the range 5-10 tonne dry solids of sludge per hectare), supply and incorporation of sludge and follow-up monitoring. Demand for sewage sludge in agriculture and for other land uses would undoubtedly be enhanced if it was clearly recognised as a product not a waste, and was accepted as being suitable for use in organic farming and other organic growing practices.

The limiting factor determining the rate of application of sewage sludge to the land is usually the maximum permissible addition of total N which for most purposes is 250 kg N/ha per year as set out in the Nitrates Directive 91/676/EEC. This figure will be reduced in Nitrate Vulnerable Zones to 175 kg N/ha per year. In some circumstances it may be permissible to apply 500 kg N/ha every 2 years if the N availability of the material is low as could be the case for dewatered sludge cake and sludge compost. This would be good for soil conditioning purposes as such an application would supply a beneficial quantity of organic matter to the land. In particular, effective land reclamation operations often require heavy applications of organic matter and nutrients to resuscitate impoverished substrates.

Rate of application of sludge may also be limited or not permissible where the P index of the soil is comparatively high (3-4+) and the P restriction may extend as the requirements of the Water Framework Directive are implemented. Sewage sludge is a P-rich fertiliser product in terms of its P/N content in relation to the P/N requirements of crops. Thus an application of sludge to the land to meet the N requirement of the crop will exceed its requirement for P. Any move to change the permissible rate of application of sludge to land away from the N factor to a baseline determined by the crop requirement for P would have serious implications for the operational viability of the agricultural outlet for sludge because the rate of application would be significantly reduced. Smith (2008) in his review noted that P concentrations in sludge are increasing with the expansion of P removal during waste water treatment and so careful management of nutrient inputs to soil in sludge is necessary to avoid excessive P application. Smith (2008) considered that more information was required on the long-term fate and release of P in sludge-treated agricultural soil in order to assess the agronomic benefit of P and the efficiency of P utilisation by crops. This information is needed as a basis for controlling P accumulation in soil and for minimising risk to the water environment.

Directive 86/278/EEC states that, 'Whereas sludge can have valuable agronomic properties and it is therefore justified to encourage its application in agriculture provided it is used correctly; whereas the use of sewage sludge must not impair the quality of the soil and of agricultural products'. The Directive states also in Article 8 that, 'the sludge shall be used in such a way that account is taken of the nutrient needs of the plants and that the quality of the soil and of the surface and ground water is not impaired'. These broad requirements remain sound at the present time and most Member States have available more detailed guidance on how to utilise effectively the nutrient and organic matter content of sludge in agriculture, based on information obtained from field trials carried out on local farms. In view of this, it would seem to be unnecessary to alter 86/278/EEC as regards sludge utilisation and nutrient management with the proviso that a watching brief is kept on P and more information is obtained about the accumulation and fate of P in sludge-treated soils.

6 Contaminants and Pathogens

6.1 Potentially Toxic Elements

The potentially toxic elements (PTEs) include heavy metals and other inorganic elements which may be found in sewage sludge. When sludge is applied to the land the PTEs will tend to accumulate in the cultivated layer of topsoil and following repeated applications of sludge the PTEs could theoretically accumulate to toxic concentrations which might adversely affect for example crop growth and quality, soil fertility and the food chain. Directive 86/278/EEC sets limits for cadmium, copper, nickel, lead, zinc and mercury. Chromium was on the list but was not given a limit. Some Member States have set limits for more PTEs e.g. in the UK there are additional guideline limits for arsenic, fluoride, molybdenum and selenium (see section 3). The way in which Directive 86/278/EEC sets the PTE limits is flexible because they are given as permissible ranges in both soil and sludge and implementation. The Directive states: ‘Whereas, moreover, it is necessary to prevent these limit values from being exceeded as a result of the use of sludge; whereas, to this end, it is necessary to limit the amount of heavy metals added to cultivated soil either by setting maximum quantities for the amounts of sludge used per annum and ensuring that the limit values for the concentration of heavy metals in the sludge used are not exceeded or by seeking to ensure that limit values for the quantities of heavy metals that can be added to the soil on the basis of a 10-year average are not exceeded’.

New developments on PTEs in sludge recycled to land include the effect of Zn on soil microorganisms and soil fertility, and the impact of Cd in soil on Cd concentrations in certain foods. Effects of PTEs on soil microorganisms and soil fertility have been the subject of detailed field investigations in the UK (DEFRA 2002, DEFRA 2007). Definitive effects requiring changes to the soil metal limits have yet to be identified but the findings confirm that the precautionary change for Zn from 300 mg/kg to 200 mg/kg for soils of pH value 5.5 – 7.0 was appropriate.

Commission Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foodstuffs set limits for Cd in foodstuffs ‘as low as reasonably achievable’ following the precautionary principle. The limits are close to background levels which occur naturally in foodstuffs from uncontaminated sources. The levels for Cd in cereal grains and offal may not be compatible with the existing soil limit of 3 mg Cd/kg where sludge is recycled to land. This needs further evaluation – however, concentrations of Cd (and indeed of other PTEs) in sludge have declined substantially over the years due to tighter controls on discharges from industrial premises and reduction in the use of PTEs in industry. In practice, it is unlikely that applications of sludge to the land, at rates determined as they are by N content, would increase the concentration of Cd in the soil to the extent that the limits for Cd in grain or offal would be exceeded.

A recent risk assessment of sludge in soil conducted by INERIS for EFAR considered the presence of the metals, cadmium, chromium III, copper, mercury, nickel, lead and zinc (together with the organic compounds, mentioned in drafts related to revision of the Sludge Directive in 2003) (EFAR, 2008). They evaluated the potential hazard of each substance to derive a toxicological reference value (TRF), which they compared with an exposure value to give a hazard quotient (Exposure ÷ TRF), a value over 1 being considered concern for human health. The exposure value considered consumers, neighbours and farmers as receptors, and ingestion via soil, water, animals, vegetables and fish for a 70 year lifespan. The results confirmed that the major exposure pathway is the ingestion of plants and animals. The major substances were the heavy metals, zinc, lead, cadmium, copper and nickel. The study concluded that the contribution of sludge spreading to land to the global risk is low compared to the ingestion of food produced on non-spread lands. Nevertheless, the report suggested a reduction in the permissible Pb concentration in sludge for recycling from a maximum of 750 mg/kg ds (in

86/278/EEC) to 500 mg/kg. This would achieve an acceptable level of risk with 70 years of exposure based on very conservative assumptions.

Smith (2008) points out that there remains further scope to reduce the concentrations of problematic contaminants, and PTEs in particular, in sludge. He suggests that this should continue to be a priority and pursued proactively by environmental regulators and the water industry as improving the chemical quality of sludge as far as practicable is central to ensuring the long-term sustainability of recycling sewage sludge in agriculture.

Monitoring and research needs to continue to assess the significance of new developments (including PTEs of new interest e.g. tungsten) as they arise.

6.2 Organic Contaminants

The presence of organic contaminants (OCs) in sludge has been considered to a much greater extent in recent years; the European Commission and JRC has launched their own review in 2001 (EC 2001). The list of potential contaminants that have been detected in sludge is now extensive and includes: products of incomplete combustion (polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and dioxins), solvents (e.g. chlorinated paraffins), flame retardants (e.g. polybrominated diphenyl ethers), plasticisers (e.g. phthalates), agricultural chemicals (e.g. pesticides), detergent residues (e.g. linear alkyl sulphonates, nonylphenol ethoxylates), pharmaceuticals and personal care products (e.g. antibiotics, endogenous and synthetic hormones, triclosan) (Smith, 2008).

Some countries such as UK, USA and Canada have not set any limit on OCs in sludge suggesting that research indicates that concentrations present are not hazardous to human health, the environment or soil quality. However, other countries have set limits for some OC groups. For example, Germany has set limits for PCBs and dioxins but not PAHs while France has limits for PAHs and PCBs but not dioxins. Denmark has set limits for a range of OCs including linear alkyl sulphonates, nonylphenol and nonylphenol ethoxylates and the phthalate, di(ethylhexyl)phthalate (DEHP). Therefore, agreement on which OCs should be regulated in sludge could prove to be a major point of discussion when the Sludge Directive is considered for revision.

A considerable amount of information is known on the fate and behaviour of these substances to enable assessment of their potential effects on human health. Ingestion of crop plants and grazing livestock that have taken up OCs from sludge is a potential exposure route for humans. OCs have a number of physicochemical properties which may affect their behaviour in sludge and potential uptake into plants and animals. OCs include volatile compounds which are rapidly lost to the atmosphere from sludge and sludge-treated soil; compounds with little persistence which are mineralised by microorganisms; and persistent compounds which are strongly absorbed to sludge and the soil organic matrix. Compounds with some water solubility have a greater potential for plant uptake but are also more susceptible to rapid degradation or lost through volatilisation or leaching. For example, nonylphenol and nonylphenol ethoxylates have the potential for uptake by crops but are rapidly degraded in soil (half-life of 20-60 days for nonylphenol). The principal concern for livestock grazing on sludge-treated pasture is the potential accumulation of lipophilic OCs in meat fat and milk. Of the main OCs, only the chlorinated hydrocarbons meet this criterion. The review of Smith (2008) suggests that the potential impact of OCs on grazing animals, in terms of subtle physiological responses is very difficult to measure in practice.

The polymer, polyacrylamide, is used extensively as a polyelectrolyte to aid mechanical dewatering of sludge and may constitute up to 1% of the dry sludge. Small amounts of the unchanged monomeric, acrylamide, may be present with the polymer and this has the potential to form *N*-nitrosodimethylamine. While the polymer is inert, both acrylamide and *N*-nitrosodimethylamine are under assessment as potential carcinogens (both classified as 2A, probable human carcinogens, by the

International Agency for Research on Cancer (IARC)). However, rapid degradation in soil and absence of plant uptake and accumulation suggests no transmission to the human foodchain via sludge.

Pharmaceuticals and personal care products have been increasingly detected in waste water. However, although less is known about their behaviour in the environment, it is envisaged that their fate and behaviour will depend on their physicochemical properties as for other OCs described above. There are particular concerns about the presence of antibiotics and the antimicrobial agent, triclosan and their potential indirect effects on human health through effects and resistance in the microbial environment. The present of antibiotic populations of bacteria in soil has been linked to the use of antibiotic in livestock. Although the concentrations of pharmaceuticals in waste water appear to be low, as more knowledge is gained on their presence in sludge, further assessment of their potential effects on human health may need to be made.

There is also concern over the presence of endocrine disrupting chemicals including natural and synthetic hormones and the much less potent industrial agents such as phthalates and their presence in sludge. Endogenous and synthetic oestrogenic compounds do partition to particulates and may be associated with sludge but there is only limited information at present on levels and biodegradation. It appears likely that oestrogenic substances excreted from farm livestock waste will constitute a greater load to the soil than sludge.

Another emerging group of potential contaminants about which nothing is known at present in terms of fate and behaviour in waste water processes are nanoparticles. These are being increasingly used in a range of technologies from personal care products to industrial processes. As more is known about their fate in the environment, assessment will have to be made on their potential presence in sludge spread to land.

There have been a number of risk assessments conducted on the presence of OCs in sludge (reviewed by Smith, 2008). These have concluded that exposure to OCs from the agricultural use of sludge is no greater than background levels. A recent risk assessment of sludge in soil conducted by INERIS(EFAR, 2008) considered the presence of the PTE together with the OCs mentioned in drafts related to revision of the Sludge Directive in 2003, PAHs (with benzo[a]pyrene considered separately), dioxins, PCBs, nonylphenols and nonylphenol ethoxylates and linear alkyl sulphonates, together with DEHP. They evaluated the potential hazard of each substance to derive a toxicological reference value (TRF), which they compared with an exposure value to give a hazard quotient (Exposure ÷ TRF), a value over 1 being considered concern for human health. The exposure value considered consumers, neighbours and farmers as receptors, and ingestion via soil, water, animals, vegetables and fish for a 70 year lifespan. The results confirmed that the major exposure pathway is the ingestion of plants and animals and that heavy metals were the major substances, with PAHs and PCBs being the only major OCs. The study concluded that the contribution of sludge spreading to land to the global risk is low compared to the ingestion of food produced on non-spread lands. OCs such as linear alkyl sulphonates, DEHP and nonylphenols did not contribute significantly to global risk.

Another consideration when assessing the need for OCs to be considered for regulation in any revision of the Sludge Directive is that many of the potential contaminants are already being controlled under other legislation and so the potential levels in sludge are already decreasing. For example, nonylphenols, DEHP, polybrominated diphenyl ethers and other flame retardants, some pesticides and some chlorinated solvents are on the Priority Hazardous Substances or other pollutants lists for the Water Framework Directive. So it appears likely that the majority of the known pollutants will be increasingly controlled at source.

In summary, the reviews of the research on OCs in sludge conducted so far have concluded that they are unlikely to have an adverse effect on human health and will be increasingly controlled by regulation. However, contaminants such as DEHP and chlorinated paraffins, found in sludge at higher levels will need to be further assessed. Further vigilance is also required on emerging contaminants such as pharmaceuticals, where the potential fate and behaviour in waste water, sludge and soil is unclear at present.

6.3 Pathogens, Treatment of Sludge and Land Uses Practices

6.3.1 Current situation

Sludges produced from the treatment of waste water contain a broad range of pathogenic organisms, including viruses, bacteria, parasitic protozoa and helminths. Human, animal and plant populations are exposed to the risk of contact with pathogens in sewage effluents and sewage sludge in the following main ways:

- discharge of sewage into watercourses and bathing waters;
- recycling of sludge onto agricultural land, or renovated land.

Of these only discharge of sewage into bathing waters is subject to specific microbial controls at European level, under the Directive on Bathing Waters (2006/7/EC), whose requirements were developed following extensive human exposure trials.

The risk of pathogen transmission from sewage sludge into human, animal or plant receptors continues to be a major concern to the public, which has been reflected in individual country regulations and codes of practice, and in the significant reduction or complete elimination of agricultural use of sewage sludge in some countries in the EU.

Implementation of the requirements of Directive 86/278/EEC provides effective barriers to the transmission of disease. These have been implemented in different ways in different countries. Although the Directive provided no specification of microbial quality or guidance on appropriate treatment methods the only clear evidence for transfer of disease from sewage sludge has been in a few instances where its requirements have not been properly implemented or where operators may have been using unhygienic practices.

This has not allayed public concerns over the potential for disease transfer. In some countries, for example the UK, regulatory requirements stemming from the Directive, with guidance provided on the types of processes that have been regarded as providing appropriate levels of treatment have been supplemented by “voluntary” agreements that enhance sewage sludge quality requirements. Hence the “Safe Sludge Matrix” in the UK was devised after extensive study of the evidence for pathogen decay in treatment and recycling processes.

The Safe Sludge Matrix provides descriptions of two levels of treatment to achieve specified numbers of *E.coli* and *Salmonella* spp in sludge. The enhanced treated sludge quality standard is only achieved as a result of a degree of treatment that achieves at least some additional pasteurisation, usually involving a thermophilic stage, and potentially also multistage treatment that reduces the likelihood of significant amounts of sludge failing to be retained for a minimum period in the process.

By instituting this and also developing a control and monitoring philosophy for sludge treatment processes that identify critical points in a process stream and ensuring that these are measured and have to meet previously agreed criteria in order for sludge to be regarded as treated or enhanced treated sludge, there appears to be improved acceptance that sludge may be beneficially used on agricultural land without unacceptable hazards to public health.

6.3.2 Pathogen exposure and consequences

Direct exposure is considered an occupational health risk to those producing and applying sludge to land. Epidemiological evidence indicates risks of illness are low from this route when sludge has been treated. There have been some examples of illness resulting from poor hygienic practice (e.g. failure to wash hands, lack of protective equipment).
Various studies have assessed the health risk of workers and other populations in the vicinity of sludge operations as a result of aerosol dispersion of pathogens and residues in the sludge. Some findings (for example Tanner et al, 2008) have suggested that there may be a significantly increased risk of illness in close proximity to loading operations from field site storage of treated sludge to the spreader trucks. Other findings on the health effects on populations residing nearby have not shown any unequivocal evidence for increased risks. These studies are difficult to carry out and many of them suffer from low population numbers and lack of equivalent non-exposed populations, as well as difficulties in assessing measurable illness. It is possible that a combination of endotoxins and pathogens may enhance infectivity.

Various indirect transmission routes exist. The most obvious are sludge applied to land and subsequent use of the land for food production, either for crops or animal husbandry. These routes have been widely studied (Carrington et al, 1998) with attempts to carry out risk assessments using assumptions about ingestion and infection rates. There have been no clearly identified public infections resulting from agricultural use of sewage sludge when it has been used in accordance with the provisions in the Directive, including local additional controls. Gale *et al.* (2003) applied Quantitative Microbial Risk Assessment (QMRA) to assess human exposure to a range of pathogens from sludge applied to land subsequently used to cultivate a range of agricultural crops. Generally, the risks were found to be low although a number of uncertainties were recognised, particularly regarding the lack of reliable data on the long term decay characteristics of pathogens in the environment.

Run-off from land on which sludge has been used is another possible route, with discharges into recreational water, or sources of water used for producing drinking water or longer term contamination of groundwater. This also ties into requirements under the Water Framework Directive. Some workers have reported that faecal indicators and viruses can be detected at a considerable distance in groundwater from possible sources of contamination.

The risk of presence of animal pathogens in sewage sludge cannot be excluded where waste from abattoirs or other animal processing may enter sewer system. Bacteria and parasites may infect humans and animals. Viruses tend to be host specific although there have been recent concerns over zoonotic transmission of certain viruses. Helminths have well defined life-cycles and host specificities but animal to animal transmission may occur where the land is used for grazing.

Plant pathogens may also be present, derived for example, from vegetable washings. Most washing is probably now carried out immediately post harvest, and is likely to be in the vicinity of the producer, so that there may now be a reduced likelihood of transmission of significant levels of pathogens into uninfected areas. Increased use of food waste disposal into sewers may be an additional route for introduction of plant pathogens into sewage and sludge.

6.3.3 Pathogen risk minimisation

The Directive 86/278/EEC includes:

- A requirement for treatment of sludge to reduce its health hazards before using it in agriculture
- A permit, on certain conditions, to use untreated sludge, without risk to human or animal health, if it is injected or worked into the soil;
- Restrictions on applications to sensitive crops and on use of the soil for periods after application.

These conditions provide barriers to the transmission of risks of infection.

In the UK extensive studies (CEC, 1992) on use of sewage sludge on agricultural land were carried out that led to guidance documents and codes of practice to control use and operations, prior to the implementation of the 1986 directive. Risks of animal, plant and human infections were recognised, although there was a lack of clear evidence that for recorded outbreaks of salmonellosis in animals sewage sludge was the route of infection, as most routes for infection were within existing agricultural activities. Other animal infections were also more closely related to agricultural activities than to the water industry.

The EU COST 68 working group studies (CEC, 1992) found some limited evidence for viral hepatitis due to use on vegetables, run-off from fields with incorrect application, and direct contamination of operators using very poor personal hygiene. The 1986 restrictions on planting, grazing and cropping, in conjunction with local additional controls have been considered appropriate to allow time for sufficient viral inactivation.

Time is not necessarily a secure barrier, as some parasites are capable of surviving non-thermophilic sludge treatments and persist in the environment for long periods of time. These include *Cryptosporidium*, and *Ascaris* spp.

Many plant pathogens could be present in sewage sludge. In the UK, before 1989, studies (Carrington et al, 1998) identified the potato cyst nematode as a significant sludge related hazard which resulted in a specific ban on sludge use on land to be used for seed potato growth in the UK Code of Practice. Some other plant diseases may also be transferred into sewage sludge but have not been considered to have sufficient risk to justify exceptional treatment or recycling restrictions.

The Sewage Sludge Directive provides no examples of appropriate treatment processes, but defines treated sludge as sludge that has undergone *"biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use"*.

The appropriateness of sludge treatments for individual applications is derogated to individual countries to regulate, with an exemption to report on the treatments required for treatment works of less than 5000 population equivalent.

The use of untreated sewage sludge is only permitted in the directive under specific conditions of requiring injection or working into the soil and under regulation by each country (Art.6).

Treatment processes used include biological (digestion), chemical (lime treatment), and physical (high temperature drying). All these have different pathogen removal or inactivation characteristics, which vary from the relatively modest capability of mesophilic anaerobic digestion to reduce measurable *E.coli* concentrations by one hundred-fold with significant variation in effectiveness, to the substantially complete inactivation of vegetative cells achieved by thermal drying.

Variants of treatment methods that include thermal stages and multiple barriers to inhibit short-circuiting enable greatly improved reliability and confidence in the expected pathogen content of treated sludge. HACCP is also now used in the UK to manage treatment processes in conjunction with the Safe Sludge Matrix to provide assurance that processes are well managed.

There are areas of uncertainty in pathogen inactivation in treatment processes. For example, inactivation mechanisms in the widely used anaerobic digestion process are poorly understood, with potential for improvements; measurements of *E.coli* after dewatering processes sometimes show unexpected increases in concentration; and thermal inactivation may be linked to development of viable but non-culturable vegetative cells, also leading to difficulty in assessing the true pathogen quality of a treated sludge.

6.3.4 Pathogens of greatest risk

The occurrence of human pathogens is of most concern and has been the subject of a considerable amount of research to assess the health risks associated with the land applications of sludge. Largely, the organisms responsible are those pathogens that infect through the faecal-oral route, although respiratory and blood borne organisms may occur although prevalence generally low.

The nature and extent of human pathogens present largely depends on prevailing levels of infection in the community where the waste water is derived and the treatment used to produce the Sludge. Demographic variation of illness across the EU will influence the pathogen composition in waste water and may place a greater burden on the treatment barriers.

Potential issues include:

- new and emerging organisms, including antibiotic resistance,
- impact of climate change.

There are no widely accepted new risk pathogens in sewage sludge, although from time to time there are new public concerns about individual human pathogens. Since the work carried out for the 1986 Directive there have been developments in understanding quantitative microbial risk assessments and new assessments have been carried out for some pathogens including new variant CJD and *E. coli* O157;H7, in response to particular topical concerns.

6.3.5 Areas of uncertainty

- Since the 1986 directive some animal health issues have been recognised to be due to a range of pathogens potentially present in sludge – rotaviruses, cryptosporidium, and various bacteria;
- Full review of wide range of pathogens was not included during development of the studies associated with the 1986 directive, and whilst information was developed for the UK implementation of the safe sludge matrix this may need to be validated for other EU states;
- Sludge treatment is a crucial barrier to prevent disease transmission and requires better regulation and improved monitoring. The current indicators of process performance, *E. coli* and *Salmonella*, are vegetative bacteria and are not sufficiently robust to act as surrogates for the fate and behaviour of all pathogens of concern. Other organisms have been considered (e.g. enterococci and spore forming bacteria). However, consideration should be given to process verification by monitoring time and temperature requirements and relegate indicator and pathogen monitoring to process validation. This approach fits very much alongside the strategy being adopted in the forthcoming revision to the Drinking Water Directive and the adoption of Water Safety Plans. On this basis, a number of specific issues should be considered, such as;

- Should all EU be regulated in the same way, with the same sludge qualities required;
- What are suitable indicator organisms – see bathing waters enquiries – *E.coli* has been considered to be a good indicator as it is usually present at high concentrations, has similar sensitivities to treatments as a range of pathogens, and inexpensive measurement methods are well established. *Salmonella* is also used in the UK to monitor enhanced treatments. Faecal streptococci, used for bathing water standards, and Clostridia, as an indicator for spore forming pathogens have both been considered as additional or alternative indicators.
- Alternatively, should treatment processes be defined on the basis of process performance and validation;

- Should the impact of regrowth / reinfection potential be taken into account – pseudo stabilised versus stabilised sludges (CEN standard) on process verification if the existing indicator organisms continued to be used ;
- Should all sludges be fully safe for all handling at all stages subsequent to leaving a treatment works, without requiring any knowledge and training of operators or applying a degree of training to reduce occupational exposure ;
- Is the importance of the agricultural outlet sufficiently great for all sludge to be treated to the extent that there is no significant risk of further fermentation and odour generation;
- Are there newly understood exposure pathways; the improved knowledge of quantitative microbial risk assessment methods may be beneficial in improved assessments of a wider range of pathogens than so far carried out.
- Sustainability – long term decay of pathogens; build up of pathogen pool? Has land with long term sludge application greater background of wide range of pathogens
- Aerosol measurements – some have been carried out to assess the extent of distribution of indicator organisms in air during sludge recycling, and have so far indicated that risks of transmission through this route are relatively low, but the extent of the studies has been limited. These studies are difficult to carry out and need to be co-ordinated with other epidemiological studies.
- How will changing compositions of sewage sludge affect pathogen content; for example, co-treatment of food wastes, and other biodegradable materials either as a result of deliberate diversion from less beneficial routes, including household diversion to drains and sewers of materials hitherto treated as domestic solid wastes.

7 Water and Air Pollution

The preamble to Directive 86/278/EEC states that: 'Whereas sludge should be used under conditions which ensure that the soil and surface and ground water are protected, in accordance with Directives 75/440/EEC (OJ No L194,25.7.1975, p.26) and 80/68/EEC (OJ No L 20, 26.1.1980, p.43)'. One of the rules in Article 8 of 86/278/EEC which shall be observed when using sludge states: 'The sludge shall be used in such a way that account is taken of the nutrient needs of the plants and that the quality of the soil and of the surface and ground water is not impaired'. If the sludge is applied to meet, as far as possible, the plant nutrient requirements of the crop then the potential for leaching or runoff of excess nutrients will be reduced. In short, the control of water pollution where sludge is recycled to land is managed by adjusting the rate of application to be compatible with crop requirements for nutrients and applying land use practices which restrict or prohibit sludge application where there is a high risk of water pollution.

The principles for water pollution control set out in Directive 86/278/EEC remain sound but a revision could take account of updates in water pollution control legislation and guidelines for land use practices where sludge is used on the land. Domestic guidelines in some Member States already work to these updates which include the Nitrates Directive 91/676/ EEC and The Water Framework Directive 2000/60/EC.

In order to provide a perspective on the potential for water pollution control from landspreading of sewage sludge it can be estimated that in the EU, sludge contributes <5% annually of the total amount of organic manure recycled to land (most of which is of farm animal origin) and is applied to <5% of the available agricultural land bank. Sludge represents a minor input of nutrients to the land compared with farm animal manure and inorganic fertilisers.

The Nitrates Directive 91/676/EEC was designed to protect waters against pollution caused by nitrates from agriculture. It aims to reduce the level of nitrate losses in the catchments of polluted waters, and to prevent further new pollution. The Directive requires Member States to designate areas at risk from nitrate pollution as Nitrate Vulnerable Zones (NVZs) and to establish mandatory "action programme" measures within them. The Action Programmes control both the timing and rate of applications of both inorganic (chemical) nitrogen fertilisers and organic manures (including sewage sludge). For organic manures, farm-based limits of 250 kg N/ha on grassland and 170 kg N/ha on arable land will apply to the overall area of the farm within the NVZ. A field-based limit of 250 kg N/ha will apply to dressings of organic manure to individual fields. Sludge is applied to land in accordance with 91/676/EEC, usually at a rate supplying 250 kg N/ha. In addition, farmers are required to maintain adequate records of their cropping and stocking, together with details, in the form of fertiliser and manure plans, of all applications of in organic nitrogen and organic manures.

The Water Framework Directive 2000/60/EC was designed to provide an integrated approach to managing water bodies in the EU by considering in an holistic manner all the environmental drivers and pressures within river basins. The WFD legislation supersedes and updates existing legislation, and although this will not include the sludge Directive 86/278/EEC, it will potentially have an impact on the application of sludge to land. Nitrogen and phosphorus are under scrutiny because of their potentially significant impact on surface waters in causing eutrophication. The need to reduce diffuse N and P from agricultural routes may result in further limitations being placed on N and P inputs to soils, this will affect landspreading of all fertilising materials. The WFD may result in higher concentrations of P in sludge as concentrations of P in final effluent from waste water treatment works are further restricted (see Section 4 on Agricultural Value of Sewage Sludge).

Apart from nutrients, sewage sludge is organic manure with a significant chemical oxygen demand (COD) and which contains enteric microorganisms which further demonstrate the need to manage sludge recycling operations so that runoff into surface water in particular is avoided. This requires attention to farm and fieldside storage, imposition of buffer zones adjacent to banksides and water sources, and taking account of topography, application rates and prevailing soil and weather conditions. Operational guidance on landspreading of sewage sludge is included in the domestic guidelines for sludge recycling in some Member States and in more general guidance on good agricultural practice.

While the emphasis of control on water pollution where sludge is used on land lies with management of N and P, PTEs, organic micropollutants and pathogens have also been investigated in this context especially as regards leaching into groundwater. A watching brief needs to be kept on leaching of persistent organic micropollutants from sludge-treated soil.

Odour is usually the issue immediately noticed by the general population during distribution of sludge onto agricultural land (see Stakeholder Interests, section 9). Odour is also a very important factor at sewage treatment works and increasingly works have to meet control requirements, including covers on tanks and limiting the storage of raw and treated sludges at the works and appropriate emission controls and treatment processes. Very many chemicals are present in odour plumes, including ammonia, hydrogen sulphide and mercaptans.

8 Greenhouse Gas Emissions and Carbon Footprint

Responsible operators will generally wish to report their emissions of greenhouse gases. This will often include a list of their on-site emissions and certain off-site emissions for which they are particularly responsible such as those associated with the use of electricity and, in the case of sludge, emissions associated with its use in agriculture. Carbon footprints are more likely to be used to assist in the selection of sludge treatment processes or routes. A carbon footprint is based on a life-cycle analysis and draws a wider envelope around a process, such that in addition to the emissions above it will also include emissions embodied in materials of construction and consumables such as chemicals, emissions associated with transport and perhaps a wider range of off-site emissions.

The major greenhouse gases associated with sludge processing and disposal or re-use are carbon dioxide, CO_2, methane, CH_4 and nitrous oxide, N_2O. Sludge solids contain from 30-40% carbon, most of which is converted to carbon dioxide during treatment and disposal or use. This carbon dioxide is considered to be 'short cycle'. It is returning CO_2 to the atmosphere that was withdrawn by plants in the recent past. This CO_2 does not contribute to global warming. The Intergovernmental Panel on Climate Change, IPCC, does not require countries to report such short cycle CO_2 and it is not considered further in this section. There are still considerable emissions of fossil fuel derived or 'long cycle' CO_2 associated with energy use, transport and embodied in materials of construction and consumables and which does contribute to global warming. Emissions of CH_4, while technically containing short-cycle carbon, are considered to be as a result of the anthropogenic conversion of CO_2 to CH_4. Since the latter has a much greater global warming potential this should be reported or included in any assessment of carbon footprint.

CO_2 emissions are associated with:

- The use of energy. Most countries will have produced country specific emissions factors for major sources of energy such as electricity and natural gas. The former, in particular will be based on the particular mix of electricity generation installed in a country.
- Transport. IPCC publish default CO2 emission factors for transport based on vehicle type and miles travelled or on quantities of fuel used.
- CO2 emissions are associated with materials of construction and consumables used. These embodied emissions include that associated with the energy consumed during manufacture, particular process emissions such as the CO_2 produced during the manufacture of cement and the carbon contained within materials such as plastics. Embodied emission factors are obtainable from databases associated with LCA software.

When a process generates useful net energy, this is seen as displacing the requirement for fossil fuel and the CO_2 associated with the generated energy is considered to be a negative emission. The largest generation of electricity is associated with the use of biogas from the anaerobic digestion of sludge in combined heat and power plant, CHP. Significant amounts of energy are generated in steam turbines on sludge incinerators. Frequently, the electricity generated is less than that consumed by the incineration process. The incineration of a well dewatered raw sludge is most likely to lead to a small surplus of energy for export but less than from the digestion of the equivalent amount of sludge. The incineration of dried sludge may produce much larger amounts of electricity but this would be balanced by the energy requirements for drying.

When a product is beneficially used, such as sludge in agriculture, the CO_2 embodied in displaced chemical fertiliser is considered to be a negative emission. If the carbon in sludge was prevented from being converted to CO_2 over a sufficiently long time, this would be considered to be sequestration, and could be ascribed a negative emission. IPCC allows the estimation of sequestration of carbon in soil due to change of use, but not due to the addition of manure or sludge. Some researchers consider that a portion of the carbon in sludge used in agriculture will be sequestered in the soil but it is not believed that any national inventories of greenhouse gas emissions consider sequestered carbon from sludge used in agriculture.

Significant amounts of methane are generated during the processing, storage and disposal or use of sewage sludge. On-site emissions in the UK have been estimated, as shown in Table 9.

Table 9 Methane losses associated with anaerobic digestion and application of cake to land

Source	**Loss as % of total gas produced**	**Loss (kg CH_4/tonne DS)**	**Loss as % of total gas produced**	**Loss (kg CH_4/tonne DS)**
	Existing plant with secondary digestion		New plant with buffer storage	
Losses via annular space of floating roof digesters	2.5%	3.3	0.0%	0.0
Venting due to ignition failure and downtime at flare stacks	0.21%	0.29	0.21%	0.29
Incomplete combustion	1%	1.45	1.0%	1.45
Fugitive emissions	3.8%	5.1	1.0%	1.3
Secondary digestion/buffer storage	5.9%	8	1.5%	2.0
Total	13.4%	18.1	3.7%	5.1

The first two columns are considered applicable to typical existing plant and form the basis for the UK to report emissions of methane from sludge treatment. The second two columns are applicable to new plant which are all of fixed roof type, will have a lower level of fugitive emissions and where 14-day secondary digestion is replaced by a much shorter period of storage prior to dewatering. There are no further emissions of methane if the digested sludge is incinerated and considerable further emissions if the sludge is sent to landfill, a disposal route which has almost ceased in the UK. When sludge is used in agriculture there are further emissions from the emissions of storage of solid cake, which might be from within a sewage treatment works or from field-side storage. Further methane emissions are associated with the spreading of sludge cake on land, which, however, are minimal in a cool climate such as the UK. IPCC Good Practice Guidelines contains emission factors for the storage and spreading of sludge.

When sewage sludge is used in agriculture, there are associated emissions of nitrous oxide as nitrogen mineralises and oxidises. These can be broken down into direct emissions from the soil following application of sludge, and indirect emissions. The indirect emissions come from both nitrogen other than N_2O which is volatilised (mostly ammonia) and which later deposits back onto the land leading to further N_2O emissions and from ammonia in leachate which ends up in rivers where it stimulates further N_2O emissions. The direct emissions of N_2O from the use of sewage sludge in agriculture are equal to 0.01 times the nitrogen content in the sludge.

When sludge is used in agriculture it will replace the use of chemical fertiliser. The nitrous oxide emissions associated with that fertiliser are considered to be a negative emission. If all of the nitrogen in the sludge were available to plants the N_2O emissions from the soil after application would be balanced by the reduced N_2O emissions from the chemical fertiliser. In fact as little as 20% of the nitrogen in digested sludge cake is considered to be readily available to plants so the emissions of N_2O from its spreading are greater than the reduction in N_2O from the displaced fertiliser.

There are also significant emissions of N_2O resulting from the incineration of sewage sludge.

Table 10 compares the estimated greenhouse gas emissions from a UK study between incineration (TD-thermal destruction) and the use of digested sludge cake (MAD-mesophilic anaerobic digestion) in agriculture. The greatest single emission comes from methane lost during anaerobic digestion. As a result the total emissions from the agricultural route appear greater than from incineration. If, however, the reduced methane emissions appropriate to modern digestion plant without secondary digestion had been used, the methane losses from the process would fall by over 300 kg CO_2eq/tonne raw DS, reducing emissions to around zero, significantly better than from incineration.

Table 10 A comparison of greenhouse gas emissions between incineration of raw sludge and the use of digested sludge cake in agriculture

Treatment / Disposal Option	Contributions from different operational sources (all expressed as kgCO_2eq/tRawDS)							
	Natural gas usage	**Electrical energy**	**Consumables**	**Transport**	**CH_4 from process & agriculture**	**N_2O from process & agriculture**	**Fertiliser displacement**	**Total**
1. TD of raw sludge	0	-156	84	1	0	308	0	236
2. MAD and recycle dewatered digested sludge cake to AL	0	-267	106	11	465	101	-137	279

9 Stakeholder Interests and Public Perception

The principal stakeholders in the sewage sludge recycling to land operation are:

- **Sludge producers**. Recycling of sewage sludge to land is the main outlet for sludge in the EU where suitable land is accessible. The recycling to land option is therefore central to the sludge management strategy of most sludge producers. However, there are differences between Member States in the extent of use of the outlet. For instance, the Netherlands does not recycle sludge to land. The reasons for these differences are discussed in the next phase of reporting on this project.
- **Farmers**. Sludge has proven agricultural value and is usually a cost-effective alternative to other fertilisers so there is a steady demand from farmers in most Member States to recycle sludge on their land.
- **Farmers' advisors**. Advisors are generally supportive of sludge recycling so long as they are reassured that the operation is efficient and properly regulated and does not affect the acceptability of farm products to customers.
- **Landowners**. There may be some concerns about long-term effects of contaminants in sludge on soil fertility where repeated applications of sludge to the land have been made.
- **Regulators**. Sludge recycling to land is established as the BPEO for sludge management and Regulators are generally supportive of sludge recycling provided that operations are carried out in accordance with the appropriate rules and guidelines.
- **Farmers' customers, food processors and retailers**. There should be no problem here so long as regulations and guidelines for sludge recycling have been followed on the farm and the recycling operation is seen to be entirely 'safe'. A problem can arise if the processor/retailer perceives that the acceptance of products may be jeopardised if customers are aware that they have been grown on land treated with sewage sludge.
- **The public**. Studies have shown that the public are generally supportive of sludge recycling when the process of sewage treatment has been explained to them and the options for sludge disposal described (Davis, 2006). However, public nuisance factors (lorries, odour) are of key importance and must be controlled and preferably avoided if the confidence of the public in sludge recycling is to be retained. There is definite public sensitivity to odour nuisance from sewage treatment works and from sludge recycling operations in the field. Every effort must be made to avoid odour nuisance and the negative public response which can escalate to threaten the recycling outlet at least on a local basis.
- **Special interest groups**. In the UK, the pressure group 'Surfers Against Sewage' has carried out a survey of public attitudes to sewage sludge disposal in south West England (Davis, 2004). The report concluded that the 'best' routes for sewage sludge disposal in south west England were spreading on agricultural land for food or non-food crops. Or should either of these two routes become unusable, pyrolysis and gasification was viewed as the main viable large-scale option for sludge disposal in the area. During focus group sessions, when attendees listened to a 25-minute presentation and had the chance to ask questions about sludge disposal, most people agreed that sludge disposal to land was the best option, with 98% of those surveyed happy for sludge to be disposed of in this way and to eat crops grown on sludge-fertilised soil.
- **The media**. Waste water treatment and safe disposal of sludge are central to the protection of public health and should thereby have a very positive public image. However, because of their faecal association sewage treatment and sewage sludge disposal are prone to a negative and sometimes sensational press response often triggered by odour nuisance.

10 Future Trends

Large increases in quantities of sludge produced have taken place since 1995 (30% overall between 1995 and 2005) in the EU15 members, as a result of the UWWTD. The increase was not the same proportion in all countries. Although , much of the development required under the UWWTD has now taken place in the existing 15 Member States, the new 12 Member States, and some of the EU-15 members, have still a long way to go before complying with the UWWT Directive and thus it is likely that a similar rate of increase will continue.

Based on an annual average sludge production rate and population prediction, future sludge quantities produced in the EU-27 can be estimated. In the EU-15, in countries with a high connection rate to sewerage and high level of treatment complying with the UWWT Directive, sludge production rates are about 25 kg per person and per year.

Overall it is predicted that 50 % of sludge is likely to be recycled to land (Alabaster and Leblanc 2008). The situation in the existing 15 member States should not change dramatically over the next 5 years. There are some indications in the new Member States which have no previous experience in this sludge management route, that agriculture recycling may become a more significant outlet in the future.

The concentrations of metals in sewage sludge in Western Europe have significantly been reduced since mid 80's as a combination between increased management of industrial effluents and a reduction of heavy industrial production. The extent of further reductions is unclear, although the range of loadings may be significantly different between different parts of the EU (including new Member states).

Changes in composition as a result of increasingly rigorous nutrient removal requirements may become more significant. This is most likely to increase phosphorus concentration. This may be linked to changes in metal concentration if P-removal is carried out using metal salts (aluminium or iron).

Recovery of energy from biodegradable materials is encouraged by the EU energy policy, in particular to increase the use of biofuels. There is potential to increase sludge production if non-sewage biodegradable materials become incorporated into the sludge treatment route. In contradiction to this, treatment processes are increasing their capability to convert organic solids to transferable fuels with less residual solids. The balance between increase and decrease of mass of residual solids from sewage sludge treatment is therefore unclear.

It is likely that processes that provide enhanced pathogen removal will become more widely used, as they also commonly produce a sludge that is less fermentable and so less odorous and will attract less public concern or criticism. Processes that can reliably and cost-effectively demonstrate substantially reduced pathogen concentrations are likely to be more widely used.

There is a continual desire to reduce sludge volumes during treatment and intensify process operations.

Co-treatment of sewage sludge with a variety of other imported organic materials, particularly with reference to digestion processes, is currently not generally carried out, for reasons that include regulatory constraints. There are potential advantages of co-treatment in terms of asset utilisation (access to energy conversion systems, utilisation of existing infrastructure).

A considerable amount of work is underway at research level, and with some individual treatment works on recovery of nutrients from sewage sludge. These are particularly linked to phosphorus, as complexes such as struvite, or in purified forms, but there are also methods to separate metals, such as iron from chemical P removal sludges, and to produce organic acids by fermentation to supplement biological nutrient removal plants. It is likely that sludges will increasingly be required to meet more rigorous compositional standards to justify their use as fertiliser. A number of Member States have introduced stricter controls on sludge recycling to land than those required by Directive 86/278/EEC and this trend is likely to continue, in parallel with developments in sludge treatment process technology.

Pyrolysis is still not an established process for sewage, but would offer increased energy recovery with a reduced cost and environmental impact compared to incineration.

Other sources of sludge, food waste, organic fractions of municipal waste, might compete for available land.

Though the carbon in sewage sludge is short cycle, the prevention of its release as CO_2 would be considered ‘sequestration’ (see Section 10). If a reliable route to sequestration could be developed, this might be more valuable than use in agriculture.

The subject of future trends will be considered further in the next stage of reporting for this project (.

11 Monitoring, record keeping and reporting

Information on sludge operations is primarily collated by the sludge producer; however, there may be several sources of the pertinent information:

- The occupier of the land receiving the sludge
- The person that applied the sludge to the land
- The sludge producer which supplied the sludge

The collated results required to be made available to a governing body would ideally relate to:

1. The location of the land receiving sludge
2. Sludge treatment, quantity and quality
3. Soil quality

The frequency of monitoring sludge **quantity** depends on the amounts applied to land units (each location), totalled over each year followed for example by the EPA (Alabaster and LeBlanc, 2008). Thus ideally, records need to be kept of sludge quantity per land unit and per unit time and this is specified in Directive 86/278/EEC. Amounts of sludge need to be recorded in metres cubed per year (total and amount to agriculture) and if possible metres cubed per land unit.

Table 11 Operational sludge data

Record	**Total produced**	**Quantity to agriculture**	**Quantity to land unit**
Units	m^3 per year	m^3 per year	m^3 per land unit per year

Data quality will depend on following standard procedures of measurement, sampling and analysis, and once more, observing the correct frequency of the analyses to be carried out.

11.1 Sludge analysis

Sludge quality will reflect original inputs to sewers and so variability can be assessed taking into account this background. Also subsequent quality will affect efficient treatment process operation. Knowledge of inputs of synthetic organic compounds and other undesirable contaminants can signal seeking specialist advice before use in agriculture (CoGAP, 2009).

Table 12 Sludge quality parameters

Parameter	**Dry matter (DM)**	**Organic matter**	**pH**	**Nitrogen and Phosphorus**	**Heavy Metals (6+)**
Units	% (w/w)	% of DM	'Units'	mg kg^{-1} DM	mg kg^{-1} DM

Parameters currently covered by directive 86/278/EEC are as above, where the heavy metals are; Cd, Cu, Hg, Ni, Pb and Zn. In the UK, further detail on crop nutrient analyses is advisory, for example total nitrogen and total phosphorus and, ammoniacal nitrogen (CoGAP, 2009). Also additional metals are currently included in UK guidelines; Cr, Mo, Se and As, and fluoride. All these additional parameters would be expressed as concentration in the sludge dry matter (mg kg^{-1} DM).

Limit values for the amounts of heavy metals (seven, as above) which may be added annually to agricultural land, based on a 10-year average (kg ha^{-1} yr^{-1}) are given in directive 86/278/EEC in annex 1C. These additions of metal have to be estimated from the sludge quantities and sludge metal analyses.

The frequency of analysis of the parameters in Table 12 above is recommended every six months for the provisions of the directive 86/278/EEC, but more frequently if sludge is found to be particularly variable and, only annually if it is thought consistent over a full year. However, consideration of the size of the waste water treatment plant is also made when deciding on frequency of analysis (CEC, 2006). Because it has been shown that sludge quality varies widely even on a daily basis, it is imperative that the adopted sampling procedure be validated by experimentation and that the sample error be established (Beckett, 1980).

11.2 Soil analysis

For sludge recycled to agricultural land from small sewage treatment plants (< 300 kg BOD/day, equivalent to 5000 population) designed primarily for the treatment of domestic waste water, soil analysis is **not** required according to Directive 86/278/EEC. When sludge is from plants larger than this soil should be analysed prior to the use of sludge and, at a suitable frequency thereafter to prevent soil metal concentrations from being exceeded. Currently only soil metals and pH are included as limit values in soil receiving sludge in the Directive 86/278/EEC. Heavy metals included are; Cd, Cu, Hg, Ni, Pb and Zn, as for sludge analysis. Soil pH is also recorded as this is related to the limit values for concentrations of heavy metal in soil.

Table 13 Soil Quality parameters

Parameter	pH	Cd	Cu	Hg	Ni	Pb	Zn
Units	mg kg^{-1} DM	mg kg^{-1} DM	mg kg^{-1} DM	mg kg^{-1} DM	mg kg^{-1} DM	mg kg^{-1} DM	mg kg^{-1} DM

11.3 Sampling and analysis methods

In the UK both sampling and analytical methods are specifically listed from those by the Standing Committee of Analysts: Methods for the Examination of Waters and Associated Materials, in the code of good agricultural practice (CoGAP 2009). In Directive 86/278/EEC, only brief details of soil and sludge sampling are given, and it is recommended simply that strong acid digestion followed by atomic absorption spectrometry are used for analysis of heavy metals in sludge and soil. Since then the Comité Européen de Normalisation (CEN) have published national standards for sludge characterisation through their technical committee; TC 308 and these would be best to follow for sludges. Relevant examples of the CEN published methods for sludges are given in Table 14 below.

Table 14 CEN/TC 308 - Sludge analyses selected published standards

Standard reference	Title	Citation in OJ	Directive
CR 13097:2001	Characterization of sludges - Good practice for utilisation in agriculture	No	-
EN 12176:1998	Characterization of sludge - Determination of pH-value	No	-
EN 12879:2000	Characterization of sludges - Determination of the loss on ignition of	No	-

	dry mass		
EN 12880:2000	Characterization of sludges - Determination of dry residue and water content	No	-
EN 13342:2000	Characterization of sludges - Determination of Kjeldahl nitrogen	No	-
EN 13346:2000	Characterization of sludges - Determination of trace elements and phosphorus - Aqua regia extraction methods	No	-
EN 14671:2006	Characterization of sludges - Pre-treatment for the determination of extractable ammonia using 2 mol/l potassium chloride	No	-
EN 14672:2005	Characterization of sludges - Determination of total phosphorus	No	86/278/EEC
EN ISO 5667-13:1997	Water quality - Sampling - Part 13: Guidance on sampling of sludges from sewage and water treatment works (ISO 5667-13:1997)	No	

Note: selected from list published on CEN website:
http://www.cen.eu/cenorm/sectors/sectors/environment/tcs/index.asp

In the full list of published standards for sludge characterisation on the CEN website, standards for microbial analyses are also included. Also included in Table 13 is a standard on sampling of sludges from sewage and water treatment works.

Soil analyses methods are under development by CEN but none are yet published covering the relevant parameters. Methods for the standard six heavy metals in soil (total by aqua-regia strong acid) are in practice broadly the same as those for sludges.

Representative soil samples are described in Directive 86/278/EEC as samples made up by mixing together 25 core samples taken over an area not exceeding 5 hectares which is farmed for the same purpose. In UK methods it is also recommended that the 25 samples are taken in a 'W' pattern over the field (Standing Committee of Analysts, 1986).

The directive designates soil samples are to be taken to a depth of 25 cm, (or less when the surface soil is below this but not less than 10 cm). In the UK, however, a plough depth of 20 cm is typical for arable land, hence soil sampling to 15 cm is recommended, to avoid edge effects (UN 2008 pp344) and, if land is under permanent or semi-permanent grass soils are sampled to 7.5 cm.

Detailed quality assurance procedures on reporting are now being followed by many of the UK water companies in line with those recommended by Water UK (Water UK, 2004).

12 Summary of areas of uncertainty and knowledge gaps

12.1 Sludge production and management and quality in the EU

Although it is expected that sludge production in the EU27 will continue to increase as population grow and the new Member States continue to implement the UWWT Directive towards 2010, there is no guarantee that all countries will be fully complying by that time. There is also a noticeable trend in some Member States which have high level of connection and treatment of sludge quantities decreasing. The reasons for this will need to be further investigated as this could add uncertainties to our future sludge estimates.

Although overall it is predicted that 50 % of sludge is likely to be recycled to land, there are uncertainties about the future sustainability of this outlet due to public opinion and the competition for land with other organic wastes. The main alternative to landspreading is likely to continue to be incineration with energy recovery for sludge produced at sites where land suitable for recycling is unavailable. Sludge management may continue to vary widely between Member States according to their particular circumstances. A number of other important factors which could influence sludge management in the future need to be evaluated.

Developments in sludge treatment will continue and there may be move towards enhanced treatment for sludge going to land so that the product to be recycled is effectively odour and pathogen free. The subject of future trends will be considered further in the next stage of reporting for this project (Section 3).

The concentrations of metals in sewage sludge in Western Europe have significantly been reduced since mid 80's as a combination between increased management of industrial effluents and a reduction of heavy industrial production. The extent of further reductions is unclear, although the range of loadings may be significantly different between different parts of the EU (including new Member states).

12.2 EU legislation, other EU acquis and Member State controls on the use of sludge on land

Directive 86/278/EEC could be said to have stood the test of time in that sludge recycling has expanded without environmental problems arising since it was adopted. However, several Member States have adopted stricter requirements since. Moreover, EC legislation has evolved in many related fields, such as chemicals regulation. Any revision should aim to retain the flexibility of the original Directive which has permitted sludge recycling to operate effectively across the wide range of agricultural and other environmental conditions found within the EU.

12.3 Economics of sludge treatment and disposal.

The baseline and future analysis of sludge management must take account of costs, and information in Section 3 provides the basis to do this.

12.4 Agricultural value of sewage sludge.

Application of sewage sludge to land provides positive agricultural benefit. Demand for sewage sludge in agriculture and for other land uses would undoubtedly be enhanced if it was clearly recognised as a product instead of a waste, and if it were accepted as being suitable for use in organic farming and other organic growing practices. However, a watching brief needs to be kept on P in soils receiving sludge and more information obtained about the accumulation and fate of P in soils.

12.5 Potentially toxic elements

Consideration needs to be given to adjusting the maximum permissible soil metal limits in Directive 86/278/EEC for cadmium and zinc in soil and for lead in sludge.

12.6 Organic contaminants (OCs)

Directive 86/278/EEC does not include specific limits for organic contaminants. Some Member States have set limits for OC groups, while others have not. In summary, the reviews of the research on OCs in sludge conducted so far have concluded that they are unlikely to have an adverse effect on human health and will be increasingly controlled by regulation. However, contaminants such as DEHP and chlorinated paraffins, found in sludge at higher levels will need to be further assessed. Further vigilance is also required on contaminants such as pharmaceuticals, where the potential fate and behaviour in waste water, sludge and soil is unclear at present.

12.7 Pathogens, treatment of sludge and land use practices

There is scope to update the controls set out in 86/278/EEC as regards the use of untreated sludge on the land, through the introduction of microbiological standards related to degree of sludge treatment. Such an update should take into account new developments in quality control of sludge treatment processes (such as HACCP) and in the safe management of sludge on the land.
Alist of 13 areas of uncertainty about pathogens is identified in paragraph 6.3.5

12.8 Water and air pollution

The principles for water pollution control set out in Directive 86/278/EEC remain sound; nonetheless, a revision could take account of the development in EC water pollution control legislation (notably the Nitrates Directive 91/676/ EEC and Water Framework Directive 2000/60/EC). A revision of the Directive might also call for guidelines for land use practices where sludge is used on the land. In both cases, one area for emphasis should be the controls of nitrogen and phosphorus. Apart from nutrients, sewage sludge is an organic manure with a significant chemical oxygen demand (COD) and which contains enteric microorganisms – this further underlines the need to manage sludge recycling operations so that runoff into surface water in particular is avoided. A revision of the Directive could draw on the operational guidance on landspreading of sewage sludge prepared in some Member States as well as more general national guidance on good agricultural practice.

While the emphasis of control on water pollution where sludge is used on land lies with management of N and P, PTEs, organic micropollutants and pathogens have also been investigated in this context especially as regards leaching into groundwater. A watching brief needs to be kept on leaching of persistent organic micropollutants from sludge-treated soil.

Odours – see stakeholder interests below

12.9 Greenhouse_gas emissions and carbon footprint

The information presented in this report provides the basis for quantifying these factors for different sludge treatment and disposal options as part of their overall environmental assessment.

12.10 Stakeholder_interests and public perception

Ten principal stakeholder groups have been identified and their interests listed.

For the general public, there is a strong sensitivity to odour nuisance from sewage treatment works and from sludge recycling operations in the field. Every effort must be made to avoid odour nuisance and the negative public response which can escalate to threaten the recycling outlet at least on a local basis.

Farmers' customers, food processors and retailers may also be affected by a perception that the use of sewage sludge could lead to environmental and health concerns. There should be no problem here so long as regulations and guidelines for sludge recycling have been followed on the farm and the recycling operation is seen to be entirely 'safe'. A problem can arise if the processor/retailer perceives that the acceptance of products may be jeopardised if customers are aware that they have been grown on land treated with sewage sludge.

12.11 Monitoring, record keeping and reporting

The requirements in this area included in Directive 86/278/EEC need to be updated with particular reference to the Standards prepared by CENT C/308.

Bibliography

ADAS (2001), *The Safe Sludge Matrix. Guidelines for the application of Sewage Sludge to Agricultural Land*, 3rd. edition, April 2001. http://www.adas.co.uk/media_files/Document%20Store/SSM.pdf

ALABASTER AND LEBLANC (2008), *UN- Habitat and Greater Moncton Sewerage Commission in collaboration with the IWA*, Global Atlas of Excreta, Wastewater Sludge, and Biosolids Management. ISBN 9789211320091, p344 & p550.

ARRETE *du 8 janvier 1998 fixant les prescriptions techniques applicables aux épandages de boues sur les sols agricoles pris en application du décret n° 97-1133 du 8 décembre 1997 relatif à l'épandage des boues issues du traitement des eaux usées*, (French order of 8 January 1998 regarding landspreading of sewage sludge)

AYRES, et al (2008): *Human Health and Environmental Impacts of using Sewage Sludge on Forestry and for Restoration of Derelict Land (Task 1 includes a literature review on application to non agricultural land),* SNIFFER, August 2008.

BAYRISCHES STAATMINISTRERIUM FUER UMWELT UND GESUNDHEIT (2008), *Pressemitteilung 30 June 2008*.

BECKETT (1980), *The Statistical Distribution of Sewage and Sludge Analyses*. Environmental Pollution (Series B) 1 (1980) pp27 – 35.

BLACKMORE, K. *et al.* (2005*), Accommodating the implications of the revised EU sludge Directive. Report No. 06/RG/07/8*. UK Water Industry Research, London.

BMU (1992), BUNDESMINSTTERIUM DER JUSTIZ IN ZUSAMMENARBEIT MIT DER JURIS GMBH, *Klaerschlammverorndung*, *www.juris.de*,1992.

BMU (2006) BUNDESMINISTREIUM FUER UMWELT (BMU), *Eckpunktepapier: Neufassung der Klärschlammverordnung Ressourcen nutzen - Böden schonen*, http://www.bmu.de/files/pdfs/allgemein/application/pdf/klaerschlammvo_eckpunkte.pdf, Dec. 2006.

BMU (2007) BUNDESMINISTREIUM FUER UMWELT (BMU), *Novellierung der Klaerschlammverordnung*, http://www.bmu.de/files/pdfs/allgemein/application/pdf/novellierung_klaerschlammverordnung.pdf, 19.11.2007.

BOOM (1991), *Besluit kwaliteit en gebruik overige organische meststoffen* (Boom 1) (Dutch Decree quality and use of other organic fertilisers) Stb. 1991, 613.

BOOM 1998. *Besluit kwaliteit en gebruik overige organische meststoffen* (Boom 2) (Decree quality and use of other organic fertilisers), Stb. 1998, 86.

BQSD (2007), *Baden-Wuerttemberg propagiert den Asustieg aus der Landwirtschaftlichen Klaerschlammverwertung Zugunsten der therminschen Entsorgung*, Offener Brief an die Umweltministerin des Landes Baden-Wuerttemberg, BQSD e.V., February 2007.

CARRINGTON, E.G. and DAVIS, R.D. (2001), *Evaluation of sludge treatments for pathogen reduction.* WRc Report CO 5026/1 to the European Commission DG Environment (No B4-3040/2001/322179/MAR/A2) also presented to EC Conference on Recycling of Sewage Sludge to Land, Brussels, October 30-31.

CARRINGTON, E.G., DAVIS, R.D. and PIKE, E.B. (1998). *Review of the scientific evidence relating to the controls on the agricultural use of sewage sludge*. Report to the Dept of Transport Environment and the Regions, UK. DETR 4415/3. ISBN 1 898920 37 0.

CEC (1990) Council of the European Communities (1990) *Amendments to the Proposal for a Council Directive amending, in respect of chromium, Directive 86/278/EEC on the protection of the* *environment, and in particular of soil, when sewage sludge is used in agriculture.* Com (90) 85 Final, Brussels, 27 March 1990.

CEC (1991), *Council of the European Communities (1991) Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC).* Official Journal of the European Communities No. L 135/40-52

CEC (1991b) *Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources.* O.J. L375. 12.12.1991.

CEC (1999) Council of the European Union (1999), *Council Directive of 26 April 1999, on the landfill of waste (99/31/EC).* Official Journal of the European Union No. L182/1-19.

CEC (2000) of the European Communities (2000, *Council Directive 2000/60/EC establishing a framework for Community action in the field of water policy*. O. J. L327 22.12.2000.

CEC (2003) *Directive 2003/53/EC of the European Parliament and of the Council of 18 June 2003 amending for the 26th time Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations (nonylphenol, nonylphenol ethoxylate and cement)*

CEC (2006) Council of the European Communities (1986), *Council Directive of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (86/278/EEC).* Official Journal of the European Communities No. L 181/6-12.

CEC (2006), *Report from the Commission to the Council and the European Parliament on the implementation of the Community waste legislation*, Directive 75/442/EEC on waste, Directive 91/689/EEC on hazardous waste,

CoGAP (2009) Code of Good Agricultural Practice – revised version (2009), Defra UK. http://www.defra.gov.uk/farm/environment/cogap/index.htm

DAVIS, M (2004) *A Green Blue-Print for Sewage Sludge Disposal. A survey of public attitudes to sewage sludge disposal in south west England. Surfers Against Sewage*. www.sas.org.uk

DAVIS, R.D. (2006), *The perception of biosolids use in agriculture: Summary of survey findings. WRc report UC7181/3 to Water UK.*

DEFRA (2002), *Impacts of heavy metals on soil quality with respect to microbial activity, a study prepared by Rothamsted Research (BBSRC) for MAFF*, available at http://randd.defra.gov.uk/Document.aspx?Document=SP0120_444_FRP.doc

DEFRA (2007), *Effects of sewage sludge on agricultural productivity and soil fertility (Phase III)* – SP0130, prepared by ADAS, Rothemsted, WRc, Macaulay Institute and SAC. available at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=10677

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste

Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration

Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council. Proposal for a Directive of the European Parliament and of the Council establishing a framework for the protection of soil and amending Directive 2004/35/EC

DOE (1989) Department of the Environment (1989) *Code of Practice for Agricultural Use of Sewage Sludge.* HMSO, London. UK SI, 1989

DoE/NWC (1986), *The Sampling and Initial Preparation of Sewage and Waterworks' Sludges, Soils, Sediments and Plant Materials Prior to Analysis 1986* .Methods for the Examination of Waters and Associated Materials. Standing Committee of Analysts. HMSO.

DREHER AND FUHRMANN (2008), R*isiko bodenbezogene Klärschlammverwertung Aktuellen Untersuchungen zufolge können sich durch die Düngung vor allem organische Schadstoffe im Boden anreichern*. in Müllmagazin, 3/2008.

EC (2000) European Commission 2000. *Working Document on Sludge 3rd Draft*. 27 April. DG Environment, Brussels

EC (2001) *Organic contaminants in sewage sludge for agricultural use.* Study coordinated by European Commission and Joint Research Centre and the Institute for Environment and Sustainable Soil and Waste Unit. Report prepared by UMEG Center for Environmental Measurements, Environmental Inventories and Product Safety, 18 October 2001.

EC (2003) European Commission (2003) *Proposal for a Directive of the European Parliament and of the Council on spreading of sludge on land*. 30 April 2003, EC, Brussels

EC (2006), *Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC*

EFAR (2008), *Public health risk assessment of sludge landspreading*, Final Report No. DRC-07-81117-09289-C, INERIS for EFAR.

EP (2008), European Parliament legislative resolution of 17 December 2008 on the proposal for a directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (COM (2008)0019 – C6-0046/2008 – 2008/0016(COD))

FOEN (2003). Swiss Federal Office for the Environment (2003) *Ban on the use of sludge as a fertiliser. FOEN, Switzerland,* available at: http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=en&msg-id=1673.

FSA (2008) *Food Safety implications of land spreading, agricultural, municipal and industrial organic materials on agricultural land used for food production in Ireland*.

GALE, P., PIKE, E.B.P. and Stanfield, G. (2003) *Pathogens in biosolids. Microbiological Risk Assessment. UKWIR,* London, UK. ISBN: 1-84057-294-9

IPCC 2006, *Good Practice Guidelines*. *Guidelines for National Greenhouse Gas Inventories*

KAIMER (2006) *Novellierung der Klärschlammverordnung – Regulierungsbedarf aus Sicht von Baden-Württemberg, Perspektiven der Klärschlammverwertung*, Expertentagung am 6./7.12.2006, BMU, Bonn.

KUNGÖRELSE SNFS (1994:2) *med föreskrifter om skydd för miljön, särskilt marken, när avloppsslam används i jordbruket* (EPA Regulations regarding protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture).

MILJÖBALK (1998:808) (The Swedish Environmental Code).

SEDE AND ARTHUR ANDERSEN (2002) *Disposal and Recycling Routes for Sewage Sludge*, European Commission, DG Environment – B2, 2002. Available at: http://ec.europa.eu/environment/waste/sludge/sludge_disposal.htm

SEPA (1998) *Förordning (1998:899) om miljöfarlig verksamhet och hälsoskydd* (Ordinance on Environmentally Hazard Activities and Protection of Heath).

SEPA (1998), Förordning (1998:944) om förbud m.m. i vissa fall i samband med hantering, införsel och utförsel av kemiska produkter (Regulation regarding prohibition etc. under certain circumstances related to handling, import and export of chemical substances)

SEPA (2001), AVFALLSFÖRORDNING (2001:1063). (Swedish Regulation regarding waste)

SEPA (2001), Förordning om deponering av avfall (2001:512), (Regulation regarding the deposit of waste) .

SEPA (2002) *Föreskrifter om avfallsförbränning, NFS 2002:28*, (Swedish EPA Regulations regarding the combustion of waste).

SEPA (2002), Förordning om avfallsförbränning (2002:1060), (Regulation regarding the combustion of waste).

SEPA (2004) *Föreskrifter (NFS 2004:4), och allmäna råd om brännbart och organiska avfall*, (Swedish EPA Regulations and general advice regarding burnable and organic waste).

SEPA (2004) *Föreskrifter om deponering av avfall NFS 2004:10*, (Swedish EPA Regulations regarding deposition of waste)

SMITH, S.R. (2008), *The implications for human health and the environment of recycling biosolids on agricultural land*. Imperial College London Centre for Environmental Control and Waste Management. http:/www3.imperial.ac.uk/ewre

SYPREA (2007) TANNER et al. (2008), *Estimated Occupational Risk from Bioaerosols Generated during Land Application of Class B Biosolids*, J Environ Qual.2008; 37: 2311-2321.

WATER UK (2004), *The Application of HACCP Procedures in the Water Industry: Biosolids Treatment and Use on Agricultural Land*. WRc report UC6332/3 to Water UK. WRc publications, Swindon.

Environmental, economic and social impacts of the use of sewage sludge on land

Summary Report 2

Baseline Scenario, Analysis of Risk and Opportunities

milieu
ENVIRONMENTAL LAW & POLICY

WRc

RPA

This report has been prepared by Milieu Ltd, WRc, and RPA for the European Commission, DG Environment under Study Contract DG ENV.G.4/ETU/2008/0076r. The primary author was Bob David. Additional expertise was provided by Anne Gendebien, Rod Palfrey and Judith Middleton

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Executive Summary

Milieu Ltd is, together with partners WRc and Risk & Policy Analysts Ltd (RPA), working on a contract for the European Commission's DG Environment, entitled *Study on the environmental, economic and social impacts of the use of sewage sludge on land* (DG ENV.G.4/ETU/2008/0076r).

Directive 86/278/EEC could be said to have stood the test of time in that sludge recycling has expanded since its adoption without environmental problems. Since its adoption, however, several Member States have put in place stricter national requirements. Moreover, EC legislation has evolved in many related fields, such as chemicals regulation. Any revision should aim to retain the flexibility of the original Directive which has permitted sludge recycling to operate effectively across the wide range of agricultural and other environmental conditions found within the expanded EU.

The aim of the study is to provide the Commission with the necessary elements for assessing the environmental, economic and social impacts, including health impacts, of present practices of sewage sludge use on land, provide an overview of prospective risks and opportunities and identify policy options related to the use of sewage sludge on land. This could lay the basis for the possible revision of Community legislation in this field.

This is the second deliverable of the study: the first was a review of literature on the topic, *Assessment of existing knowledge*. The aim of this second report is to develop a baseline scenario to 2020 concerning the spreading of sewage sludge on land and to analyse the relevant risks and opportunities. This report provides information to establish a baseline scenario under which Directive 86/278/EEC remains in place and is not revised.

This study has used existing sources of data as well as forecasts. On this basis, it can be broadly estimated that as compliance with the UWWT Directive is achieved, total sludge generation in the EU15 may increase from 2005 to 2020 by about 20% to 10.4 Mt DS; and for the EU12, by approximately 100% to 2.5 Mt DS. Thus, the total for EU sludge generation in 2020 will be approximately 12.9 Mt DS per annum, compared with 10 Mt DS in 2005, an overall increase of 2.9 Mt DS per annum or about 30%.

From the data on sludge disposal and recycling in the Member States, the proportion of sludge recycled to agriculture has not altered significantly since 1995, remaining at around 40 – 50%. The situation in some Member States has changed; the Netherlands, for example, no longer recycles sludge to land, while the UK and some other Member States have increased the amount of sludge to land. It seems reasonably likely that by 2020 the overall recycling figure for the EU15 will remain at around 40 - 50% and that the EU12 – where overall sludge recycling to land is currently lower – will move towards this value as the UWWT Directive is implemented and the disposal to landfills is phased out. The main alternative to recycling to land will be thermal treatment.

The report considers the expected impacts of current EU legislation, such as the Nitrates Directive, the Water Framework Directive, as well as that of the new renewable energy goals.

The report assesses future trends and future risks and opportunities which are relevant to revision of Directive 86/278/EEC. The areas considered are: sludge production, sludge quality (agricultural value; potentially toxic elements; organic contaminants; pathogenic micro-organisms); sludge treatment, land restrictions; other routes and other factors which have an impact on the outlet such as greenhouse gas emissions and carbon footprint; stakeholder interests and public perception.

This report is presented as a draft for comments on the part of Member States, stakeholders and researchers as part of the first consultation for the study. For this reason, a total of 28 questions are interspersed through the main sections of the report. These request further data as well as opinions and suggestions for individual topic areas.

1 Introduction

Although it could be said that the Sludge Directive 86/278/EEC has permitted sludge recycling to operate effectively across the wide range of agricultural and other environmental conditions found within the expanded EU, since its adoption, the situation in the EU has since changed substantially and all these changes must be considered.

Several Member States have adopted stricter requirements than the 86/278 Directive, new research findings in the field have been published, 12 new Member States with specific sludge management practices have joined the EU, technological progress has been made and new EC regulatory orientations (e.g. in wastewater, waste, soil, emission controls and energy policy, etc.) which have various impacts on sludge production and management, have been or are being implemented. Moreover, several Community legislative requests have been made to the Commission to revise this Directive; the Thematic Soil Strategy and the waste prevention and recycling Strategy.

This is the second deliverable of the study on "Environmental, economic and social impacts of the use of sewage sludge on land" for the European Commission (DG Environment). This assessment will build on the existing studies and knowledge (see report 1) and fill any identified knowledge and data gaps in order to provide a full picture of the current situation and the future needs.

The aim of the report is to develop the baseline scenario and the analysis of future risks and opportunities. It aims to prepare a debate on the possible need for future policy action, seeking views on how to improve sludge land recycling management in line with the waste hierarchy, possible economic, social and environmental gains, as well as the most efficient policy instruments to reach this objective.

From the baseline scenario, an assessment will be undertaken of the likely benefits and costs of additional or changed policy measures on the recycling of sewage sludge to agriculture in the EU when compared to the existing and planned policies. The assessment will find if the current policy measures are sufficient to address the issue of proper sewage sludge recycling to agricultural land and whether additional measures on sludge management would deliver significant improvements. The final set of options to be assessed will be based on the results of the baseline scenario and analysis of risks and opportunities as well as those from the consultation.

It is clear that there are data gaps and uncertainties with regards to sewage sludge recycling options, highlighted throughout the report. The Commission would therefore like to invite all Stakeholders to provide any data available to facilitate the subsequent Impact Assessment of different revision options. We have also included directed questions in sections throughout this document. We will invite stakeholders to contribute their knowledge and views on this assessment via a web consultation.

2 Baseline scenario

If no changes are implemented to the current Sewage Sludge Directive, the foreseen changes over the next 10 years due to other Community legislation and policies mentioned below will possibly affect the sewage sludge recycling route in terms of:

- Quantity and quality of sludge generated.
- Sludge treatment requirements.
- Restrictions for application of sewage sludge on soil and
- Monitoring and control requirements.

The baseline or "business as usual" scenario acts as the reference against which the other scenarios are compared. It is therefore the scenario that would emerge if the Directive 86/278/EEC was not revised and was still in force during the considered period of time. Hence, the necessity of considering a baseline scenario that accurately reflects current trends in technical progress, public behaviour, and regulatory policies.

The general objective of the baseline scenario is to provide an appropriate assessment of policies and practices across the EU over the next 10 years (2010 and 2020) and their possible implications on the production and treatment of sewage sludge and recycling to land for each Member State and at EU27 level.

2.1 Sludge quantities

The sludge quantities produced are directly linked to the volume and characteristics of wastewater treated which is dependent on the rate of wastewater collection, type of treatment, size of population connected and type of industries connected.

Sludge production is mainly linked to the following factors:
- size of the population,
- rate of population connected to public sewer system;
- level of wastewater treatment (no treatment, primary, secondary or tertiary treatment),
- type of sludge treatments applied; and
- size and number of industries connected to sewerage system.

2.1.1 Regulatory framework

The 91/271 UWWT Directive has had and will have a direct impact on sludge production in the EU in the next 15 years as it continues to drive the investment in wastewater collection and treatment capacities in the EU. In the EU15, the time schedules for achieving the environmental objectives of the UWWT Directive were phased (1998 – 2000 –2005), depending on the characteristics of the affected waters and the size of the wastewater pollution load ('agglomeration'). As for the new Member States in Central and Eastern Europe and the Mediterranean, interim targets and staged transition periods were allowed which should not be later than 2015 (2019 for Romania) (Table 1).

Table 8 Transitional periods for the implementation of UWWT Directive in EU 12

Member State	Final deadline
Bulgaria	31 Dec 2014
Cyprus	31 Dec 2012
Czech republic	31 Dec 2010
Estonia	31 Dec 2010
Hungary	31 Dec 2015
Latvia	31 Dec 2015
Lithuania	31 Dec 2009
Malta	31 Dec 2006
Poland	31 Dec 2015
Romania	31 Dec 2018
Slovakia	31 Dec 2015
Slovenia	31 Dec 2015

The latest available information (for 2003) on the implementation of the Urban Waste Water Treatment (UWWT) Directive can be found on http://ec.europa.eu/environment/water/water-framework/implrep2007/index_en.htm (CEC, 2008). Preliminary reports on the latest figures (end of 2005) have recently been made available. Unfortunately there is not a comprehensive picture of the implementation as only 18 Member States have provided information in time (10 out of the EU15 and 8 out of the EU12).

By 1 January 2003, overall, 81.4% of total reported load (470 million pe) for EU15 was treated to the required level of treatment as defined by the UWWT Directive. At the end of 2005, development of collecting systems had made good progress but there were still differences between Member States regarding compliance with secondary treatment. Most of the 18 Member States have reported a rate of collecting systems above 95% of total load. Overall, the pollution load for these 18 Member States amounted to 313 million pe from 13,734 agglomerations above 2000 pe. Collection systems were in place for 93% of the total load. Secondary treatment was in place for 87% of the load. More stringent treatment is used for 72% of the load.

For the previous reporting period, Denmark, Germany and Austria had recorded high levels of compliance of close to 100%, closely followed by the Netherlands (90%) with an only slightly less ambitious record, while the implementation across the other Member States is less successful and still represents a major challenge (Figure 1). In Denmark, Germany, and Sweden the majority of the population is connected to wastewater treatment works with tertiary treatment (EEA 2005).

For the new Member States, the investment programme is on-going and is not expected to be completed before 2015 (2019 for Romania). According to EEA reports (EEA 2005, EEA 2009), in Malta, almost 90% of population has no treatment of their wastewater. More than 65% of the population in the Czech Republic, Estonia, Latvia and Lithuania are connected to wastewater treatment, and roughly half of the wastewater treated undergoes tertiary treatment. For Poland and Hungary around 60% of the population are connected to wastewater treatment systems. In Poland about half of the connected wastewater is given tertiary treatment, whereas in Hungary only 10% gets tertiary treatment. The lowest connection rate is found in Slovenia, where almost 70% of the population are not connected to wastewater treatment systems. For Slovakia there is no detailed information on treatment type available. In Bulgaria and Romania, only around 40% of the population are connected to wastewater treatment, with most of the connected wastewater receiving primary or secondary treatment but with no tertiary treatment.

Although all EU15 countries should have been complying with all the requirements of the Directive by the end of 2005, this was not the case. Although there are uncertainties regarding the delay and level of compliance achieved for the 27 EU Member States over the next 15 years, for the baseline scenario, we have assumed that, by 2020, all Member States of the EU27 should have completed their obligations under the UWWT Directive. We have assumed that by 2010, the EU15 would have achieved full compliance as well as Czech Republic, Estonia, Lithuania and Malta. For the other EU12, the level of compliance would not have changed from 2006.

Table 2 below shows the number of agglomerations in the EU27 and the generated load discharge (CEC 2006). Figure 3 shows the percentage conformity for the EU15 states. Based on our assumptions regarding compliance with the UWWT in the different Member States, by 2020, a total of 671 million pe for EU27 will be discharged and treated in wastewater treatment plants.

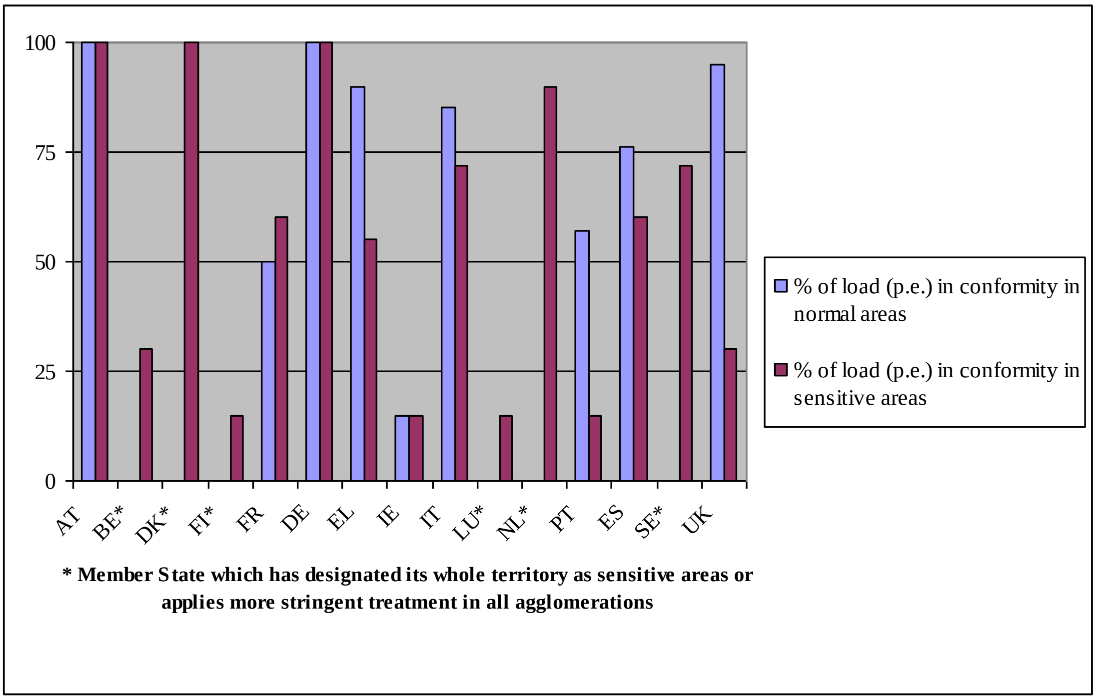

Figure 3 **Compliance with treatment level by EU15 Member States (as reported by 1/01/2003) (CEC 2007)**

	Agglomerations (having the load of more than 2,000pe) to which the Directive applies		Agglomerations >10000 pe discharging to sensitive areas and >15000 pe discharging to normal areas		Agglomerations 2000-10,000 and number of agglomerations >10,000 pe discharging to normal areas		Big cities / big dischargers (having generated pollution load of more than 150,000 pe)	
	Number	**Load (million pe)**	**Number**	**Load (million pe)**	**Number**	**Load (million pe)**	**Number**	**Load (million pe)**
EU15	31374	550	8500	476	22874	74	556	252
EU10	3348	85	1103	73	2254	12	98	39
EU2	2903	36	367	22	2536	14	0	0
Total EU27	**37625**	**671**	**9970**	**571**	**27664**	**100**	**654**	**291**

Table 9 Total number of agglomerations in EU27 and total generated organic pollution load discharged (CEC 2006).

2.1.2 Size of population

A factor to take into account for estimating future sludge quantities is the population growth. The EU population growth is currently 0.4% per year (CEC 2008). For the baseline scenario, we have assumed that there would be no new accession between 2010 and 2020.

The current population growth is positive in some of the old EU15 Member States (Ireland close to 3%, Spain, Cyprus, Luxembourg, over 1%), while in Germany there has been a recent slight decline in population, a pattern that is reported to be common for most of the new Member States like Bulgaria, the Baltic States, Romania, Hungary, Poland and Croatia.

Figures from CEC (2008) show that from around 2010 onwards, the population is expected to decline for the European Union as a whole and that by the year 2050 the population of the European Union is expected to have declined from its current 493 million inhabitants (2007) to 472 millions. The Eurostat projections (Table 3), on the other hand show future population for the EU27 increasing to about 500 millions by 2010 and to 514 million by 2020.

Table 10 Population projection for 2010 and 2020 (Eurostat 2009)

Member State	2010	2020
Austria	8,404,899	8,723,363
Belgium	10,783,738	11,321,733
Denmark	5,512,296	5,661,099
Finland	5,337,461	5,500,929
France	62,582,650	65,606,558
Germany	82,144,902	81,471,598
Greece	11,306,765	11,555,829
Ireland	4,614,218	5,404,231
Italy	60,017,346	61,420,962
Luxembourg	494,153	551,045
Netherlands	16,503,473	16,895,747
Portugal	10,723,195	11,108,159
Spain	46,673,372	51,108,563
Sweden	9,305,631	9,852,965
United Kingdom	61,983,950	65,683,056
EU15	***396,388,049***	***411,867,857***
Bulgaria	7,564,300	7,187,743
Cyprus	820,709	954,522
Czech Republic	10,394,112	10,543,351
Estonia	1,333,210	1,310,993
Hungary	10,023,453	9,892,967
Latvia	2,247,275	2,151,445
Lithuania	3,337,008	3,219,837
Malta	413,542	427,045
Poland	38,092,173	37,959,838
Romania	21,333,838	20,833,786
Slovakia	5,407,491	5,432,265
Slovenia	2,034,220	2,058,003
EU12	***103,001,331***	***101,971,795***
EU27	**499,389,380**	**513,837,632**

2.1.3 Domestic connection rate

Wastewater pollution load and thus sludge production is directly linked to the proportion of inhabitants connected to wastewater treatment plants. Following the implementation of the UWWT Directive which requires the collection of wastewater from all agglomerations above 2000 pe, the current rate of connection is steadily increasing across the EU.

From the latest available information, at the end of 2005, developments of collecting systems have made good progress but there are still differences between Member States regarding compliance with secondary treatment. Most of the 18 Member States have reported a rate of collecting systems above 95% of total load apart from, in decreasing order: Lithuania (93%), Estonia (89%), Hungary (80%), Slovakia (76%), Slovenia (73%), Cyprus (49%), and Romania (47%). No information was submitted by Bulgaria, Czech Republic, Greece, Ireland, Italy, Latvia, Malta, Poland, Spain, and the UK.

Although some Member States will not reach 100% coverage, for our baseline scenario we have considered that by 2010, EU15 will be fully connected to sewage collection systems and that by 2020, the whole of the EU27 will have achieved full coverage.

2.1.4 Industrial connection rate and level of pre-treatment

Industrial and trade effluents discharging to municipal sewer systems also contribute to pollution load and sludge production at municipal wastewater treatment plants (see below). The ratio between the total pollution load in influent of a treatment plant expressed in population equivalent (pe) and the number of inhabitants ranges from 1 (small communities without industry) to more than 2 (larger cities).

Industries connected to municipal sewers contribute to sewage sludge production in the following ways:

- Untreated industrial effluent permitted under a trade effluent licence;
- Treated effluent which may not be treated to sufficient standard for discharge to a surface water and still contain degradable material or separable suspended solids;
- Treated effluent with waste sludge from the treatment process combined together in a discharge to sewer;
- Combination of liquids and solids transported separately but to be treated as part of the municipal sewage treatment processes.

In Austria (Alabaster and LeBlanc, 2008) the actual BOD5 load to all Austrian treatment plants is, on average, ~2 pe/capita. Figures from other Member States have not been thoroughly investigated and this could be clarified during the consultation period.

We have considered that the contribution of industries to sludge solids production will not change from 2005 till 2020, as a result of opposing effects that include the following factors:.

- Industrial production is expected to grow due to economic growth which will increase liquid and solid effluents.
- Quantities discharged by industry will decrease due to process improvement and pollution prevention;
- The rate of industries with strong wastewaters connected to the sewer may decrease, due to increasing industrial onsite wastewater treatments. Sludge produced from some of these processes may be managed as a separate material.

2.1.5 Level of treatment

The type of wastewater treatment influences sludge production. However it is difficult to predict such changes at Member State level as these will be highly dependant on local situations at each plant. Works that are required to achieve reduced effluent phosphorus concentrations, for example, may see an increase or a decrease in amount of sludge production. Biological P removal may result in slightly lower rates of sludge production rate due to biomass recycle and longer retention times while chemical P removal may result in up to 65% more secondary sludge produced. For N removal, there is a likely reduction in sludge production due to the installation of long sludge age systems, or no change, unless separate denitrification processes are required driven by addition of other chemicals.

Sludge stabilisation processes also have an impact on the ultimate sludge quantities to be disposed of. The most recently constructed sludge treatment processes that involve anaerobic digestion have been designed to achieve increased conversion of volatile solids to biogas. The increase from 45% volatile solids destruction to 55% volatile solids destruction could lead to a reduction in sludge production by 10% to 15% at a single works, or if all works in the country were modified or replaced to achieve the same extent of conversion.

No attempt has been made at this time to closely model the forms of sludge treatment used in each country as the combinations of sewage and sludge treatment processes lead to a very wide variety of possible scenarios.

2.1.6 Sludge production trends

Sludge production rate per capita is considered to be a good indicator for future sludge estimates at Member State level. However, current sludge production per capita shown in Table 4 varies greatly across countries. Countries that have the most comprehensive infrastructure and treatment technologies (e.g. secondary and tertiary treatments) produce the largest mass of sewage sludge per person. Countries which have less developed wastewater treatment infrastructure and collect and treat wastewater from lower percentages of their populations produce less sewage sludge per person on a national level. The proportion of industrial discharges to municipal sewer influence the sludge production rate by increasing the relative sludge production per capita.

For our baseline scenario, we have considered that sludge production will increase and be stabilised once the UWWT Directive is fully implemented. We have considered that full implementation of UWWT across all of the 27 Member States will be achieved by 2020.

The sludge production per capita in the complying countries (i.e. Austria, Denmark and Germany) should be a good indicator of the maximum sludge quantities that can be expected when a Member State will be in compliance with the UWWT Directive. Per capita, sludge production in these countries ranges from 23 to 29 kg/person per year. Thus an average 25 kg per capita per year is a good estimate for maximum sludge production rate.

Thus for our baseline scenario we have considered that, by 2020, sludge production per capita across the 27 EU Member States will reach at least 25 kg per capita per year. This value has been used for estimating future sludge production in Member States which currently have lower sludge production rates. For countries with higher rates, future sludge production rates have been estimated using these higher values.

Table 11 Current annual sludge production (period 2004-2006) and production rate per capita in the EU27

Member State	Year data recorded	Sludge production (t DS / year)	Population [a] ($x10^6$)	Sludge production (kg DS /capita)
Austria	2005	238,100/ 420,000 [b]	8.3	29/ 50 [b]
Belgium				
• Wallonia	2003	23,520	3.4	7
• Flemish	2005	76,254	6.1	13
Denmark	2002	140,021	5.5	25
Finland	2005	147,000	5.2	28
France	2002	910,255	64.4	14
Germany	2006	2,059,351	82.2	25
Greece	2006	125,977	11.1	11
Ireland	2003	42,147	4.5	9
Italy	2006	1,070,080	59.6	18
Luxembourg	2003	7,750	0.48	16
Netherlands	2003	550,000	16.5	33
Portugal	2002	408,710	10.6	38
Spain	2006	1,064,972	46	23
Sweden	2006	210,000	9.2	23
United Kingdom	2006	1,544,919	61	25
Sub-total EU15		***8,786,569***	***394***	***22***
Bulgaria	2006	29,987	7.6	4
Cyprus	2006	7,586	0.77	10
Czech republic	2006	220,700	10.3	21
Estonia	2006	nd	1.3	?
Hungary	2006	128,380	10	13
Latvia	2006	23,942	2.3	10
Lithuania	2006	71,252	3.4	21
Malta		nd	0.4	
Poland	2006	523,674	38.1	14
Romania	2006	137,145	21.5	6
Slovakia	2006	54,780	5.4	10
Slovenia	2006	19,434	2	10
Sub-total for EU12		***1,216,880***	***103***	***12***
Total		**10,003,449**	**497**	**20**

Notes:

a) Based on data from national Statistical offices. Depending on Member States, reference year is mainly 2007 or 2008 with a few figures for 2006

b) without/with industrial discharges especially from cellulose and paper industry

Questions for the consultation

If you disagree with our assumptions on per capita sludge production rate for your country please provide corrections and if possible explain the reasons using the following supporting questions.

Q1 – What are the special reasons in your country that result in a reported sludge production rate of less than 23kg/pe/year or greater than 28 kg/pe/year?

Q2 - What change in the rate of sludge production do you expect will take place up to 2020?

Q3 - Why would any change in the reported rates of sludge production per person take place?

Q4 – What proportion of total sewage sludge reported here is due to industrial sources in your country? Is this expected to change, and to what proportion?

Although, it may not be the case, for our baseline scenario, by 2010, we have considered that compliance with the UWWT Directive should have been achieved in all EU15 and in 4 of the EU12, i.e. Czech Republic, Estonia, Lithuania and Malta. For the remaining EU12, sludge production in the baseline year of 2010 will remain the same as reported for 2006 and that by 2020, full compliance with the UWWT Directive will be achieved across the EU27. Unless recent figures (calculated after 2005) on future sludge production have been found in the literature, future sludge production quantities have been calculated using the 25 kg/capita per year figure or greater if reported in Table 4 and population projection in Table 3.

Table 12 Future forecasted (2010 and 2020) sludge quantities arising in the EU27

Member State	2010 ($x10^3$ tds pa)	2020 ($x10^3$tds pa)
Austria	270	280
Belgium	170	170
Denmark	140	140
Finland	155	155
France	1,600	1,600
Germany	2,000	2,000
Greece	260	260
Ireland	135	135
Italy	1,500	1,500
Luxembourg	10	10
Netherlands	560	560
Portugal	420	420
Spain	1,280	1,280
Sweden	250	250
United Kingdom	1640	1,640
EU15	***10,393***	***10,400***
Bulgaria	47	180
Cyprus	8	16
Czech Republic	264	264
Estonia	33	33
Hungary	175	200
Latvia	25	50
Lithuania	80	80
Malta	10	10
Poland	520	950
Romania	165	520
Slovakia	55	135
Slovenia	40	50
EU12	***1,418***	***2,484***
EU27	**11,811**	**12,884**

Note: As working estimates 2010 production rates have been taken to be the same as 2020 production for states expected to be in full compliance in 2010. For non-compliant states a rounded 2006 production rates have been used – see text in Annex 2 for detail

Future sludge production has been estimated to increase by approximately:

- For the EU15 - 20% to 10.4 Mt DS by 2020, and
- For the EU12 - 100% to 2.5 Mt DS by 2020.

This gives a grand total for EU27 sludge production by 2020 of approximately 13 Mt DS per annum, compared with 12.0 Mt DS in 2010, an overall increase of about 30% compared with 2006 (Table 5 above). Figure 2 (below) presents the past and future trends for sludge production in the EU15 and EU12.

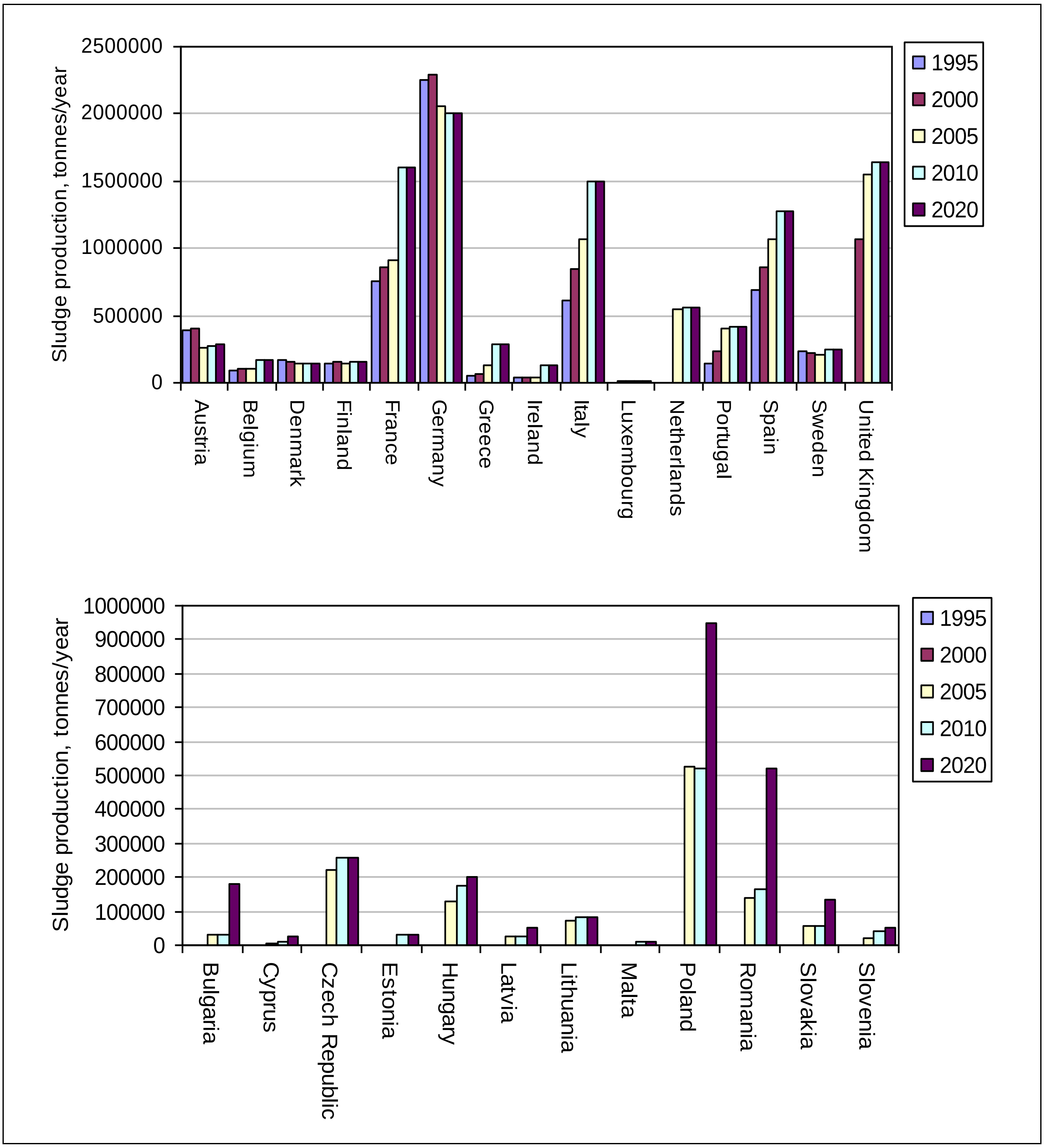

Figure 4 Past and future trends in sludge production in the EU15 and EU12 sludge production case studies

Sludge estimates in Austria and Slovenia

Austria (Doujak, 2007) is already in line with the UWWT Directive requirements with about 1,500 municipal sewage treatment plants collecting wastewater from about 90% of a population of 8.2 million for a territory of 84,000 km^2. Municipal sludge production amounts to 266,000 tds pa; 47% are thermally treated; 18% recycled to agriculture; 1% sent to landfill and 34% to other outlets including composting (77%), landscaping (12%) and unknown (data for 2005). The connection rate to sewer and treatment plant is forecast to be 92% of population by 2010 and sludge production to amount to 273,000 t DM and to stabilise to a maximum of 94% by 2015/2020 with a total municipal sludge production of 280,000 tds – 100% coverage is not foreseen. In 2015/2020, the outlets for municipal sewage sludge are forecast to be: 5% going to agriculture, 10% to be treated by bio-mechanical treatment and 85% to be treated thermally.

Slovenia is reported to struggle to implement EU environmental legislation on wastewater treatment (Slokar, 2006). Slovenia's two million people live in 6,000 settlements, scattered over 20,000 km^2. About 53% of population is connected to about 200 municipal WWTPs while 42% of the population rely on septic tanks. Nevertheless, it is reported that when work on wastewater treatment plants for the country's three largest cities are completed, 60% of the nation's settlements will be compliant with the UWWTD. Sludge production amounts to 30,000 tds (2005 data). Although sludge was recycled in the past in agriculture; after 2002, the quantities decreased down to 1% due to the quality of the sludge and most sludge is landfilled. By 2010, with the construction of 50 new WWTPs, sludge production is forecast to amount to 40,000 tds. Thermal treatment will be the preferred option.

The values in Table 5 forecast that each country will produce sludge at a rate at least equal to 25kg/pe/year even if not currently doing so as treatment works develop to meet current frequently applied requirements. These include a small proportion of works with sewage effluent quality requirements that include restrictions on phosphorus and nitrogen concentrations. No adjustment has been made to these data to apply more detailed analysis of the likely increase in works that are required to achieve reduced effluent phosphorus concentrations and do so by using chemical treatments. These works would significantly increase the amount of sludge production from the combination of the chemical treatment and the associated requirement for low effluent suspended solids concentrations.

The sludge production values are the reported values of treated sludge, but before any conversion to ash through incineration or sludge powered generators. No attempt has been made at this time to closely model the forms of sludge treatment used in each country as the combinations of sewage and sludge treatment processes lead to a very wide variety of possible scenarios.

Two case studies from Austria and from Slovenia illustrate the disparity in meeting the EC requirements and thus the uncertainties in future forecasted sludge production (see box above).

Questions for the consultation

In assessing the likely amount of sludge production in 2020 the effect of the WFD and the UWWTD must be considered with respect to nutrient removal processes used in sewage treatment. Biological nutrient removal (N and P) which can meet requirements for total N<10mg/l and P < 2mg/l may have little impact on sludge production dependant on requirements for imported additional substrates, but use of chemical P removal to enable reliable enhanced P removal may increase whole works sludge production by 30% or more. This assumes current common technologies, and does not take into account any future off-line sludge processing to extract nutrients.

Q5 – What proportion of your country is likely to have sewage effluent consents for:

- Total Nitrogen
- Phosphorus.

Q6 – What are the likely consent values?

- Total Nitrogen < 15mg/l – for what population
- Total N < 10 mg/l, P < 2mg/l – for what population
- Total N < 10mg/l, P < 1mg/l – for what population
- Total N < 10 mg/l, P < 0.2mg/l – for what population

Q7 – What other combinations of consents may have significant impact on treatment processes?

Q8 – How will these consents be achieved?

- Biological nitrogen removal
- Tertiary nitrogen removal using chemical addition (methanol)
- Biological nitrogen and phosphorus removal
- Chemical phosphorus removal
- Combination of chemical and biological removal
- Other likely common process combination

2.2 Sludge disposal routes

The main factors in decision-making for selecting a disposal route for sewage sludge are transportation cost, PTEs concentration in sludge, and landfill capacity. Furthermore, the efficiency and cost of dewatering and drying are important for each disposal option. In addition to the factors mentioned above, EU and national regulation is an important factor as it can impose stricter limits values precluding its use in agriculture. Another important factor is public confidence.

Other factors which can also affect the decision in this field are concerns about global warming and the focus on energy efficiency and sustainability at wastewater treatment and wastewater sludge management facilities driven by energy prices.

Which approach prevails in any given region seems to be best predicted by the following factors:

1. population density;
2. availability of agricultural land; and
3. local social, political – and thus regulatory requirements.

2.2.1 Regulatory framework

Although, the Sludge Directive only concerns sewage sludge used in agriculture, this cannot be looked at in isolation of the other routes. For example, existing legal requirements on landfilling, thermal treatment as well as alternative energy production, by restricting or encouraging one outlet can have an indirect impact on sewage sludge recycled to land. In addition, other sources of sludge, food waste, organic fractions of municipal waste, might compete for available land and thus restrict the amount of sewage sludge which is recycled to land in the future.

If the Directive 86/278/EEC is not revised, some Member States may change their national legislation in the future – several have indicated that they would like to do so and some have already published draft proposals (for example, Germany) and/or introduced their own national voluntary guidelines to supplement the Directive (for example, The UK Sludge Safe Matrix).

It seems unlikely that if sewage sludge use is banned already, and consequently alternate routes have been found, that there would be a reversal unless sludge could be beneficially mixed with other organic wastes (to improve for example the conditioning properties) and processed using a high quality treatment (negligible pathogens, no smell) then the zero use could be reversed to a limited extent.

We have considered the baseline scenario as the current regulatory situation in each Member State regarding sludge recycled to agriculture/land. No other safe prediction can be made regarding possible developments of national legislation in the coming years.

The Community regulatory framework on waste management and energy is impacting on sludge management. Community waste policy applies a five-step waste management hierarchy as a priority order. The highest priority is given to waste prevention, followed by preparation for reuse, recycling, other recovery and disposal. Recycling to land of sewage sludge fits within the highest priority and is thus supported by the EC waste regulatory framework.

EC controls on landfills are reducing and restricting the proportion biodegradable waste (including sewage sludge) disposed into landfills. This potentially creates a desire to recycle more sludge to land and/or to improve or change treatment of sludge. Treatment and disposal methods that stabilise and reduce solids mass and volume will be encouraged, especially with energy recovery; these include thermal decomposition processes.

Recovery of energy from biodegradable materials is encouraged by the EU energy policy, in particular to increase the use of biofuels. There is potential to increase sludge production if non-sewage biodegradable materials become incorporated into the sludge treatment route. In contradiction to this, treatment processes are increasing their capability to convert organic solids to transferable fuels with less residual solids. The balance between increase and decrease of mass of residual solids from sewage sludge treatment is therefore unclear.

Facilities in which biological treatment takes place will have to comply with higher standards through the upcoming review of the IPPC Directive.

The Thematic Strategy on Soil addresses the wider subject of carbon depletion in soil and how to avoid and remedy it. This will take into account the potential of using compost as a means to increase the carbon content of soil.

A summary of drivers that may affect the disposal of sludge is shown below with a judgement of the importance of each driver in either promoting use or restricting the use of sewage sludge on land.

Technical issues will continue to require research, and best management practices for sludge management will continue to evolve. For example, the potential for excessive phosphorus to be applied to soils through sludge and animal manures may require application of developing technologies for removal of phosphorus. Likewise, current issues about trace chemical contaminants in sludge used on soils will continue to require support for research and analysis of risks.

Driver	Expected consequences	Potential influence on use of sludge on land	Overall Importance
EC Landfill Directive	• Reduction of biodegradable fraction in landfill • Increased treatment of sludge (i.e. composting) • Increase diversion of sludge to land • Increased diversion of sludge to incineration	Uncertain (Both positive and negative)	High
Incineration Directive	• Regulates emission limit values for selected potential contaminants (e.g. NOx, SOx, HCl, particulates, heavy metals and dioxins), • indirect improvement of sludge quality	Positive	Low
IPPC Directive	• Permits for biological treatment of organic waste (if pre-treatment before disposal) (i.e. composting capacity and of anaerobic digestion)	Negative	Medium
Renewable energy Directive	• By 2020, 20% share of energy from renewable sources • Incentives for the use of renewable energy sources such as biogas from sewage sludge.	Positive	Medium
Waste Directive	• Recycling has priority over energy • End of waste status for compost	Positive	Medium
Decision 2006/799/EC – eco-label requirements for soil improvers – sewage sludge not eligible	• Increased competition with alternate improvers that meet eco-label criteria • Sludge users not currently demanding additional quality standard • Reduces prospect of promoting sewage sludge as a beneficial product	Negative	Low – no significant demand for eco-label sludge
Decision 2007/64/EC – revised eco-label requirements for growing media – sewage sludge not eligible	• Sewage sludge not used currently to any significant extent as a growing media • Eliminates opportunity of promoting co-digested or co-composted materials	Negative	Low
Environmental Liability Directive 2004/35/EC	• In countries that adopt a strict liability regime for the use of sewage sludge on land, this might a) somewhat encourage the use of sewage sludge; and b) where used, encourage a preference for sludge treated to higher standards.	Negative	Low

Questions for the consultation

If you disagree with our judgements on regulatory influences on agricultural recycling please provide us with corrections and if possible explain the reasons using the following questions.

Q9 – In your country, what are the special conditions that encourage or discourage the amount of agricultural recycling?

Q10 – What change do you expect to take place in the rate of agricultural recycling by 2020?

Q11 – How will the existing regulations noted above affect your recycling and other disposal routes?

Q12 – Will the Nitrate Directive and the WFD have a significant effect on restricting or reducing the availability of land for agricultural recycling of sewage sludge? How much of an effect?

2.2.2 Population density and land availability

Population density and the availability of agricultural lands for sludge recycling to land will continue to be an important factor influencing policy decisions on sludge management. Indeed, these factors interact with social and political factors.

Even though most Member States hypothetically would only need to utilize less than 5% of their agricultural area to apply all of sludge produced, there still needs to be a relatively high level of acceptance by farmers and public for this outlet to be sustainable.

A simple view of the opportunity for using agricultural land for recycling sewage sludge is shown in Figure 3. The amounts of sludge produced and the amounts that are recycled to agriculture have been normalised to the total ‘utilisable’ agricultural land. This shows distinct differences between Member States, with the Netherlands having the smallest ‘utilisable’ area compared to the amount of sludge production. In general the EU12 have greater opportunities for recycling to agriculture.

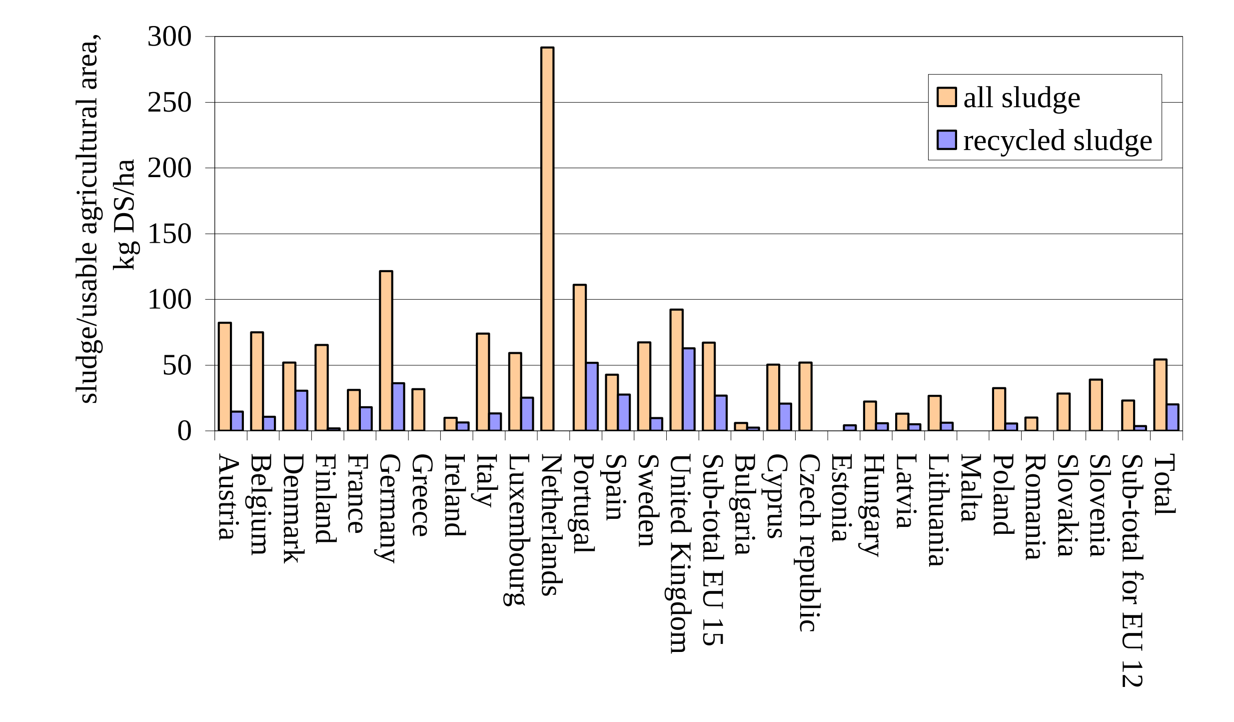

Figure 5 Comparing sludge arisings and extent of agricultural land: Total arisings and sewage sludge recycling to land per hectare of available agricultural land[7]

This approach does not take account of other recycling that may be taking place, such as the use of animal manure, which represents an alternative to sewage sludge and reduces the amount of available land for the latter. Nor does it take account of the different nature of farming across different countries: sewage sludge may be less suitable for some uses than for others.

In northern Europe, some of the most densely populated countries as well as regions (notably Netherlands; as well as Vienna and many cities in Germany) rely almost entirely on incineration as they have limited available agricultural land for the spreading of sludge.

2.2.3 Incineration as an alternative

Concerns have also been expressed about contaminants in sludge applied to soils. While scientific studies have not indicated major concerns, the future development of public opinion in this area is uncertain. These issues are addressed further in section 2.7.

A further influence will be the potential attraction of incineration of sewage sludge as an alternative, in particular as a potential source of renewable energy.

It can be noted that in general sewage sludge incineration occurs in large cities, but large cities do not always rely on incineration and some prefer recycling to land. However, as technology advances and population densities increase, a country may move toward more incineration for sludge management. This shift is advancing more quickly now, because of the higher costs of fossil fuel energy as well as European policy goals calling for the increased use of renewable energy.

Whether this trend toward incineration will continue is uncertain. Some studies have found incineration of sewage sludge to be much more costly in terms of total life cycle analysis,

[7] Data for utilisable agricultural land from: www.ec.europa.eu/agriculture/agrista/2008/table_en/2012.pdf

economically and environmentally – including impacts on greenhouse gas emissions. In contrast, the most sustainable option has been assessed to be treatment by anaerobic digestion followed by some form of use on soils that offsets fertilizer use, such as composting. It is very important that these decisions take full account at each individual location of all factors including land availability, transport requirements, energy recovery and greenhouse gas emissions.

Some policy makers consider incineration to be a second choice to the recycling of sludge to land. However, negative public perceptions of sludge use on land may direct the political decision in favour of incineration.

2.2.4 Past, current and future trends in sludge treatment and disposal options

In 2008, sludge recycling to agriculture appears to be the dominant management option across the EU27 and is growing in the some of the new Member States (for example, Bulgaria). Many are developing sludge recycling programmes, and this option is expected to substantially replace landfill in the coming years. Figure 6 presents overall trends in management routes for the EU15, EU12 and overall EU members. Figure 7 presents past and future trends in terms of member country sludge recycling to agriculture in the EU15 and EU12.

The two most common treatments prior to sludge applications to agriculture seem to be anaerobic digestion and lime stabilization. In some of the old Member States (EU15), land application of raw and/or limited treated sludge is diminishing and composting and other treated products are increasingly used. There is also an increase of advanced treated sludge to be used in non-agricultural applications.

In many countries, corn is the crop most likely to receive sludge, but vineyards, orchards, grains, and other crops are also fertilized with sludge. Most countries discourage or prohibit the use of sludge on food crops destined for direct human consumption, and, if allowed, there are prescribed waiting periods between applications of sludge and harvesting of crops.

Most of the sludge used in domestic, horticultural, and green space (landscaping, parks, sports fields) is composted; some is heat-dried (for example, heat-dried pellet fertilizer).

Sludge is also used as a soil improver on degraded soils at mine sites, construction sites, and other disturbed areas such as in Portugal (Duarte) where sludge has been used for stabilising soils after forest fires. However, use of sludge in forests is relatively uncommon or even prohibited in some Member States.

Most Member States are, in general, moving away from landfilling to recycling sludge to land and/or – to a lesser extent – incineration with some recovery of energy.

Some (for example, Germany) have diversified outlets, with growing reliance on incineration with energy recovery (sludge powered generators) while some countries are committed to single options (for example, Netherlands relies almost entirely on incineration or Romania on landfilling). Norway implements the Sewage Sludge Directive as an EEA country, and it has followed a path that combines extensive use of sewage sludge on land, high environmental standards and public acceptance (see box)

Sewage sludge recycling in Norway

Norway recycles the majority of sludge to land. The reasons for successfully achieving this high level of recycling with public acceptance are many but include:

- stringent standards for the content of heavy metals (stricter than the EU standards) and pathogens, and
- high priority given to control of the odour nuisance.

This requires sanitation systems that keep significant levels of toxic elements (heavy metals) and chemicals (POPs, PPCPs, etc.) out of wastewater and thus sludge. It requires industrial and commercial pre-treatment programmes, stringent regulatory controls that encourage the recycling to soils of high-quality sludge and other organic residuals in integrated, nutrient management systems.

The level of public understanding and support is a major determinant in whether or not a country recycles significant portions of its wastewater sludge to soils. Therefore, public consultations, local demonstration projects, with the involvement of diverse stakeholders, to show the benefits of sludge recycling to land, and information to political leaders, regulators, and the public are important.

Finally, the development of products (other than soil amendments) from sewage sludge continues to be explored. Incinerator ash and melted slag are being used more in construction materials (mostly cement) and there are some examples of extracting phosphorus (P) from wastewater sludge and distributing it as fertilizer. But the complex technologies and operational costs required to extract or produce products from sewage sludge continue to be less cost efficient in comparison to the traditional, proven options such as recycling to land, incineration, and landfilling.

In comparison, there are relatively few EU15 countries – notably Austria, the Flemish region of Belgium and Germany – that are currently moving away from sludge recycling to land. Together with the Netherlands, they are moving toward more incineration with a focus on energy recovery. On the other hand, some cities are focusing on increasing methane gas production from anaerobic digestion, because of the energy benefits and climate change focus.

Although the proportion of sludge recycled to agriculture has not altered overall since 1995, at around 40 – 50%, the situation in some Member States has dramatically changed. Thus the overall recycling average of 40% of sewage sludge obscures substantial differences between Member States (see Annex 2). These trends have been used to predict future trends in sludge recycling to land in the different Member States. Table 13 summarises past trends regarding sludge recycled to land in the EU based on figures reported to the Commission between 1995-2006. Some of the main changes include:

- In Italy, in the mid 1990's, experts were predicting that incineration was going to increase; this did not happen and today, composting is on the increase.
- In the Netherlands, in 1996, 11% of wastewater sludge was recycled in agriculture and 82% was disposed in landfills while currently, most of the sewage sludge is sent to incinerators inside the country or in Germany, some of it after composting or heat drying.
- In Bulgaria, in 1996, all the sewage sludge was sent to landfill. New national regulations should lead to a high level of land application and a reduction in landfilling.

Table 13 Past trends (1995-2006) in sludge recycling to agriculture and current (2006) level of recycling in the EU27

Increasing (current %)	Status quo [1)] (current %)	Diminishing[2)] (current %)	Already very little use[3)]
United Kingdom (70%)	Sweden (10%)	Italy (18%)	Netherlands
Spain (65%)	France (60%)	Finland (3%)	Flemish Region [4)] (Belgium) (3%)
Ireland (63%)	Norway (~95%)	Austria (10%)	
Latvia (37%)	Denmark (50%)	Germany (30%)	Greece
Portugal (46%)	Walloon Region (50%)	Czech Republic (12%)	Slovenia
Bulgaria (40%)	Lithuania (25%)	Slovakia (0% but 61 % being composted)	Romania
Estonia	Poland (17%)	Cyprus (40%)	Malta
	Luxembourg	Hungary (26%)	

Note:

1) Although the quantities recycled to land have decreased over the years, the level seems to have stabilised in the last 3 years.
2) Although quantities recycled to agriculture are reported to have decreased over the years, for some of these Member States this masks the fact that sludge is still used on land but there has been a shift towards composting followed by recycling to agriculture and/or to other land uses
3) Although for some of these Member States (i.e. Netherlands and Flemish Region) recycling to land is definitely no longer an option while for some it may well become a sustainable outlet (i.e. Romania).
4) Although for the latest reported year (2006) 3% was still recycled to land, there was indication that no more sludge would be recycled to land in the following years.

The future trends in sludge management for most of the Member States are detailed in Annex 2, together with Table 15 and Table 16 that summarise sludge management routes for each country and the EU15, EU12 and EU27 groups. The trends for the EU15, EU12 and EU27 groups for the agriculture, incineration (or thermal treatments), landfill, and other routes (including land recovery, compost production) are shown in Figure 6 with additional details for the agricultural route for individual countries shown in Figure 7.

The overall trends for the EU27 are summarised below:

- Continued increased level of sewer connection and wastewater treatment across the EU27 which means more sewage sludge being produced which will need proper management.
- Increased treatment of sludge before recycling to land through anaerobic digestion and other biological treatments, like composting. The use of raw sludge will no longer be acceptable.
- Potential increased restrictions on types of crops being allowed to receive treated sludge.
- Enhanced production and utilisation of biogas. For example, trials with anaerobic co-digestion of wastewater sludge and MSW have proved to produce increased volumes of methane and to improve the quality of the wastewater sludge in Italy, Norway and Slovenia. Another technique is lysis and thermophilic anaerobic digestion as tested in the Czech Republic.
- Production of alcohols and other fuels directly from sewage sludge using pyrolysis and gasification.
- Similar proportion of treated sludge recycled to agriculture at around 40-50% by 2020. The situation in the existing 15 Member States should not change dramatically over the next 5 years. There are some indications in the new Member States which have no previous experience in this sludge management route that agriculture recycling may become a more significant outlet in the future.
- Phasing out sludge being sent to landfill due to EC restrictions on organic waste going to landfill and increased dislike by the public of use of landfill disposal. The most likely change will be for Member States which currently rely heavily on landfill as sludge disposal options –

these quantities will be diminishing over the next 15 years. By 2010, in these Member States, the proportion of sludge going to landfill will be lower than currently reported, and we have assumed that by 2020 there will be no significant amounts of sludge regularly going to landfill in the EU27.

- The main alternative to landspreading is likely to continue to be incineration with energy recovery for sludge produced at sites where land suitable for recycling is unavailable.
- Co-treatment of sewage sludge with a variety of other imported organic materials, particularly with reference to digestion processes, is currently not generally carried out, for reasons that include regulatory constraints. There are potential advantages of co-treatment in terms of asset utilisation (access to energy conversion systems, utilisation of existing infrastructure).
- Where population densities make it more difficult to recycle to land and/or where animal manures are over-abundant, increased treatment of sludge with energy recovery through anaerobic digestion, incineration or other thermal treatment, with recycling of the ash.
- Increased application of sludge to fuel crops such as miscanthus, hybrid poplars and other non-food energy crops.
- Increased industrial water pre-treatment and pollution prevention, reducing or eliminating discharge of toxic substances (heavy metals, chemicals) and improving sludge quality.
- Introduction of semi-voluntary and voluntary quality management programs such as the ones in place in England and Sweden to increase the safety of sludge use on food chain crops.
- Increased attention to climate change and mitigation of greenhouse gas emissions and thus recognised additional benefits of sludge applications to soils.
- Increased attention to recovery of organic nutrients, including those in sludge.

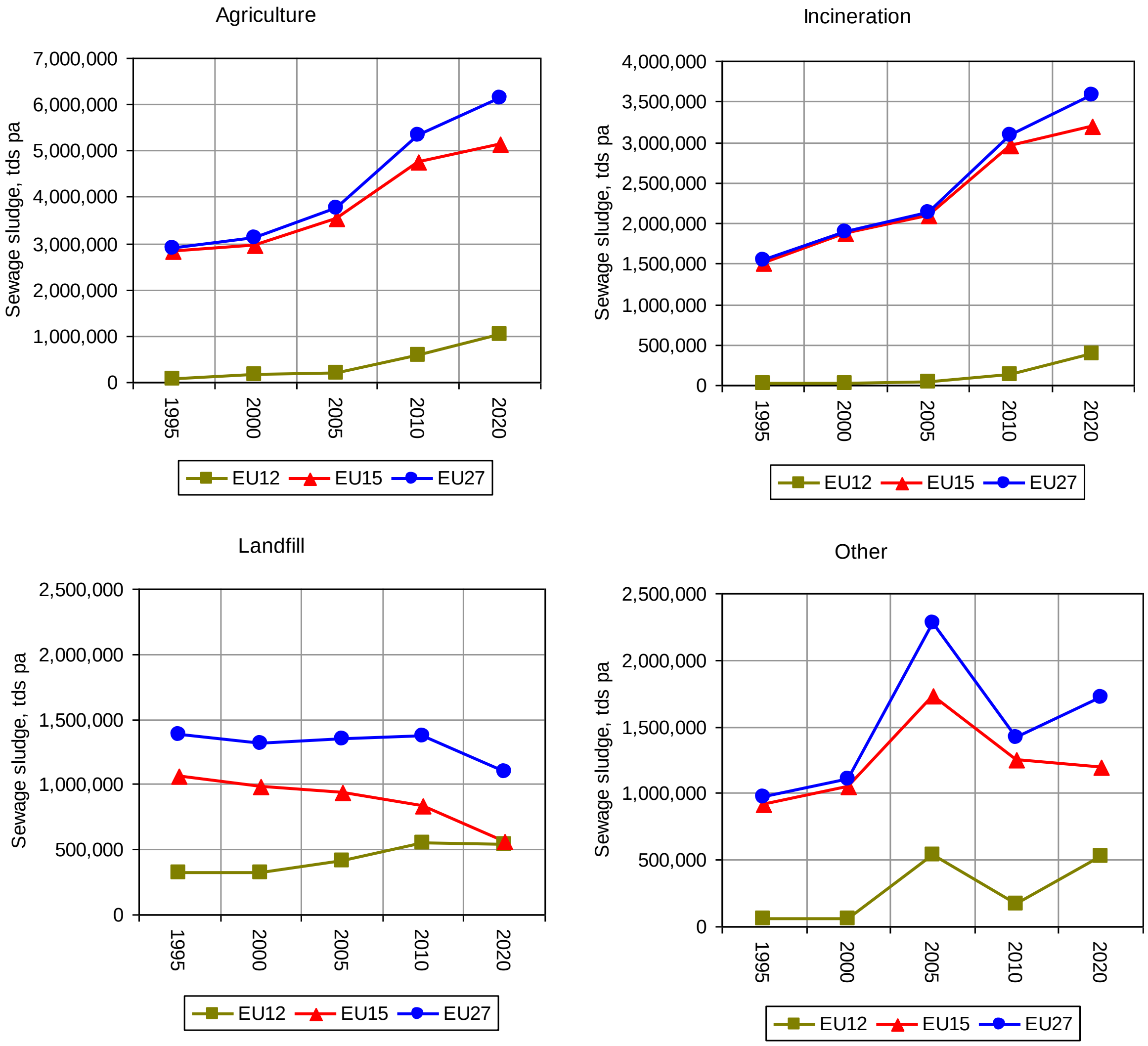

Figure 6 Main routes for sewage sludge recycling and disposal in the EU

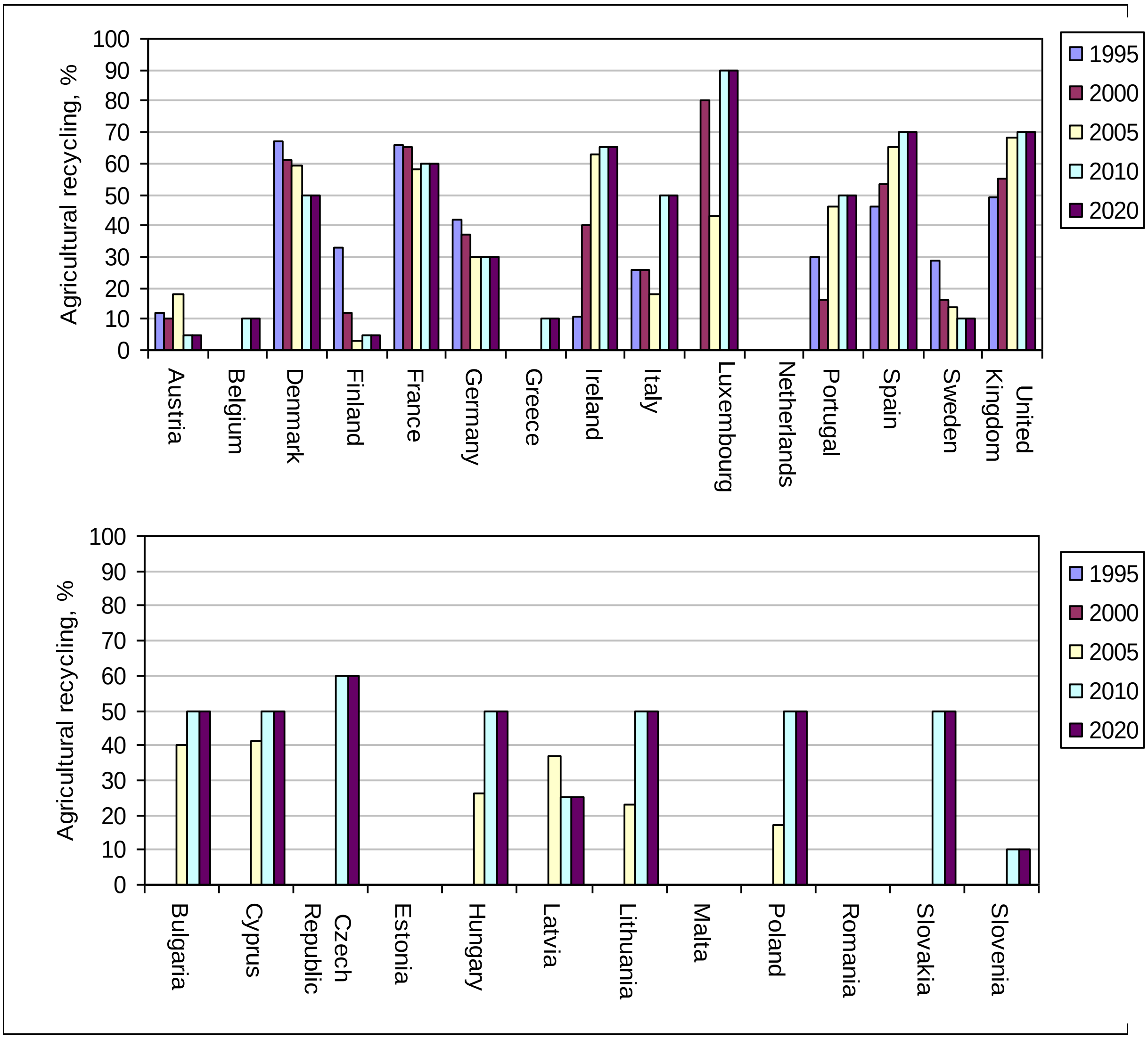

Figure 7 **Past and Future trends for sludge recycling to agriculture in the EU15 and EU12**

2.3 Sludge quality

The concentrations of metals in sewage sludge in Western Europe have been significantly reduced since the mid 80's as a combination between regulatory industrial effluent controls and a reduction of heavy industrial production. The extent of further reductions is unclear, although the range of loadings may be significantly different between different parts of the EU (including new Member states).

As new and existing environmental legislation at Community level is implemented (for example, REACH), it should also have a positive impact on the quality of sludge as better understanding and reduced use of hazardous substances is encouraged and better controls on environmental emissions are implemented.

A considerable amount of work is underway at research level, and with some individual treatment works on recovery of nutrients from sewage sludge. These are particularly linked to phosphorus, as complexes such as struvite, or in purified forms, but there are also methods to separate metals, such as iron from chemical P removal sludges, and to produce organic acids by fermentation to supplement biological nutrient removal plants.

It is likely that sludges will increasingly be required to meet more rigorous compositional standards to justify their use as fertilizer. A number of Member States have introduced stricter controls on sludge recycling to land than those required by Directive 86/278/EEC and this trend is likely to continue, in parallel with developments in sludge treatment process technology. This has however not been covered in detail country by country but will be further researched during the consultation. It can be noted that in general sewage sludge incineration occurs in large cities, but large cities do not always rely on incineration and some prefer recycling to land. However, as technology advances and population densities increase, a country may move toward more incineration for sludge management. This shift is advancing more quickly now, because of the current increases in costs of fossil fuel energy.

2.3.1 Regulatory framework

A summary of drivers that may affect the quality of sewage sludge is shown below with a judgement of the importance of each driver.

Driver	Consequence	Potential influence on use of sludge on land	Importance
EC Regulation 1907/2006 – REACH regulations	• Reduction in poorly degradable chemicals in sludge • Increased confidence in sludge composition; improved acceptability	Positive	Medium
EC Regulation 466/2001 – foodstuff contaminants limits, including cadmium to be as low as reasonably achievable	• Sludges that contain measurable trace metals may be increasingly difficult to use on agricultural land • Increased landbank required to manage metal rich sludges • Diversion of metal rich sludges to thermal processes or investment in metal removal processes	Negative – EU15 mostly low Cadmium contents; some high contents in individual EU12 countries	Low
Decision 2006/799/EC – eco-label requirements for soil improvers – sewage sludge not eligible	• Increased competition with alternate improvers that meet eco-label criteria • Sludge users not currently demanding additional quality standard • Reduces prospect of promoting sewage sludge as a beneficial product	Negative	Low – no significant demand for eco-label sludge
Decision 2007/64/EC – revised eco-label requirements for growing media – sewage sludge not eligible	• Sewage sludge not used currently to any significant extent as a growing media • Eliminates opportunity of promoting co-digested or co-composted materials	Negative	Low
Monitoring of organic contaminants in sewage and sewage sludges	• Public perception that sludges may contain substances with adverse effects on health drives unacceptability of agricultural use	Negative	Medium
Water Framework Directive 2000/60/EC – enhanced nutrient removal requirements	• Increased phosphorus concentrations, may be linked to increased metals • Increased production	Negative	Low

Local controls on pathogen content	• Improved public acceptability defends and increases available landbank • Enhanced treatment reduces nuisance and so defends available landbank • Enhanced treatment can improve energy efficiency • Operating costs to customers increase	Positive – apart from operating cost negative	High
Compost standards – PAS 100	• Need to improve definition and quality standards of sewage sludges to compete with alternate materials	Negative	Low

2.3.2 Potentially toxic elements, PTEs

It has been confirmed by several studies (Sede and Andersen 2002, Smith 2008) that since the mid 1980's concentrations of heavy metals in sewage sludge have steadily declined in the EU15 (illustrated by figures for France, Austria, Germany and the UK) due to regulatory controls on the use and discharge of dangerous substances, voluntary agreements and improved industrial practices; all measures that lead to the cessation or phasing out of discharges, emissions and losses of these PTEs into wastewater and the wider environment.

The extent of further reductions is unclear. There is probably a minimum for PTE concentrations in sludge determined by diffuse inputs of PTEs to the sewer, which are less easily controlled. The range of loadings may be significantly different between different areas of the EU (including the new Member States). Indeed, Smith (2008) has pointed out that there remains further scope to reduce the concentrations of problematic contaminants, and PTEs in particular, in sludge. He suggests that this should continue to be a priority and pursued proactively by environmental regulators and the water industry as improving the chemical quality of sludge as far as practicable is central to ensuring the long-term sustainability of recycling sewage sludge in agriculture.

Monitoring and research needs to continue to assess the significance of new developments (including PTEs of new interest, for example, tungsten) as they arise.

2.3.3 Organic contaminants

The presence of organic contaminants (OCs) in sludge has been increasingly considered and the list of potential contaminants that have been detected in sludge is now extensive and includes: products of incomplete combustion (polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and dioxins), solvents (e.g. chlorinated paraffins), flame retardants (e.g. polybrominated diphenyl ethers), plasticisers (e.g. phthalates), agricultural chemicals (e.g. pesticides), detergent residues (e.g. linear alkyl sulphonates, nonylphenol ethoxylates), pharmaceuticals and personal care products (e.g. antibiotics, endogenous and synthetic hormones, triclosan).

However, at present, only a few countries, such as France, Germany and Denmark, have set limits for some individual OCs in sludge, while others, such as UK, USA and Canada have not, citing that research suggests that concentration present in sludge are not hazardous to human health, the environment or soil quality. Agreement on which, if any, OCs should be regulated in Europe could be important when the Sludge Directive is considered for revision.

OCs are being increasingly monitored in both sewage treatment waters and sludge and environmental waters. Improving analytical methods mean that OCs can be detected at very low concentrations. This fact and new toxicological information on effects at low levels and possible synergistic effects of mixtures mean that the presence of OCs in sludge will be increasingly under scrutiny, although present research does not indicate a concern for human health.

Pharmaceuticals are one group of OCs being extensively monitored in the sewage treatment process. While they are normally present at extremely low levels, it is possible that rapidly increasing use of a drug in, for example, a pandemic flu epidemic, may lead to a high concentration at the sewage treatment works and its potential presence in sludge. This potential problem will need to be considered, preferably in advance of the problem occurring.

Other OCs which are continuing to cause concern as they are detected in environmental waters are endocrine disrupting chemicals, including natural and synthetic oestrogenic hormones, such as 17β-oestradiol and ethinyl oestradiol and much less potent industrial chemicals such as nonyl and octyl phenols and their ethoxylates, and phthalates. Oestrogenic substances do partition to particulates and may be associated with sludge. Better known OCs such as PAHS, dioxins, flame retardants and perfluorinated compounds (and their new alternatives as they are phased out) will continue to be studied while novel technology may lead to the emergence of new OCs or substances such as nanoparticles, which will require new methodology for the detection of their potential presence in sludge and assessment of their risk to human health, the environment and soil quality.

While concern over OCs in sludge will continue and probably increase as our ability to detect low levels and their effect also increases, it should be remembered that many potential contaminants are already controlled by legislation, such as the Water Framework Directive. Therefore, levels in sludge of these chemicals should already be decreasing. The new REACH regulations although not specifically concerning waste, will add to our knowledge of toxicity, use, exposure and disposal of a wide range of chemicals which can be of use in predicting potential presence in sludge. As this knowledge increases, emerging hazardous pollutants will also be controlled where necessary, although persistence in the environment may mean that it takes some time before concentrations in the environment are undetectable.

2.3.4 Nutrient value

The concentrations of nitrogen (N) and phosphorus (P) are the factors which determine the rate of application of sludge to the soil in most landspreading operations. This results from the need to comply with the Nitrates and Water Framework Directives (91/676/EEC and 2000/60/EC respectively). Changes in the N and P composition of sludge as a result of increasingly rigorous nutrient removal requirements from wastewater may become more significant. They are most likely to increase the P concentration of sludge. This may be linked to changes in the metal concentration of sludge if P-removal is carried out using metal salts (aluminium or iron).

2.3.5 Pathogens

The Sludge Directive provides no specific controls on pathogen content apart from the general requirement for treatment before use in agriculture. It permits implementation of local rules or codes of practice suitable for local conditions and circumstances. Treatment under the sludge directive requires biological, chemical or heat-treatment, long term storage and any other appropriate process to reduce fermentability and health hazards associated with its use.

Local controls which specify indicator pathogen limits in the sludge have been implemented in several of the EU15 countries. These have been driven by stakeholder demands (farmers, food retailers, public requirements). Associated with these developments have been demands to reduce nuisance, in particular, odour, and perceptions that aerosols may contain pathogens. To meet these requirements sludge producers have been installing new treatment processes that achieve more reliable and greater levels of pathogen destruction during treatment.

The installation of processes that recover greater fractions of the energy present in the sewage sludge is also a factor in the greater reduction of pathogens initially present in the sewage sludge.

There are no widely accepted newly present pathogens in sewage sludges. However, concerns are frequently raised regarding one or more pathogens that may be normally present, or present as a result of unusual levels of population infections.

It is likely that a combination of:

- Replacement and new sludge treatment equipment;
- Economic and environmental drivers that enhance energy recovery and efficient treatment;
- Public and agricultural products users pressure on producers;

will combine to continue to enhance the microbial quality of treated sludges, both in countries in which there are existing pathogen content controls and extend these to countries that have hitherto not had specific additional pathogen content controls.

Other materials are in competition with sewage sludge as beneficial fertilizers for agricultural use, including a variety of composted organic wastes. Increasingly these are also being made to standards, such as the UK PAS100 standard, that includes specifications for pathogens content in the compost.

Questions for consultation

If you disagree with our estimations and assumptions concerning your country please provide us with corrections and if possible explain the reasons, using the following supporting questions if they are applicable.

Q13 – In your country what are the most significant local restrictions on sewage sludge quality that affect the availability of land for sewage sludge recycling?

Q14 – What changes to local statutory or practice requirements do you expect up to 2020 (in terms of limits on quality, etc.)?

Q15 – To what extent do the current requirements in the EU sludge directive affect the availability of land for sludge recycling? To what extent are the requirements believed to be unsuited to current farming and public needs?

Q16 – In your country what changes to the concentrations of metals in sludges do you expect up to 2020?

Q17 – What changes to concentrations of the nutrients nitrogen and phosphorus do you expect up to 2020? Will changes to sewage effluent phosphorus concentration requirements affect the balance of nutrients in sewage sludge?

2.4 Sludge treatment requirements

There is a continual desire to reduce sludge volumes during treatment and intensify process operations balanced by cost implications.

2.4.1 Regulatory framework

Directive 86/278/EEC requires that sewage sludge be treated before it is used in agriculture (Member States may authorise the injection or working of untreated sludge in soil in certain conditions, including that human and animal health are not at risk). The Directive specifies that for sludge to be defined as treated it should have undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as to significantly reduce its fermentability and the health hazards associated with its use.

These overall requirements have been interpreted and implemented within individual Member States differently, in part based on specific local conditions and circumstances. In general, untreated sludge is no longer applied and where it is to be used on land, it is usually stabilised by mesophilic anaerobic digestion or aerobic digestion and then treated with polymers and mechanically dewatered using filter presses, vacuum filters or centrifuges. Other treatment processes for sludge going to land include long-term storage, conditioning with lime, thermal drying and composting.

A number of Member States have introduced stricter controls on sludge recycling to land than those required by Directive 86/278/EEC and this trend is likely to continue, in parallel with developments in sludge treatment process technology. For example, The Safe Sludge Matrix, agreed between the British Retail Consortium and the UK Water Companies, requires either conventionally treated or enhanced (or 'advanced') treated sludge be used on agricultural land. Conventional treatment requires that at least 99% of pathogens have been destroyed and enhanced treated sludge requires that it is free from *Salmonella* spp. and that there has been a 99.9999% reduction in *E.coli* as a surrogate for a range of other pathogens. Enhanced treatment processes produce residual sludges for recycling to land which are low in odour and sanitised. These advanced treatment sludges have the advantages that they cause much less odour nuisance during landspreading, and do introduce fewer pathogens into the agricultural environment – so public perception and acceptability problems are likely to be avoided.

A summary of drivers that may affect the quality of sewage sludge is shown below with a judgement of the importance of each driver.

Driver	Consequence	Potential influence on use of sludge on land	Importance
Directive 86/278/EEC – Sludge use on agriculture – requires treatment	• Sludge treatment methods must be installed and used	Positive; most sludge is already treated in most countries	Low
Proposed directive on promotion of renewable energy sources	• Would promote use of more efficient and complete energy recovery biogas production processes • May promote other sludge powered generation systems (thermal processes) •	Positive – treats sludge as a resource with value	Medium
Directive 2000/76/EC on incineration of waste	• Allows use of thermal processes when appropriate to meet publicly acceptable standards so maintaining range of treatment options	Positive	Low
Local use of HACCP procedures	• Enables claims of treatment quality standards to be defended • Identifies treatment critical points for efficient monitoring	Positive	Medium
Local rules on renewable energy obligations and uses	• Promotes treatment efficiency	Positive	Medium

2.2.4 Future treatment of sludge

It is likely that processes that provide enhanced pathogen removal will become more widely used, as they also commonly produce a sludge that is less fermentable and so less odorous and will attract less public concern or criticism. Processes that can reliably and cost-effectively demonstrate substantially reduced pathogen concentrations are likely to be more widely used.

Co-treatment of sewage sludge with a variety of other imported organic materials, particularly with reference to digestion processes, is currently not generally carried out, for reasons that include regulatory constraints. There are potential advantages of co-treatment in terms of asset utilisation (access to energy conversion systems, utilisation of existing infrastructure).

A considerable amount of work is underway at research level, and with some individual treatment works on recovery of nutrients from sewage sludge. These are particularly linked to phosphorus, as complexes such as struvite, or in purified forms, but there are also methods to separate metals, such as iron from chemical P removal sludges, and to produce organic acids by fermentation to supplement biological nutrient removal plants. It is likely that sludges will increasingly be required to meet more rigorous compositional standards to justify their use as fertilizer.

When updating plants operators have the following factors foremost:

- Reducing sludge solids quantity;
- Increasing energy recovery;
- Meeting current standards (current regulation AND any additional code of practices);
- Minimising operating costs;
- Capital cost minimisation is required by operators or financial regulators.

Treatment processes are listed below and described in more detailed in Annex 1.

Current	**Proven new processes or variants being used to replace or supplement existing processes**	**Novel**
MAD – Mesophilic anaerobic digestion TD – Thermal destruction (normally now with energy recovery) Lime addition for stabilisation or pasteurisation Compost Aerobic or Thermophilic aerobic digestion Landfill Drying	THP – Thermal Hydrolysis Process APD – Acid phase digestion processes Co-digestion or co-composting with non-sludge organic materials Wet oxidation (after digestion)	Pyrolysis Gasification (Both of the above already exist but few installations)

Questions for consultation

We have made estimations of current and future sludge management routes in individual countries, shown in Table 15 and Table 16 in Annex 2. If you disagree with our estimates, or our judgment of influences of treatment and management processes in your country, please correct them, and if possible explain the reasons, using the following supporting questions.

Q18 – What are the proportions of your sludges that are treated with the following main processes:

- Anaerobic digestion
- Advanced anaerobic digestion
- Drying
- Lime treatment

Q19 – What are the proportions of sludge converted or disposed of using:

- Incineration
- Landfill
- Other thermal processes (gasification, pyrolysis, wet oxidation)

2.5 Restrictions for application of sewage sludge on soil

2.5.1 Regulatory framework

A summary of drivers that may affect the use of sludge for agricultural and soil improvement purposes is shown below with a judgement of the importance of each driver in either promoting use or restricting use of sewage sludge.

The Nitrates Directive could be a significant restricting factor locally for the application of sewage sludge to land in regions where nitrates vulnerable zones have been identified and intensive animal production zones. The rules for organic farming could also have a negative impact on the proportion of sludge recycled to land as in most Member States – organic farming labels implicitly or specifically mean that no sewage sludge is allowed to be recycled to land.

The other drivers may have an impact but it has been estimated that it would be low negative.

We have, however, not carried out a detailed analysis of the effect of this impact at this stage. This aspect will need to be discussed during the consultation period.

According to the latest implementation report (CEC 2007), during the period 2000-2003, progress has been made in nitrate vulnerable zone designation. Seven out of fifteen Member States took the option in the Nitrates Directive not to identify specific nitrate vulnerable zones, but to establish and apply an action programme through the whole territory. In addition to Austria, Denmark, Finland, Germany, Luxemburg and the Netherlands, Ireland established a whole territory approach in March 2003. Other Member States increased, in several cases substantially, the nitrate vulnerable zones since 1999: United Kingdom (from 2,4% to 32,8% of the territory), Spain (from 5% to 11%), Italy (from 2% to 6%), Sweden (from 9% to 15%), Belgium (from 5,8% to 24%). Motivation for increased designation was not always provided.

Overall, in EU15, designation of nitrate vulnerable zones increased from 35.5% of the territory at the end of 1999 to 44% at the end of 2003. From 2003 onwards further designations were made, in Italy, Spain, Portugal and United Kingdom, Northern Ireland. Belgium has established the procedure to increase its designation to include 42% of Wallonia territory and all Flanders

Driver	**Consequence**	**Potential influence on use of sludge on land**	**Importance**
Directive 91/676/EEC – Nitrates Directive	• Nitrate vulnerable zones limiting fertilizer application • Good agricultural practice required with particular care in the zones • Sludge cake may be more beneficial as nitrogen in slow release form	Negative	Medium
Council Regulation (EC) No 834/2007 on organic production and labelling of organic products	• No clear ban on organic labelling of sewage sludge • Member state practices generally do not accept sewage sludge as organic	Negative	Medium
EC Decisions 2006/799 and 2007/64 on criteria for the award of a Community eco-label to growing media	• Growing media containing sludge shall not be awarded an eco-label	Negative	Low
Soil protection – proposal for amending Directive 2004/35/EC	• Impacts of sludge recycling to land to be evaluated	Negative	Low
Directive 2003/87/EC on greenhouse gas emissions	• Impact on ammonia production	Positive	Low
The effort sharing Decision	• Recovery of biogas from sludge treatment	Positive	Low
Directive 2006/118/EC – groundwater protection against pollution and groundwater quality standards	• Spreading of sludge requires local rules • In some areas may require change in farming or forestry practice	Negative	Low
Directive 2008/105/EC – EQS for pollutants to achieve good surface water quality	• Local rules may be required either to control pollutants in the sludge or to control sludge distribution and incorporation in soil • Undefined sludge composition in competition with defined inorganic fertilizers	Negative	Low

2.5.2 Future land use restrictions

As Member States increase their designation of vulnerable zones, land application of sewage sludge will be more restricted in terms of loading rate and land available for application.

Questions for consultation

If you disagree with our judgements on the effects of regulatory requirements on sewage sludge agricultural recycling in your country please correct them, and provide explanations using the following questions if they are applicable.

Q20 – What are the likely impacts of the Nitrates Directives on the current sludge recycling proportion in your country? By how much?

Q 21 – What local codes of practice or other restrictions related to land use have the greatest impact on sludge recycling to agricultural land in your country?

Q22 – What changes in land use are likely to affect sewage sludge recycling?

Q23 – Will the lack of eco-label qualities (including organic farming) affect the use of sewage sludge in your country? By how much? Would other standards improve desirability?

2.6 Monitoring and control requirements

2.6.1 Regulatory framework

The existing Directive imposes periods of prohibition between sludge spreading and grazing or harvesting. These vary according to the Member State (EC 2006). In Ireland, Spain, Luxembourg, the Netherlands, Portugal and the United Kingdom, the provisions of the Directive apply: that is, sludge must be spread at least three weeks before grazing or harvesting and on soil in which fruit and vegetable crops are growing, or at least ten months for soils where fruit and vegetable crops that are eaten raw are cultivated in direct contact with soil. In the other Member States the rules are generally stricter than those provided for by the Directive. Some Member States ban the application of sludge on forestry or land recreation areas.

Some Member States have published specific Code of Good Agricultural practices for land application of sludge and have also introduced quality assurance systems (for example, HACCP, Hazard Analysis and Critical Control Point management). HACCP applies risk management and control procedures to manage and reduce potential risks to human health and the environment from agricultural application of sludge. It is designed to provide assurance that specified microbiological requirements are met and that risk management and reduction combined with appropriate quality assurance procedures are in place, thus preventing the use on farmland of sludge that does not comply with the microbiological standards.

2.6.2 Future monitoring and controls

Although there is no regulatory requirements, the use of quality assurance systems will be generalised on a voluntary basis mainly though the pressure from the food industry.

Questions for consultation

Q24 – Are further restrictions needed on types of crops and or specific land areas (i.e. forest) or longer harvesting intervals?

Q25 - Should formal risk management methods be consistent throughout the EU?

2.7 Other factors which could influence sludge recycling to land

A number of other factors which could influence sludge management in the future need to be further evaluated including their risks and opportunities for the recycling outlet. This will require further discussion with the Stakeholders during the consultation period. Some areas of uncertainties are listed below:

- Treatment technologies - Developments in sludge treatment will continue and there may be a move towards enhanced treatment for sludge going to land so that the product to be recycled is effectively odour and pathogen free.
- Another possible change is the opportunity to co- treat sludge with other materials such as municipal solid waste
- Public perceptions - Although overall it is predicted that 50 % of sludge is likely to be recycled to land, there are uncertainties about the future sustainability of this outlet due to public opinion and the competition for land with other organic wastes.
- Mineral fertilizers – sewage sludge represents only a very small amount of total nutrients spread on land, of which mineral fertilizers provide the largest share. The future demand and supply of mineral fertilizers could thus influence the use of sewage sludge..

Factor	Potential risk	Potential opportunity	Degree of uncertainty	Influence on future changes on spreading sewage sludge on land
Public opinion	Widespread rejection of sewage sludge use	Wider acceptance of land spreading as effective recycling	No major changes expected; but future opinion is uncertain	National level: stricter requirements or bans possible NGO and public opposition Farmers acceptance of sludge
Scientific research	Could identify new health risks. Ambiguous results could be interpreted as health risks	Could provide stronger evidence for a lack of health risks	No major changes expected	National level: stricter requirements or bans possible NGO and public opposition
Sludge treatment technology	Could be expensive compared with other outlets for sludge. Lower level of nutrients	Greatly reduced levels of odour and pathogens	Level of developments Proportion of sludge being treated	On the one hand, improve public acceptance; on the other, lower nutrient value
Mineral fertilizer	A fall in fertilizer prices could lead to lower demand for sludge.	Possible shortage of natural resources and higher prices could increase demand for sludge. Added conditioning value with sludge	Future availability	On a local basis only not nationally

2.7.1 Competition with inorganic fertilizers

In coming decades, global fertilizer consumption is predicted to increase steadily (see Figure 8). In industrialised countries such as the EU15, FAO forecasts that consumption will rise by about 20% from the late 1990s to 2030. Elsewhere, consumption will increase even higher. World fertilizer demand has been increasing to meet global plant nutrient requirements driven by a combination of population changes, increased crop production, and development of biofuel crops (Heffer and Prudhomme, 2008). The increased consumption has also been reported with forecast increases in consumption by the EEA and shown in Figure 8.

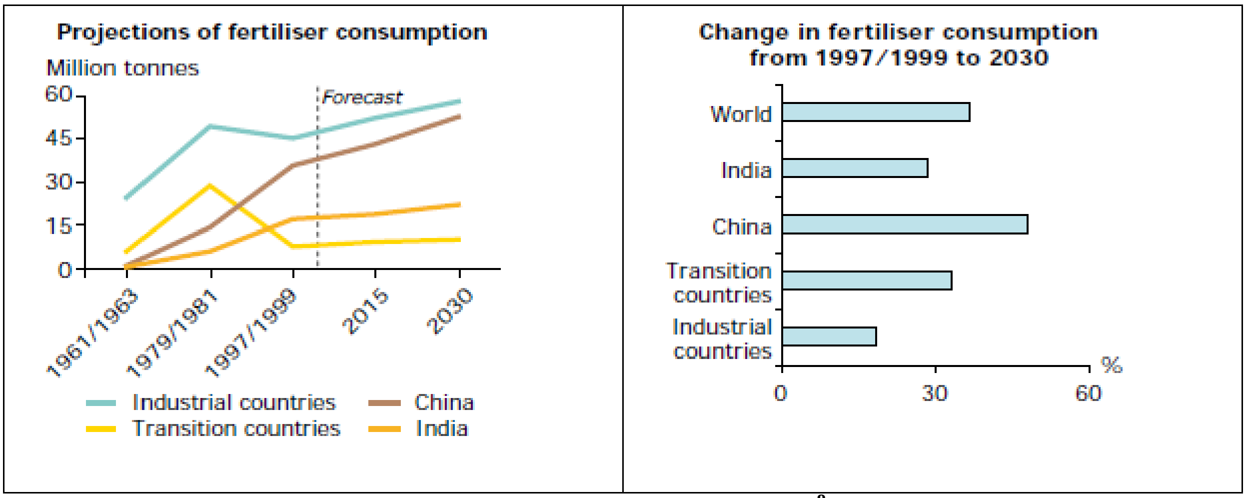

Figure 8 Forecast of world fertilizer requirements to 2030[8]

The increase in demand in the current decade has led to higher prices of the raw materials used in mineral fertilizers, as shown in Table 14. A possible shortage phosphate for use in fertilizer has been forecast for many years, and this could be a concern in the coming decade. Nonetheless, current forecasts of known extractable sources of phosphate rock indicate that at current rates of use reserves are available for almost three centuries.

More generally, the increased demand for fertilizer is now being matched by newly available supply, with further increases in supply of all components including phosphate expected from current extraction developments (Heffer & Prud'homme, 2008).

Table 14 Fertilizer component costs at source

	$/tonne	$/tonne
	2004	Jul 2007
Sulphur	60	110
MOP (Potassium brine)	110	200
NH_3 (ammonia)	250	240
Urea	150	270
DAP (Di ammonium Phosphate)	310	420

While sewage sludge – due to the much smaller volumes – cannot be regarded as a significant alternative source of fertilizer components, a shortage of fertilizer would likely lead to higher demand

[8] http://www.eea.europa.eu/publications/technical_report_2008_8

for alternatives, including sewage sludge. Moreover, sludge may be a valuable alternative or supplemental source with its particular properties of soil conditioning and long release fertilizer components which may be particularly valuable in areas sensitive to high nitrate or phosphate loading. Whilst inorganic fertilizers remain available increases in transport and energy costs may make locally available sewage sludge a more desirable source of fertility.

Questions for consultation

If you disagree with our judgements of influences or effects of factors that include public opinion, financial pressures or materials availability, please correct them and provide explanations where possible using the following questions.

Q26 – Is sewage sludge likely to be used as a replacement for inorganic fertilizers? To what degree is the use of sewage sludge influenced by the market for inorganic fertilizers? Are the qualities of sewage sludge as a replacement for inorganic fertilizers sufficiently well understood to increase the demand for sewage sludge recycling onto agricultural land?

Q27 – How will public opinion in Member States that currently send high levels of sludge to landfills (e.g. EU12) react to greater use of sewage sludge on land?

Q28 – Will the co-treatment of sludge with municipal solid waste become an important path for the future?

References

ACONSULT (2007). Guide pratique pour les collectivités locales. Le Maire et les boues d'epuration. AMF. http://www.amf.asso.fr/documents/document.asp?ID_DOC=8153

ALABASTER AND LEBLANC (2008), *UN- Habitat and Greater Moncton Sewerage Commission in collaboration with the IWA*, Global Atlas of Excreta, Wastewater Sludge, and Biosolids Management. ISBN 9789211320091, p344 & p550.

BENDERE, R (2008) Approaches for organic waste management in Latvia and the role of Regional Waste Management Centers. Presented at the 2nd Baltic Conference on implementation of organic waste management in the Baltic States. Available at http://www.lasa.lv/2008/0804/080429_12_bendere.pdf

CEC (2006) Report from the Commission to the council and the European Parliament on implementation of the community waste legislation (Directive 75/442/EEC on waste: Directive 91/689/EEC on hazardous waste, Directive 75/439/EEC on waste oils, Directive 86/278/EEC on sewage sludge, Directive 94/62/EC on packaging and packaging waste and Directive 1999/31/EC on the landfill of waste FOR THE PERIOD 2001-2003. SEC(2006)972. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0406:FIN:EN:PDF

CEC (2007) 4th Commission Report (Executive Summary) on Implementation of the Urban Waste water Treatment Directive. Commission Staff Working Document. Annex to the Communication from the commission to the European Parliament and the Council. (COM (2007) 128 final) (SEC (2007) 362).

CEC (2008) Demographic Trends, Socio-economic Impacts and Policy Implications in the European Union – 2007.

CEPELE, A. (2008) Biodegradable waste management in Lithuania. Legislation and implementation. Presented at the 2nd Baltic Conference on implementation of organic waste management in the Baltic States. Available at http://biowaste.info/bbc/download/04_Cepele.pdf

CIUDARIENE D (2007). Sludge treatment management scheme. Presented on 28 November 2007 in Oslo. Available at http://www.innovationnorway.no/Internasjonalisering_fs/Utekontorer/ReNEW/Lithuania.pdf

CRAC, L. (200?) Waste management in Romania – scenario. Entrance data for the assessment of costs.

DEFRA (2002) Department for Environment, Food and Rural Affairs. Sewage Treatment in the UK UK Implementation of the EC Urban Waste Water Treatment Directive. Available at http://www.defra.gov.uk/environment/water/quality/uwwtd/report02/pdf/uwwtreport2.pdf

DGRNE (2005) Direction Générale des Ressources Naturelles et de l'Environnement. Environmental Dashboard 2005 of the Walloon Region (Belgium) Water. Available at http://www.google.co.uk/search?hl=en&q=wallonia+dashboard+sludge&meta=

Doujak K. (2007) Sewage sludge – waste from waste water treatment. Presentation on 12.11.2007. Available at

EEA (2005) Effectiveness of urban wastewater treatment policies in selected countries: an EEA pilot study. EEA report No 2/2005.

EEA (2008) Catalogue of forward-looking indicators from selected sources. A contribution to the forward-looking component of a shared environmental information system (SEIS?Forward) EEA Technical report no 8/2008.

EEA (2009). CSI 029 Urban waste water treatment – Assessment published 2009. http://themes.eea.europa.eu/IMS/IMS/ISpecs/ISpecification20041007132045/IAssessment1196343193294/view_content.

EPA (2005) Environmental Protection Agency. Urban Waste Water Discharges in Ireland for Population Equivalents Greater than 500 Persons. A Report for the Years 2004 and 2005. available at
http://www.epa.ie/downloads/pubs/water/wastewater/UWWT_Report_2004_2005.pdf

Eurostat (2009) Population projections - http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tps00002

GHK (2006) Strategic Evaluation on Environmenta dn Risk Prevention under Structural and Cohesion Funds for the period 2007-2013. National evaluation report for Latvia.

Heffer P & Prud'homme M (2008) Medium term outlook for Global Fertilizer Demand, Supply and Trade 2008 – 2012. 76th IFA Annual Conference, Vienna. In www.fertilizer.org

HULTMAN, Bengt (1999) Trends in Swedish Sludge Handling. *Proceedings of a Polish-Swedish seminar, KTH, August 24, 1999*. Sustainable Municipal Sludge And Solid Waste Handling, E. Plaza, E. Levlin, B. Hultman, (Editors), TRITA-AMI REPORT 3063, ISSN 1400-1306, ISRN KTH/AMI/REPORT 3063-SE, ISBN 91-7170-439-6, 1999

IRGT (2005) Institut Royal pour la Gestion durable des Ressources naturelles et la Promotion des Technologies propres. Gestion des Boues en Belgique. Etat des Lieux. Arriéré du passé et defies environnementaux.

JENSEN, J () Ecotoxicological effect assessment and risk characterisation of selected contaminants in sewage sludge. PhD Thesis for the Danish university of pharmaceutical sciences. Department of analytical chemistry.

KARAMANOS, A.;. AGGELIDES, S. and LONDRA, P. (2004) NON-CONVENTIONAL WATER USE IN GREECE. Presentation in Cairo 6-11 December 2004

KATHIJOTES N. (2004) Reclamation of disturbed Asbestos Mine in Cyprus using Wastewater Sludge for Soil Enrichment. Proceedings of International Scientific Conference UNITECH '04 Technical University of Gabrovo, Nov 2004 Gabrovo, BG.

LEONARD (2009) Making the most of wastewater purification sludge. Presented at the workshop organised by Université de Liège on 6 April 2009.

MAYR, B. and Zugman, J. (2005). Treatment of communal sewage sludge. Presentation at the conference on Biological treatment of waste, 22. 09. 2005, Ljubljana, Slovenia. Available at http://www.envicare.at/cro/files/Vortrag-2005-09-22.pdf

MEDVED, M. (2006) Final disposal of sewage sludge in Slovenia, Presented at EREF 2006. Building Knowledge Society through Regional innovation support.

Mesimeris (2004) and Sludge utilisation and handling in Cyprus. Slide presentation. http://www.ymparisto.fi/download.asp?contentid=80492

MOEW (2003) Ministry of Environment and Water of Bugaria. Programme for implementation of Directive 91/272/EC for treatment of urban wastewaters.

ONR (National Observatory on Wastes) (2006). Il sistema integrato di gestione dei rifiuti in Italia: trasformazioni e tendenze" (The integrated system of waste management in Italy: transformations and trends). ONR Report 2006, Part 1, Rome (in Italian). (www. osservatorionazionalerifiuti.it/RapRif2006.asp).

PRZEWROCKI P ET AL (2004) Risk Analysis of Sewage Sludge – Poland and EU

SEDE AND ARTHUR ANDERSEN (2002) *Disposal and Recycling Routes for Sewage Sludge*, European Commission, DG Environment – B2, 2002. Available at: http://ec.europa.eu/environment/waste/sludge/sludge_disposal.htm

SMITH, S.R. (2008), *The implications for human health and the environment of recycling biosolids on agricultural land*. Imperial College London Centre for Environmental Control and Waste Management. http:/www3.imperial.ac.uk/ewre

SPINOSA (2007) Waste water sludge: a global overview of the current status and future prospects. Prepared for the Water21 Market Briefing Series in collaboration with the International Water Association's Specialist Group on Sludge Management..

TAKAC, P. ET AL (2008). Possibilities of sewage sludge application in the conditions of Slovak republic. In Proceedings of World Academy of Science, Engineering and Technology, vol 34. October 2008.

TOTH, I. (2008) Budapest sludge management case study. Slide Presentation on 22-23 June 2008. Available at http://www.eau-seine-normandie.fr/fileadmin/mediatheque/Votre_agence_de_leau/International/Atelier_assainissement/presentation_atelier3/presentation_Budapest.pdf

TWARDOWSKA, I. (2006) Sewage sludge and sustainable development – general problems and specific issues in accession countries exemplified in Poland and in the EU Member States. Slide presentation available at http://viso.ei.jrc.it/pecosludge2003/Twardowska%20(Poland).pps

UBA (2009) . Umwelt Bundesamt. Technical report on UWWTD-2007. Lenz K, Nagy, M. and Zieritz I. Available at http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/treatment_directive/uwwtd_reporting_11-12&vm=detailed&sb=Title

UK PAS100 compost standard -
http://www.wrap.org.uk/downloads/Introduction_to_BSI_PAS_100-20052.d45a2757.2181.pdf

UNDP/GEF (2004) Assessment and Development of Municipal Water and Wastewater Tariffs and effluent Charges in the Danube River Basin. Vol. 2 Bulgaria.

VUDADIN and Podakar (2007) Sewage sludge from urban waste water treatment plants. Environmental indicators in Slovenia. http://kazalci.arso.gov.si/

ZABANIOTOU A. and THEOFILOU C. (2008) Green energy at cement kiln in Cyprus : Use of sewage sludge as a conventional fuel substitute. Renewable & sustainable energy review. **ISSN** 1364-0321, vol. 12, n°2, pp. 531-541.

Annex 1 Sludge Treatment processes

Mesophilic Anaerobic Digestion (MAD) is a well established process for treating sewage sludge that operates in the mesophilic temperature range (30 – 38°C). The organic matter that can be converted to biogas within the sludge, referred to as volatile solids, is metabolised microbially, typically over a period of 12-15 days. The volatile solids are first broken down by acid-producing (acidogenic) bacteria and produce smaller, volatile fatty acids (VFA) compounds, which can then be used by methane-producing (methanogenic) bacteria to produce biogas.

In conventional MAD approximately 40-45% of the volatile solids can be converted to biogas. Biogas is approximately 65% methane (CH_4) and 35% carbon dioxide (CO_2) and will typically be burnt in a CHP engine to generate electricity and heat, a portion of which will be used to maintain the optimum temperature in the MAD. Conventional MAD may not always destroy pathogens to the required level and therefore a pasteurisation step is sometimes incorporated.

Acid Phase Digestion (APD) is a variation of the MAD process. Instead of the one reactor in a conventional MAD plant, APD uses two or more reactors, whereby the acidogenic phase and the methanogenic phase are separated. In the first reactor a large amount of volatile solids are added and the pH drops over 3-4 days as VFAs are produced. This material is then fed to the main digester where the methanogenic process occurs, producing biogas. In APD it has been estimated that 53% of the volatile solids is converted to biogas. Therefore, more biogas is produced in APD compared to a conventional MAD. The low pH of the acid stage leads to an increased destruction of pathogenic organisms.

The Thermal Hydrolysis Process (THP) is also a two stage process. In the first stage the sludge is treated in a reactor by injecting steam at high temperature (150°C – 170°C) and pressure (5 - 7 bar) for approximately 30 minutes. This essentially 'pressure cooks' the sludge, solubilising more of the organic material and making it easier to digest. It will also destroy pathogens. In the second stage, this residue is fed to an anaerobic digester where approximately 60% of the volatile solids can be converted to biogas. Therefore, more biogas is produced by THP than by either conventional MAD or APD. An additional benefit of THP is that higher concentrations of volatile solids can be added to a digester, meaning that a higher throughput of sludge is possible for a given volume of digester. Retrospectively fitting THP to a MAD plant can therefore increase the capacity of the plant.

The Wet Oxidation Process for sewage sludge involves the injection of air, or oxygen, into sewage sludge at high temperature and pressure. It was first used for sludge in the 1960's but has not been widely installed for sludge treatment. It has some similarity to incineration in terms of the completeness of the conversion, but with a reduced risk of production of substances such as dioxins, furans, nitrogen oxides and dusts that could or are present in incinerator off-gases. The process has chiefly been used previously for strong and poorly degradable industrial effluents, with a reputation for being highly corrosive to equipment. The Athos® process (Veolia) uses conditions of 250°C temperature and 50 Bar pressure, injects pure oxygen and uses a copper sulphate catalyst, to achieve 85% COD removal, a residual solid that dewaters readily to 55% dry solids, and a liquid effluent rich in acetic acid that can be used to drive a biological phosphorus removal plant. Recently installed processes in France, Belgium and Italy treat sludge after anaerobic digestion to reduce the oxygen and energy demands,

Brief description of pyrolysis and gasification

Pyrolysis is the heating of a substrate such as coal, wood or sewage sludge at around 500°C. This drives off hydrocarbon vapours which on cooling produce a mixture of tar, oil and permanent gases. The residue left after pyrolysis is termed a char – coke and charcoal being examples. The char contains the ash that would be produced by incineration, together with non-volatile carbon compounds. It should be assumed that the environmental impact from char is greater than that of incinerator ash.

Gasification involves heating the substrate to 800°C or higher, sometimes with added steam. This enables the water gas or syngas reaction to take place, which produces a mixture of carbon monoxide and hydrogen. In principle this reaction can proceed to completion, leaving behind a mineral ash essentially the same as incinerator ash, though in practice it may retain some of the characteristics of a char.

The high temperatures are often obtained by introducing a limited supply of air, allowing combustion of part of the substrate. This will introduce CO_2 into the gas, reducing its calorific value. As sludge is heated up to gasification temperatures, a certain amount of pyrolysis will always take place. In practice there are a large number of process configurations which can be geared towards producing oil, hydrocarbon gas or syngas and which may produce char or ash as a solid residue. Sometimes the char is incinerated. In general, these processes have not been developed at any significant scale for sewage sludge, except for one large scale oil from sludge plant in Perth, Western Australia. Pyrolysis/gasification cannot yet be considered to be a developed process for sewage sludge.

Incineration or complete gasification with combustion of the gas both liberate essentially the same amounts of energy. Fluidised bed incinerators, however, require substantial amounts of electricity to run. While sludge gasifiers are at a much earlier stage of development, it is believed they will require much less energy to operate than an incinerator. As a result, the net electricity production from gasification should be considerably greater than from incineration.

Annex 2 – Country files

Reviews of individual EU countries are presented, with summary tables of annual sludge production and percentages to different disposal routes shown as Table 15 (1995 – 2005) and Table 16 (2010 – 2020).

Austria

The following description is based on information provided by Kroiss for the latest version Global Atlas (Alabaster and LeBlanc, 2008) and a presentation given by Doujak in 2007.

In 2005, there were about 1500 municipal treatment plants in Austria with a treatment capacity of 18.6 million capita. Approximately 90% of the population was connected to a municipal treatment plant while 10% had in-house treatment plants (for example, septic tanks, cesspits).

The annual sludge generating rate is reported to vary between 11 to 32 kg DS per capita per year. In 2005, municipal sewage sludge production in Austria amounted to 266,100 tds including 28,000 tds of imported sludge; 47% was incinerated; 18% was recycled to agriculture, 1% sent to landfill and 34% disposed by other routes such as composting (77%); landscaping (12.3%), intermediate storage (2.4%) and unspecified.

It is expected that, by 2010, the connection rate will increase to 92% and annual sludge production will rise to 273,000 tds and that, by 2015, the connection rate will rise to 94% and sludge production is expected to have reached 280,000 tds pa. By 2020 the sludge production will stay at this level as 100% connection is not expected.

Region	**Sludge production (tds/y)**	**Agriculture**	**Incineration**	**Landfill**	**Other (inc. composting, landscaping, intermediate storage and unknown)**
Burgenland	10,700	5650	110		4910
Kärnten	11,800	830	2560		8410
Niederösterreich	41,000	13410	5690		21900
Oberöstereich	44,200	17550	23810		2810
Salsburg	12,800	1950	8320		2560
Steiermak	25,900	5430	4930	2850	12710
Tyrol	16,400	170	2460	990	12810
Voralberg	10,400	2200			8180
Vienna	64,900		62780		2160
Imports	28,000		12800		15200
Total	**266,100**	**47,190 (18%)**	**123,460 (47%)**	**3,840 (1%)**	**91,650 (34%)**

In addition, there was also 155,000 tds of sewage sludge from industries (mainly cellulose and paper industry) being produced in 2005, which was mainly incinerated (83%) or sent to landfill (13%), with 3% recycled to agriculture and 1% to other outlets.

Based on predictions presented by Doujak, for our baseline scenario, we have assumed that by 2020 in Austria, the proportion of municipal sewage sludge recycled to agriculture will decrease to 5% and that about 10% will be treated in MBT plants (mainly composted) to be recycled to land reclamation projects and that about 85% will be thermally treated (by either incineration and/or co-incineration). In addition, sludge from industries will be entirely thermally treated (100%).

The development of sludge disposal routes in Austria is strongly influenced by the regional regulatory framework for sludge and waste management.

There are stringent restrictions on the application of sewage sludge and compost on agricultural land specified in the regulations. These requirements vary according to the federal state: two of the 9 federal states have, for example, banned sewage sludge application in agriculture. Where it is allowed, sludge has to be treated and at least dewatered. At the treatment works, up to a half-year storage capacity is necessary to fulfil the requirement that sludge must not be applied during late autumn and winter. Direct application of sewage sludge on grass land has little relevance today in Austria. The use of sludge on forestry in Austria is forbidden by law.

There are additional restrictions imposed on the use of sewage sludge and compost in agriculture due to product quality requirements for different markets (for example, organic farming, eco-labelling, and retailer requirements).

As the legal prescriptions and the restrictions for use of sludge and compost for land reclamation or landscaping are much less stringent; an increasing part of sewage sludge, mainly after composting, is used for this purpose especially where the agricultural reuse is no longer accepted.

In recent years, there has been an increase of sludge-drying facilities with different processes (drum dryers, solar drying) to reduce storage volume and transport load. On a national scale this method still has low relevance. There is also an increase of adding other organic wastes into anaerobic sludge digestion to increase biogas production. Mechanical Biological Treatment plants (MBT) have been proposed as a suitable option for sewage sludge composting in combination with other organic materials.

While in the past 11% of sewage sludge was sent to landfill for disposal, since 2004, only material meeting the following criteria is permitted in landfill disposal:

- Less than 5 % TOC related to total dry solids
- Less than 6000 MJ/kg dry solids.

These criteria cannot be met by conventional sludge treatment and stabilization processes; only the ashes after incineration meet the requirements which means that sludge disposal on landfill sites is effectively banned and has no major role in Austria.

During the last 10 years, waste incineration capacity in Austria has increased. The overall capacity is still dominated by fluidized bed incineration plant on the site of the Vienna Main Treatment Plant where about 25% of the total sewage sludge production in Austria is incinerated. For the remaining, sludge is mainly co-incinerated with other wastes in coal-fired power plants and cement kilns.

The current debate in Austria on sludge disposal is dominated by soil and food protection from potentially hazardous organic micro-pollutants and sustainable phosphorus management.

In Austria there is general requirement for treatment plants > 1000 pe for P-removal which results in a ~80 to 85% transfer of P from waste water to sewage sludge. It has been estimated that the P-load in sewage sludge could replace up to ~40% of P-market fertilizer imports to Austria.

There are two clear options in the debate on sludge disposal. The first favours incineration as organic pollutants are destroyed. The second favours sludge application in agriculture as this is the least-cost solution for recycling phosphorus and favours mono-incineration of sewage sludge with P-recovery from the ashes. It does not favour co-incineration with cement coal and wastes as it interferes with P-recovery.

Under waste legislation, energy recovery from sewage sludge has a lower priority compared to nutrient and organic material recycling. But as the political discussion on sludge treatment and disposal is increasingly focussing on possible risks for soil and food due to application of sewage sludge that may contain organic micro-pollutants, public acceptance of incineration is increasing.

Belgium

The situation in Belgium has to be described separately for the 3 regions. The description below is based on information provided by DGRNE 2005, IRGT 2005 and from a presentation given by Leonard in 2008.

Wallonia

Since 2000, a public water management company (SPGE) has been coordinating and financing wastewater treatment in Wallonia. While in 1999, only 38% of wastewater could be treated in Wallonia, at the end of 2004, 137 UWWT plants with capacity of 2,000 p.e. or more were in service with a total treatment capacity of 2,500,000 pe or about 60% of the 2005 UWWT target (i.e. 4,215,775 pe). An additional (700,000 pe + 483,000 pe.) treatment capacity was constructed and had been commissioned, respectively, thus leaving about 11 % short of the target to be met. By 2007, treatment capacity had increased to 88 % of population, compared with 60% in 2005 and 38% in 1999. Treatment capacity is reported to be over scaled by 20% to allow for population and industrial growth. From 3,413,978 inhabitants in 2006, population is expected to grow up to 3,450,555 by 2011 and to 3,551,351 inhabitants by 2020.

About 80% of the population are located in agglomerations above 2,000 pe, about 9% are in agglomerations less than 2,000 pe with both connected to sewer while about 12% of the population (400,000 inhabitants) live in areas without municipal sewer and need to install an individual wastewater treatment system.

The whole territory has been designated as sensitive area which means that all the plants with a capacity of more than 10,000 pe have to have been equipped with tertiary treatment by 2008 at the latest. Ninety percent of the 137 plants in 2004 were small or medium-sized (less than 10,000 pe). Most treatment plants had secondary treatment and only 33 plants with a capacity above 10,000 pe had tertiary treatment.

From the latest figures submitted to the Commission, sludge production amounted to 18, 514 tds in 2001, 20,300 tds in 2002 and 23,520 tds in 2003. By 2005, sludge production was estimated to 30,000 tds and it is expected that by 2010, when Wallonia will have completed investment for the UWWT Directive, IRGT (2005) and Leonard (2008) estimated that sludge production will rise to 45,000 tds which is lower than our estimate of 80,000 tds based on 25kg per capita, 3.5 M inhabitants and 88% connection. For our baseline scenario, we have assumed that it will stay at that level until 2020 as population growth and industry expansion is expected to be limited.

In Wallonia, recycling to agriculture has traditionally been the preferred option although the proportions have decreased over the last 10 years from more than 70% in 1995, 88% in 1998, 65% in 2000 to about 50% in 2002 and 2003. It was reported by Leonard that, in 2006, about 32% was still recycled to agriculture. Quantities sent to landfill have first increased from 18% in 1998 to 45% in 1999, 34% in 2000 and 37% in 2001 but would only be around 5% in 2006. Proportions of sludge sent to MSW incinerators have dramatically increased since 1999 from 2% to more than 60% in 2006. The agriculture outlet should continue to play an important role in sludge management despite some fear and opposition from the population.

For our baseline scenario we have assumed that the proportion of sludge recycled to land will remain at the current level for the next 15 years, i.e. 30-35%.

Leonard reported the growing interest in drying facilities and methods to improve dewatering of sludge.

Flemish region

In the Flemish Region, in 1990, approximately 78 % of the wastewater from households was collected in sewer systems, but only 30 % was treated in a wastewater treatment plant. In 2002 the collection and treatment rates increased respectively up to 86% and 60%. By the end of 2005, treatment levels amounted to 64.4% (VMM, 2006) and by 2007 this figure was expected to have reached 80%.

From the figures submitted to the Commission, sludge production amounted to 81,351 tds in 2001, 82,871 tds in 2002 and 76,072 tds in 2003 (CEC 2006). From the latest reports (CEC 2009, personal communication), sludge production was reported to amount to 87,382 tds in 2004, 76,254 tds in 2005 with no figure available for 2006. According to IRGT (2005), it is expected that by 2010, when Flanders should have completed investment for the UWWT Directive, sludge quantities will increase by 43% compared with the 2002 figure amounting to about 118.000 tds which is lower than our estimates of 135,000 tds based on 25kg per capita, 6.1 M inhabitants and 88% connection.

Due to more stringent restrictions on PTEs, quantities of sludge recycled to agriculture have decreased sharply since 1998 from 22% down to 7% in 1999, 0% in 2000/2001, 2 % in 2002 and 3% in 2006. Quantities sent to landfill have also decreased steadily since 1998 from 35% down to 3 % in 2002 while quantities sent to incineration have risen steadily since 1998 from 43% to 95 % in 2002. For our baseline scenario we have assumed that there will be no longer any sludge recycled to agriculture in 2010 and in 2020 and that all sludge will be thermally treated.

Brussel region

In the Brussels region, it is currently estimated that 90% of inhabitants are connected to the sewage system. It is expected that, by the year 2015, 100% of inhabitants will be connected. The first (and only) wastewater treatment plant with a capacity of 360,000 pe started operation in 2000. The second UWWT plant with a capacity of 1.1 M pe started operating in 2008. Since 2009, sewage sludge is treated by thermal hydrolysis/anaerobic digestion followed by wet oxidation reducing sludge quantities by 99% and the final product will sent to landfill or used in construction materials.

Following the implementation of the UWWT Directive, sludge quantities are expected to increase by 300% by 2010 compared with 2002 figure of 2,792 tds. However with the wet oxidation treatment applied, the final quantities should not increase dramatically. In 2002, sludge produced at the first works was recycled to land (32%), sent to landfill (66%) and incinerated (2%). For our baseline scenario we have assumed that there will be no longer any sludge recycled to agriculture by 2010 but sludge will be treated by wet oxidation and disposed of for other uses and that the situation will not change by 2020.

Bulgaria

The following description is based on information provided by Paskalev for the latest version Global Atlas (Alabaster and LeBlanc, 2008) and various other reports including MoEW 2003 and UNDP/GEF Danube Project 2004.

Bulgaria joined the EU only recently (January 2007) and has been granted an extended deadline until December 2014 to comply with the UWWT Directive.

The population in Bulgaria was around 8.1 M in 2000 and decreased to 7.8 M in 2002. The forecast is for continued decline: from 7,785,091 inhabitants in 2003 to 7,323,708 inhabitants in 2014 that is a 6% decrease of population (MoEW, 2003).

The transition period for implementing the Directive 91/271/EC in Bulgaria is as follows:

- By 1 January 2011 - construction of sewerage systems and WWTPs for settlements with more than 10000 pe;
- By 1 January 2015 - construction of sewerage systems and WWTPs for settlements with 2000-10000 pe.

In 2002, the proportion of population served by public sewer network and wastewater treatment was 68.4% and 38.6%, respectively. The number of WWTPs was 55, of which 43 plants had biological treatment while the remaining had only mechanical treatment. The total length of the network is around 9,000 km and is in poor condition and needs to be upgraded. The Government plans to build an additional 16,000 km of sewers to connect 2.4 million people as part of the plan to meet the EU directives. The plans of the Government are to treat wastewater generated by 85% of the population.

In 2002, about 500Mm^3 of urban wastewater was discharged annually into sewer; 21.7% is untreated, 2.5% is treated by primary treatment and 75.8% is treated by secondary biological treatment. In addition, 64Mm^3 is not collected. The existing WWTPs with biological treatment were under utilised by 44%.

About 1,000 new urban wastewater treatment plants are planned between 2003 and 2015 in Bulgaria for agglomerations with populations over 2,000 pe (MoEW 2003 reported by UNDP/GEF 2004).

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
New WWTPs >10,000 pe:	1	2	7	22	43	53	48	33	0	0	0	0	209
New WWTPs for 2,000-10,000 pe;	0	0	0	0	0	19	87	129	177	196	154	87	849
WWTP for completion	6	8	7	9	8	5	2	2	0	0	0	0	47
WWTPs for reconstruction and modernisation	6	16	18	29	30	32	20	23	4	2	0	0	180

Sludge production was reported to amount to 31,300 tds in 2004, 33,700 tds in 2005 and 30,000 tds in 2006 for a population of 7.5 million (CEC 2009, personal communication). Based on the above table, by the end of 2010, Bulgaria is expected to have completed 50% of construction of new WWT plants (mainly above 10,000 pe) and to have upgraded existing plants; and thus sludge production is expected to increase by 50% compared with 2004, amounting to around 47,000 tds. By 2020, compliance should be achieved and sludge production has been estimated to reach 151,000 tds (85% of 7.1 M * 25 kg/capita and per year).

In Bulgaria, there is a National Plan for sewage sludge. The Plan recommends development of a programme for recycling of sewage sludge in agriculture and forestry, as well as in land reclamation projects. The Plan requires that sludge be, at least, mechanically dewatered for WWTPs with more than 10,000 pe; and treated by anaerobic digestion for WWTPs with more than 150,000 pe. It is also planned to incinerate sludge in fluidized bed furnace units for WWTPs with more than 500,000 pe.

In Bulgaria, the majority of sludge is currently sent to landfill after stabilization. The most common method of stabilization of sludge from a treatment plant of this size (100,000 pe) is mesophilic anaerobic digestion, while aerobic digestion is rarely used. Recent practice for landfilling is to partition special cells for sludge at the landfills.

There is currently no incineration plant for municipal sewage sludge in Bulgaria. A project for incineration of waste produced in Sofia is under development. This could potentially also handle sewage sludge.

Although there was no experience of recycling sludge on land in Bulgaria in 2006, 40% of sludge was reported to be used in agriculture. There have been only a few cases of sludge recycling in land reclamation and it is considered in Sludge Management Plans. There are no special regulations for the use of sludge in land reclamation and there are other possibilities of reuse on non-agricultural land.

For our baseline scenario, we have assumed that in Bulgaria, by 2010, the current outlets for sludge will be the same as in 2006 but that recycling to agriculture will increase together with recycling to land reclamation; with the combination reaching around 80 % by the year 2020. Disposal of sludge to landfill will decrease to below 10% by 2020 and incineration and co-incineration will increase to about 10% by 2020.

Cyprus

The following description is mainly based on information provided from different presentations by Mesimeris in 2004 and Pantelis in 2005 both from the Ministry of Agriculture, National Resources and Environment (MANRE).

Cyprus joined the EU in May 2004 and has been granted an extended period until 2012 for full implementation of the requirements of the UWWT Directive. In 2005, the total load for rural and urban agglomerations was estimated at 675,000 pe (545,000 pe+130,000 pe, respectively). In 2005, overall 73% of urban agglomerations and only 9% of rural agglomerations were in compliance. However, it is expected that by 2012 Cyprus would have completed its implementation programme for wastewater connection and treatment. In 2007, wastewater treatment plants were in operation for the 4 largest agglomerations on the coast of Cyprus. Treated effluent is almost entirely reused for irrigation. There is no discharge of untreated wastewater (municipal or industrial) to the sea. Two of these treatment plants, e.g. the Limassol/ Amathousa STP and the Larnaca STP, periodically discharge tertiary treated effluent to the sea during the winter months. Two sensitive areas have been designated.

It was reported that previous to 2004, no data were available on sludge production and disposal routes but that only limited quantities were recycled to agriculture. The quantities produced and recycled to land reported to the Commission for 2004-2006 (CEC 2006) are presented below:

Year	Total production Tds/annum	Agriculture Tds/annum	%
2004	4,735	3,134	66%
2005	6,542	3,427	52%
2006	7,586	3,116	41%

The future sludge production estimated by Pantelis (2005) in Cyprus is presented in table below and will amount to about 9,000 tds. This gives a sludge production rate per pe of 24 kg pe per annum. For our baseline scenario, we have assumed that by 2010, the future sludge production will be similar to the figure reported in table below and that by 2020, sludge production will have increased to 16,000 tds when all effluent will be treated (24 kg/pe* 675,000 pe).

WWTP	Design capacity (pe)	Future sludge production (tds/y)
Vathia Gonia (1)	56,000	1,200
Limassol	76,000	1,600
Nicosia	150,000	3,000
Larnaca	32,000	700
Agia Napa/ Paralimni	54,000	1,100
Paphos	63,000	1,300
Total	377,000	8,900

Notes:
1) include imported sludge from smaller works

Some studies have considered alternative disposal outlets for sewage sludge such as an alternative fuel at cement kilns. Trials have started in Vassiliko Cement Plant (Cyprus) (Zabaniotou and Theofilou, 2008). Also reclamation of disturbed mine land with sewage sludge has been investigated (Kathijotes, 2004).

Czech Republic

The following description is based on information provided by Michalova, 2004 and Jenicek for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

The Czech Republic joined European Union in 2002. Sludge production has increased by about 50% from 146,000 tds in 1995 to 220,000 tds in 2006 (see table below based on data from Michalova, 2004, CEC 2006, CEC 2009, personal communication). Compliance with the UWWT Directive is expected to be achieved by 2010, and future sludge production is estimated to increase by about 20% by 2010 and to stabilise to that level (263,600 tds per annum) for the next 10 years as population growth is reported to be limited over that period.

Year	Annual sludge production ($x10^3$ tds)	Quantities recycled to agriculture ($x10^3$ tds)	Quantities sent to landfill ($x10^3$tds)
1995	150	35	60
1996	140	Ni	30
1997	180	Ni	40
1998	180	Ni	20
1999	190	Ni	40
2000	210	Ni	45
2001	146	70	40
2002	206	0.2	45
2003	211	0.3	25
2004	206	33	Ni
2005	211	35	Ni
2006	221	25	Ni
Ni – no information			

Historically, sludge was typically recycled to agriculture. Untreated sludge application to land has decreased in recent years due to stricter rules concerning sludge quality in terms of heavy metal and pathogens content. At the same time, application of composted sludge has increased. While in 2001, 42-48% of sewage sludge produced was reported to be recycled to agriculture, there was nearly no recycling in 2002 and 2003. From the latest report to the Commission (CEC 2009, personal communication), quantities recycled to agriculture have risen again to around 12% in 2006. However, it is reported that 66% of sewage sludge is ultimately recycled to agriculture, probably after composting.

The amount of sludge landfilled in the Czech Republic has steadily decreased over the last decade from 50% down to about 10-15 % of annual production.

A negligible amount of sludge is incinerated in the Czech Republic. At present, only one municipal wastewater treatment plant has such technology. The incineration of sludge in cement plants is also practiced. A slow increase in the market share of more expensive technologies, such as incineration or other thermal treatment methods can be expected. However, this increase will probably be lower than in Western Europe.

For our baseline scenario, we have considered that recycling of sludge to agriculture will remain high at about 75% mainly after composting and that by 2020, landfilling will only cover 5 to 10 % and thermal treatment will rise to 15-20 % of annual production.

Denmark

Denmark has achieved high level of compliance with the UWWT directive. By 2010, based on a sludge production of 25kg/capita, the increase in annual sludge production should be limited to 141,500 tds. As population growth is limited, sludge quantities should not change between 2010 and 2020.

No recent figures on sludge quantities have been submitted to the Commission for Denmark, but past records showed that sludge production has decreased significantly since 1995 from 167,000 tds down to around 140,000 tds in 2002. According to Eureau survey, sludge production amounts to 77,530 tds.

There is a target for 2008 for 50% recycling through agriculture, 45% incineration corresponding to 25% incineration with recycling of ashes in industrial processes and 20% “normal” incineration.

For our baseline scenario, these proportions have been estimated to be valid for 2010 and 2020.

Finland

The following description is based on information provided by Rantanen for the latest version Global Atlas (Alabaster and LeBlanc, 2008) and data provided to the Commission.

In Finland, in 2005, around 4.4 M inhabitants lived in cities or smaller towns (Santala et al. 2006). Finland has achieved high level of compliance with the UWWT directive. The total amount of municipal sewage sludge produced in Finland was about 150,00 tds in 2004 and 2005 (see table below). Quantities seem to have decreased since 2002.

Although in 2003, 17% of sludge was recycled to agriculture, only 3 % of the sludge was used in agriculture by 2006. The rest was used in landscaping (Syke, 2007). Although the concentrations of heavy metals and nitrogen and phosphorus were well below the levels described in the Sludge Directive and also below the more stringent Finnish requirements, the proportion of sludge recycled to agriculture has diminished and has shifted to landscaping operations.

Future sludge production by 2010 is estimated to have a limited increase to 154,000 tds and proportions for the two main outlets to stay the same; that is less than 10% recycled to agriculture and 90% recycled to other land after composting.

	Total amount of municipal sewage sludge (tds per annum)	Sewage sludge used in agriculture	
		(tds per annum)	%
1995	141 000	47 000	33
1996	130 000	49 000	38
1997	136 000	53 000	39
1998	158 000	23 000	14
1999	160 000	23 000	14
2000	160 000	23 000	14
2001	159 900	25 000	16
2002	161 500	22 000	14
2003	150 000	26 000	17
2004	149 900	11 600	8
2005	147 700	4 200	3

In 2006, Finland passed a new legislation, Government Decree (539/2006), concerning the use of organic fertilizers including sludge. The Decree regulates potentially harmful elements, pathogens and pathogen indicators as limit values in products as well as rates of application. The amounts of nutrients are also regulated. The Decree also stipulates which treatment methods are suitable for producing products of high hygienic quality. The listed methods for sludge treatment are thermophilic anaerobic digestion, thermal drying, composting, lime stabilization, chemical treatment. Other methods can also be validated, that is, each new method has to demonstrate a product with a consistently good hygienic quality.

The old legislation, which is the national implementation of Sludge Directive, is still enforced. More can be found in *http://www.finlex.fi/fi/viranomaiset/normi/400001/28518* in Finnish and Swedish.

The most typical sludge treatment process in Finland is composting, which is done in windrows, reactors or both. According to a survey, 73 % of the wastewater treatment plants compost their sludges (Sänkiaho and Toivikko, 2005). Mesophilic anaerobic digestion is also common in the largest cities. Other methods that include lime stabilization, thermal drying, incineration, thermophilic digestion and chemical treatment are marginal.

France

In France, results from a national survey by the Agences de l'Eau in 2004, show that there were about 16,400 WWT plants with a treatment capacity of 90 M pe. There are regional differences (see table below) but overall the quantities of sludge produced amounted to 807,000 tds per annum; 62% recycled to agriculture, 20% disposed of to landfill, 16% to incineration and 3% to others. According to 2008 Eureau survey, 963,800 tds of sludge were produced.; 55% were recycled to agriculture; 24% sent to landfill; 17% tds were incinerated; and 3% to other outlets.

For our baseline scenario, we have considered that future sludge production will continue to increase and should amount to 1.6 million tds by 2010 and that quantities produced should stabilise to that level until 2020. The proportion of sludge recycling to agriculture will stabilise at around 60-65% over the next 15 years.

Region	**Sludge production ($x10^3$ tds)**	**Agriculture (%)**	**Landfill (%)**	**Incineration (%)**	**Other (%)**
Artois picardie	57	90	10	0	0
Rhin Meuse	82	46	23	24	7
Loire Bretagne	160	68	19	13	0
Seine Normandie	192	81	4	9	6
Adour Garonne	70	63	22	8	7
Rhone Mediterranee Corse	246	36	34	28	2
Total	**807**	**62**	**20**	**16**	**3**

Germany

The following description is based on information provided by Schulte for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

In 2008, about 10,000 municipal wastewater treatment plants were in operation in Germany; 250 of the biggest plants (with design capacities of more than 100,000 pe treat about 50% of the wastewater volume, while a further 7,000 small sewage works (with design capacities less than 5,000 pe) contribute less than 10 % of treatment capacity. About 94% of the wastewater volume is treated according to a high standard that comprises biological treatment with nutrient removal.

In 2003, about 2 million tonnes of sewage sludge (dry matter) were produced in Germany. A substantial increase in sewage production in the future is not expected due to the existing high connection rate to sewer and thus to wastewater treatment. Our baseline estimate for 2010 and 2020 is a sludge production of 2 million tds.

Over the past few years, thermal processes have gained greater importance for sludge management, at the expense of landfilling and recycling to land (agriculture and landscaping). This was primarily due to the following developments:

1. Since 2005, disposal of sludge to landfill is no longer possible in Germany, as materials with a total organic content (TOC) of more then 3% are banned from landfill; and

2. The political debate about sludge recycling to land which went on during the past few years in Germany caused a lot of uncertainty. These discussions proposed not only the possible introduction of higher requirements, but also the possibility of a complete ban on sludge recycling. In consequence, some operators of sewage treatment plants felt that sludge recycling to agriculture might not be a reliable disposal option in Germany and therefore viewed thermal treatment as more sustainable choice.

Even though the use of sewage sludge has been strictly regulated by the 1992 Federal Ordinance in terms of limit values for heavy metals and some organic compounds, many experts considered the maximum permissible values as too high, and in November 2007, the Federal Environment Ministry published a draft for a new sludge ordinance. The draft proposes a significant reduction of existing limit values for heavy metals and limit values for additional organic substances.

The proportions of sludge going to the different disposal outlets for sewage sludge in Germany in 2003 are presented in the table below.

Year	**Agriculture**	**Landscaping**	**Mono-incineration**	**Thermal treatment - Co-incineration**	**Thermal treatment - special process**	**Landfill**	**Intermediae storage**
2003	32	25	20	14	3	3	3

For our baseline scenario, for 2010 and 2020, the proportion of sludge recycled to agriculture may decrease slightly to around 25 to 30% and proportion being used for landscaping remains stable at around 25% and the proportion treated thermally increases to about 50%.

Greece

The following description is based on information provided in a presentation from Karamanos et al (2004) and information on implementation of UWWT Directive.

In 2004, it was estimated that about 95% of households were connected to a sewerage system and that about 60% of the permanent population was served by around 350 municipal wastewater treatment plants. The remaining population is in small villages and remote areas for which individual sanitation technologies should be used. According to the Commission, there are around 100 agglomerations above 2,000 pe in Greece with a total generated load of about 10 M pe; 600,000 pe in sensitive areas; 3.7 M pe. in normal areas and 5.5 M pe from large agglomerations.

Following the implementation of the UWWT Directive, large-scale sewage treatment plants have been constructed in recent years. However, by 2009, Greece has not yet fully complied with the UWWT Directive requirements. About 56% of generated load from agglomerations discharging into sensitive areas was in compliance while about 90% of generated load from agglomerations discharging into normal areas was in compliance

In Greece, sludge production is reported to have dramatically increased from 52,000 tds in 1995, 83,400 tds in 2004, 116,800 tds in 2005 to about 126,000 tds in 2006 (CEC 2006 and CEC 2009, personal communication). There are currently only small trials of recycling of sludge to agriculture (less than 100 tds per annum), the majority of sludge produced is sent to landfill. This is in agreement with figures provided from a recent Eureau survey (2008), which reported that sludge production amounted to about 126,000 tds; the majority being disposed of to landfill with only minor trials of sludge recycling to agriculture (100 tds).

For our baseline scenario, we have assumed that, by 2010, Greece will be complying with the UWWT Directive and thus that sludge production will have more than doubled to amount to 260,000 tds (25 kg * 95% of 11.1 M inhabitants). By 2010, recycling to agriculture will remain low to inexistent (5%) and landfilling will remain the main outlet at 95%. By 2020, sludge production will remain at around 260,000 tds but landfilling will have decreased to 55-60 % and be replaced by thermal treatment (35-40%) while agriculture will remain low at about 5%.

Hungary

The following description is based on information provided by Garai for the latest version Global Atlas (Alabaster and LeBlanc, 2008) and from a presentation by Toth (2008).

Hungary joined the EU in May 2004. It has a population of around 10 million people and a total area of 93,000 km^2. Budapest has a population of 1.85 million with 96% connected to sewer but only 49% are served by one of the 2 existing wastewater treatment plants and thus untreated sewage is discharged into the Danube. A new plant (Central) has been commissioned and should be operational in 2010. In the rest of the country the situation is worse with only an estimated 68% of population connected to sewer and less than 1/3 of 3000 settlements having adequate wastewater treatment.

The priority is to tackle sewerage problems from industry and 10 large cities. There are smaller investments for settlements below 15,000 people and by 2015, it is planned that all agglomerations of more than 2,000 pe will have a modern sewage treatment system.

In Hungary, the most commonly applied wastewater treatment technology is activated sludge. Sewage sludge is usually dewatered by filter belt press or centrifuge to a typical dry solids content of 18-20%. At the largest treatment plant in Hungary (North-Budapest Wastewater Treatment Plant), membrane presses are operated and sludge dry content is between 36-38%. A small proportion is dried.

At the larger plants, sludge is usually treated by mesophilic anaerobic digestion. At some plants, electricity is produced by biogas engines.

According to a 2008 Eureau survey, the total sludge production in Hungary was about 119,000 tds per year. Sewage sludge was predominantly sent to landfill (72,000 tds, 69%) or recycled to agriculture (47,000 tds, 39%). The quantities produced in the latest Commission survey for 2004-2006 are reported to be slightly higher (128,400 tds in 2006) while a smaller proportion was recycled to agriculture (24%). Figures reported by Toth (2008) for 2005 also differ significantly from the ones reported in the Eureau and Commission surveys; quantities produced amounted to 105,000 tds; quantities recycled to land including recycling to agriculture and land reclamation directly and after composting amounted to 70,000 tds (67%) while quantities sent to landfill were only about 25,000 tds (24%) and about 10,000 tds to other/unknown outlets (9%).

According to Toth (2008), total sludge production will rise to 175,000 tds by 2010 and reach a plateau of 200,00 tds by 2020. The proportion of sludge recycled to agriculture will increase until 2010 up to 135,000 tds (77%) and then decrease to about 115,000 tds (58%) by 2020. Quantities sent to landfill will steadily decrease down to 20,000 tds in 2010 and 10,000 tds by 2020 while quantities sent for incineration will increase from 2010 until 2020 to reach about 60,000 tds per annum. The quantities sent to other/unknown will not change.

According to Garai (2008), the goal of the government is to decrease landfilling and increase the proportion of sludge being recycled to agricultural. By 2015, the proportion of landfilling is expected decrease to 33%.

Year	**Sludge production (tds per annum)**	**Agriculture (tds)**	**Forestry (tds)**	**Incineration (tds)**	**Landfill (tds)**	**Other (tds)**	**Ref**
2004	120,741	36,105					a)
2005	125,143	42,329					a)
2005	105,000	70,000			25,000	10,000	c)
2006	128,379	32,813					a)
2007	120,000	47,000	0	1,000	72,000	0	b)

References:

a) CEC 2009, personnel communication
b) Eureau survey 2008

c) Toth 2008

Agricultural recycling is controlled under two regulations: the first covers compost product and the second one is for use of sewage sludge in agriculture. Sewage sludge is allowed to be disposed in municipal waste landfill if it is treated, not contagious, and the dry content is at least 25% and complies with leaching tests**.**

There are no incinerators for sewage sludge in Hungary as the capacity of hazardous waste incinerators is not sufficient to receive significant amount of sewage sludge, and the price of processing is too high. Some cement factories are authorised for sludge incineration and trials have been performed, but it is not used on a regular basis (Garai 2008).

For our baseline scenario, we have used figures presented by Toth (2008). We have assumed that by 2010 sludge production would amount to 175,000 tds reaching 200,000 tds by 2020. The proportion of sludge recycled to agriculture will increase until 2010 up to 135,000 tds (77%) and then decrease to about 115,000 tds (58%) by 2020. This will include a certain proportion of composted sludge. Quantities sent to landfill will steadily decrease down to 20,000 tds in 2010 and 10,000 tds by 2020 while quantities sent for incineration will dramatically increase from 5,000 tds in 2010 until 60,000 tds by 2020. The quantities sent to other/unknown will not change over that period and remain at 10,000 tds.

Ireland

Information has been extracted from an EPA report on urban wastewater discharges in Ireland for 2004/2005 (EPA 2005).

In Ireland, there are 478 agglomerations with populations greater than 500 pe, which collectively represent a total of 5.6 M pe. It is reported that in 2004/2005, 11% of wastewater received no treatment; 7% of wastewater received preliminary or primary treatment; 70% of wastewater received secondary treatment; and 12% of wastewater received nutrient reduction in addition to secondary treatment.

By the 31st of December, 2005, secondary treatment was required for all agglomerations discharging to freshwaters and estuaries with a population equivalent of 2,000 or greater and for agglomerations with a population equivalent of 10,000 or greater discharging to coastal waters. There have been delays in providing the required treatment plants at a number of locations throughout the country. Of the 158 agglomerations requiring secondary treatment or better by 31st December 2005, the required level of treatment was not in place at 30 of these agglomerations. The level of compliance with discharge limits was 86% for agglomerations above 10,000 pe discharging into sensitive areas and 67% for agglomerations above 15,000 pe and 38% of plants between 2000 and 15,000 pe.

Sludge quantities produced and recycled to land have sharply increased over the last 10 years from 38,000 tds in 1997 to 42,000 tds in 2003. The proportion of sludge recycled to land has also increased dramatically over the same period from 11% to 63%. (CEC 2006). About 62,000 tds in 2004 and 60,000 tds in 2005 respectively were reported to have been produced nationally; 76% (45,5000 tds) was used in agriculture and 17% (10,300 tds) went to landfill and a small proportion (4,000 tds, 7%) was either recycled to forestry or composted (EPA 2005).

We have estimated that, by 2010, sludge quantities will continue to increase and reach up to twice the current amount with full implementation of the UWWT directive, and reach 135,000 tds and remain at that level until 2020. By 2010, we have assumed that proportions recycled to agriculture and disposed of to landfills and other outlets would be at the similar level as in 2005 – i.e. 75%, 15 % and 10%, respectively and that by 2020, while agriculture would still be the major outlet at about 65-70%, incineration would steadily increase to replace landfilling.

Italy

The following description is based on information provided by Spinoza and Canzian for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

Sludge management in Italy varies widely as far as local disposal or reuse options are concerned due to different geographical, geological, technical, economic and social contexts. Some Italian Regions have undertaken the revision of the regional legislation on sludge utilisation in agriculture. For example, the Region Emilia-Romagna, in Northern Italy, published a new Regional Decree 2773 of December 30, 2004, modified and completed by Decree 285 of February 14, 2005.

In addition, as monitoring of sludge recycled in agriculture in Region Emilia-Romagna showed an almost constant occurrence of toluene and hydrocarbons, a research programme to define limits values for the above components was started in April 2007. Preliminary theoretical evaluations indicated possible safety limits of 500 mg/kg-ds for toluene and 10,000 mg/kg-ds for hydrocarbons.

In 2004, it was estimated that annual production of sewage sludge was about 4.3 Mt, corresponding to about 1 Mt of dry solids at a solids concentration of 25%, with an increase of about 10% with respect to years 2001-2003 (ONR, 2006). This is in line with the figures reported to the Commission for the period 2004-2006 which are presented in table below.

Year	Sludge production (t DS per annum)	Agriculture	
		(t DS per annum)	%
2004	970,235	195,161	20
2005	1,074644	215,742	20
2006	1,070,080	189,555	18

According to ONR (2006), disposal of sludge to landfill now accounts for only 24% of total quantities of sludge produced, and agricultural recycling, including co-composting and land reclamation, has increased to 69%. About 2% of sewage sludge is incinerated and 5% kept in temporary storage basins.

Sewage sludge is usually thickened and digested before being recycled to agriculture or sent to landfill. Sludge post-treatments, such as pasteurisation and thermal drying, are seldom practiced. Increasingly combined composting is performed by treating sewage sludge with other organic fractions, for example municipal solid wastes, food wastes, wood chips from broken pallets, cuttings from gardening and forest maintenance, and other similar materials.

When the quality of the compost is not good, mainly because of heavy metals exceeding the limits for unrestricted use, the resulting material can be used in land reclamation or as landfill cover. In 2005, wastes treated in composting plants amounted to about 3 million tons, with an increase of 125% with respect to 1999. Plant inflow consisted of 70 % of organic fraction deriving from separate collection and green wastes, 16% of sludge (+7% with respect to 2004) and 15% of other organic wastes, mainly from the food industry.

In some cases, sewage sludge is added in small amounts (up to 5%) to lime and clay in thermal processes to produce inert materials, such as expanded clay for construction.

Adoption of sludge thermal treatment in Italy is low, and accounts as already stated for a mere 6% at most. Incineration or co-incineration with municipal solid wastes is the most common thermal sludge disposal route in Italy. Sludge pyrolysis with gasification is currently under evaluation by a few water service companies.

In all cases, current management practices are influenced by both sludge characteristics and plant size.

In Italy, small WWTPs (those not exceeding 2,000 pe) usually treat domestic wastewater only, no primary sedimentation is usually provided and excess sludge is often already stabilized as deriving from extended aeration activated sludge processes. Alternatively, excess sludge is stabilized by separate aerobic digestion. Sludge is seldom treated on site, but is hauled to centralized plants for dewatering and final disposal or reuse.

In small to medium size plants (up to approx. 100,000 pe), anaerobic digesters are commonly used, and normally built to treat mixed primary and putrescible biological excess sludge However, in areas where eutrophication must be controlled, strict standards on nutrients require biological processes for nutrient removal, with long sludge retention times. Often, in these cases, primary settling is not present or it is by-passed to save internal organic carbon for denitrification. As a result, in these plants anaerobic digesters are no longer used and the sludge is stabilized aerobically. A typical example is the Milan Nosedo WWTP, serving over 1 million pe, that has been built without anaerobic digestion.

Thermal driers have seldom been used in medium-size WWTPs, as 100,000 pe is usually considered the minimum threshold for economic viability. However, recent regulatory restrictions on disposal to agriculture are favouring this technology, as dried sludge can be used as alternative fuel in cement kilns or for energy recovery in waste-to-energy plants. Especially for large size WWTPs, thermal treatment of sludge (drying, pyrolysis with gasification, incineration with energy recovery), is currently considered a feasible solution, as agriculture and landfilling will be no longer be viable disposal routes within few years.

Sludge composition is reported to be highly variable in Italy because almost all WWTPs serve urban areas where industrial activities contribute to the organic pollution load. Further, many medium and large size plants are located in industrial districts, such as (i) the wool district (Biella, Piedmont), (ii) the silk district (Como, Lombardy), (iii) other textile finishing district (Prato, Tuscany), (iv) tannery districts in Veneto and Tuscany, (v) metal surface finishing districts in Piedmont and Lombardy, and other minor districts.

In such cases, obviously, sludge characteristics strongly depend on the influent industrial wastewater, as, for example, it carries many organic recalcitrant compounds that are absorbed by the sludge (such as hydrocarbons and LAS) and contain heavy metals, which usually precipitate as metal hydroxides during treatment and accumulate in the sludge.

It is also worth noting that sludge deriving from textile finishing districts has often poor dewatering characteristics: it is very hard to reach values higher than 22% solids concentration by centrifugation, while belt-presses hardly reach 17-18%.

According to the Italian National Institute of Statistics (ISTAT, 2006), the total population equivalent (urban + industrial) in Italy is estimated to be around 175 million pe, of which the urban fraction is as much as 102 million pe (55.9% resident population, 14.9% tourists, 16.6% commercial sites, 12.6% crafts and small enterprises).

Based on an average annual production of dry solids per capita (after aerobic or anaerobic digestion) of 30 kg ds/annum/pe, the potential total sludge production in Italy can be estimated at around 5.25 million tds/annum, of which about 3 million tds/annum is linked to the urban population only. This is a three-fold potential increase compared with the current sludge production when all the population would be served by sewerage and subsequent appropriate treatment.

It is expected that, at least in Northern Italy, where co-management with municipal solid wastes due to the integration of public services (energy, waste and water), could become a real possibility for the future, anaerobic co-digestion of sludge and wet fraction deriving from separate collection of municipal solid wastes would increase. This is still a marginal practice in Italy but some examples of this type are listed below:

- Treviso: 3,500 t/annum of solid waste wet fraction and 30,000 t/annum of sewage sludge are co-digested.
- Cagliari: 40,000 t/annum of solid waste wet fraction and 15,000 t/annum of sewage sludge,
- Camposampiero: 12,000 t/annum and 12,000 t/annum, plus 25,000 t/annum from zootechnical wastewaters,
- Bassano: 16,000 t/annum of MSW and 3,000 t/annum of SS,
- Viareggio: 5,000 t/annum of MSW and 50,000 t/annum of SS.

The co-incineration of sewage sludge and solid wastes in incineration plants appears feasible if a drying step for sludge is introduced. Some trials are being carried out in Sesto San Giovanni, near Milan, involving the cooperation with two public companies and results are encouraging.

To meet requirements of the UWWT directive, Italy has had to put systems in place for adequately collecting and treating wastewater of agglomerations of more than 15,000 pe before 31 December 2000. Some 299 towns and cities have been listed as not yet being in compliance with EU standard. Discharges of untreated urban wastewater are the most significant source of pollution in coastal and inland waters and Italy faces the prospect of being brought before the European Court of Justice (ECJ).

For our baseline scenario, we have assumed that, by 2010, Italy will have complied with the UWWT Directive and that sludge production will have reached its maximum at about 1.5 M tds and remain at that level for the next 10 years. Sludge recycling to agriculture will increased to about 50% and a large proportion will also be recycled to land reclamation projects both totalising 70% of sludge produced. Most of the sludge recycled to land will be first co-composted.

Latvia

Information is mainly extracted from a report produced by GHK (2006).

Latvia is a small Baltic state with an area of 65,000 km^2 and 2.5M inhabitants. Agricultural land occupies 39% and forestry 44% of Latvia's territory. In the last decade, with the dismantling of collective farms, the area devoted to farming decreased dramatically - now farms are predominantly small. Latvia joined the Union in January 2007 but Latvia started a programme of improving wastewater treatment in 1995. The whole territory of Latvia has been classified as sensitive area under the UWWTD. In 2005, it was reported that overall 71 % of the population was connected to the sewer system (almost all connected to a WWTP). The availability of a centralised wastewater infrastructure varies from town to town. In towns with a population above 10,000 it typically reaches 70-85% of the population while in towns with a population below 10,000 it can be as low as 30% of the population.

Out of 71 agglomerations that have a wastewater treatment plant, only 7 are complying with the UWWTD standards while 64 have a WWT plant which is not fully compliant. All together, in the wastewater sector, numerous projects have been planned to be implemented during the time period from 2006 – 2015. By the end of 2008, Latvia should have finished improvements to the wastewater collection in the largest cities above 100,000 pe and investment will continue until 2015 to construct about 60 new WWT plants with a total capacity of 1.9 M pe and upgrade existing non-compliant WWT plants with a capacity of 1.17 M pe.

Most of wastewater treatment plants do not have adequate sludge treatment. The most common final disposal routes for sewage sludge are agriculture and compost.

Wastewater volumes have decreased by 2.2 times between 1990 and 2000 and thus the quantities of sewage sludge. It was estimated that about 20,000 tds were produced in 2000 and about 29% was recycled to agriculture, 38% stored (landfilled?), 26% for other uses and 7% was composted. No incineration was reported (EIL, 2002). Sludge production seems to have continued to decrease between 2004 and 2006 from 36,000 tds, 28,900 tds down to 24,000 tds (CEC, 2009, personal communication) and quantities recycled to agriculture have fluctuated from 7,700 tds (31%) in 2004, 6,500 tds (22%) in 2005 and nearly 9,000 tds (39%) in 2006. It was mentioned that the high level of heavy metals sometimes restrict the recycling of sludge to agriculture.

For our baseline scenario, we have assumed that by 2010, Latvia will not have finished installing new WWT capacity and thus that sludge quantities will not have increased substantially compared with 2006 figure while, by 2020, compliance with the UWWT directive will have been achieved and sludge quantities will have more than doubled to 55,000 tds. In 2010, we have considered that recycling to agriculture will remain at around 30 %, landfilling at 40% and 30% to other unspecified outlets and that, by 2020, while agriculture remains at around 30%, landfilling will have decreased to 20% and incineration will have increased at about 5 to 10% .

Lithuania

The following description is based on information provided from a presentation by Ciudariene in 2007 and Cepelė in 2008.

Lithuania has a population of 3.4 million inhabitants – its territory is divided in 10 counties and 61 municipalities with regional differences in economic development and treatment connection rates. It has joined the Union in May 2004. Lithuania has designed the whole territory as sensitive area under the UWWT Directive. It was granted until 31 December 2007 to provide collection of wastewater and more stringent treatment for agglomerations of more 10,000 pe (i.e. 38 agglomerations) and until 31 December 2009 to fully comply with the requirements of the UWWT Directive (collection and more stringent treatment for all agglomerations of more than 2,000 pe, i.e. 57 agglomerations). It is reported that there are about 95 agglomerations with more than 2,000 pe generating a total load of 3.34 M pe.

In 2006, 60% of the population was connected to a centralised wastewater treatment plant and at least 32% of wastewater received at least secondary treatment. Sewerage and wastewater treatment plants are reported to be in great need of upgrade and further investments have been identified for the period 2007 - 2013. From the latest Commission report on implementation of UWWT Directive (UBA 2009), in 2005/06, 93% of generated load of all agglomerations >2,000 pe were reported to be collected with 82% of the total generated load treated by secondary treatment and 61% with more stringent treatment.

Between 2004 and 2006, sludge production increased from 60,500 tds to about 71,000 tds per annum (see table below). Due to lack of digestion capacity, most sludge is only dewatered before being recycled to land (25%) or sent to landfill (75%).

Year	Total sludge production (tds/y)	Quantities recycled to agriculture	
		(tds)	%
2004	60,579	14,315	24
2005	65,680	16,240	25
2006	71,252	16,376	23

There is a national plan for strategic waste management which prioritises management of bio-waste with energy recovery (biogas production) and preservation of nutrients (composting). This is encouraging separate collection or MBT treatment.

The plan includes establishing 10 regional sludge treatment centres between 2007 and 2013, to include digestion, drying and composting plants. There are 2 existing centralised plants for anaerobic digestion of sewage sludge; 3 private composting plants including one for sewage sludge and 13 public regional waste composting plants. 76 additional composting plants are to be built between 2007 and 2013 using EU funding. There are currently no municipal waste incineration plants.

For our baseline scenario, we have assumed that Lithuania would have reached compliance with UWWTD by 2010 and that sludge production would reach its maximum by then and amount to 80,000 tds with no further change to 2020. In 2010, recycling to land may increase up to 30% as landfilling is increasingly restricted down to 70% of produced sludge and incineration capacity will not yet be available. By 2020, landfilling will have decreased further down to 30%, agricultural recycling up to 50-60 % and incineration and other thermal treatment up to 10-20% of produced sludge solids.

Luxembourg

According to the latest figures from the Commission (UBA 2009), the collection rate for wastewater in Luxembourg has reached 98% with 93% of generated load treated by secondary treatment and up to 80% to a more stringent level. Luxembourg has wastewater treatment capacities of for approximately 950,000 pe; 80% of the treatment is provided by 10 biological wastewater treatment plants with capacities > 10,000 pe. 5 out of these 10 WWTP's do not comply with the EU standards with regard to organic discharges and 6 out of 10 do not comply with the emission limits for nutrients.

Sludge quantities produced are reported to amount to 9,300 tds (2008 Eureau survey) and to be mainly recycled to agriculture 8,736 tds (95%). The remaining sludge is sent to incineration.

For our baseline, by 2010, we have assumed that there will be no change in the collection rate but that compliance with UWWT will have been reached for all the sewage and that sludge quantities would have risen by 7% to their maximum of 10,000 tds. The majority (95%) will still be recycled to agriculture including after composting and 5% thermally treated. In 2020, the proportion of composted sludge recycled to land will have increased. The proportion of sludge thermally treated either by incineration or co-incineration in cement plants will increase to at least 20% after a study found it to be the best environmentally option (CRTE).

Malta

No information is available, but it is believed that until 2004 there was only a very small amount of sludge produced as there was limited wastewater treatment (17% of generated load). Under the UWWT Directive, by 31 March 2007, all untreated wastewater (25 M m^3 per year) should have been collected and treated to relevant standards. Since 2006, 3 new wastewater treatment plants have been built or are under construction with the construction for the final one having started in January 2009.

For our baseline, by 2010, we have assumed that all urban wastewater will be collected and treated to the relevant standards and that sludge production will have risen to 10,000 tds (25 kg * 400,000 inhabitants). By 2010, agriculture will not an important outlet but all sludge will be landfilled. By 2020, a small proportion may be recycled to agriculture (up to 10%) while the rest is landfilled.

Netherlands

The following description is based on information provided by Kreunen for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

Netherlands has already achieved high compliance with the UWWTD. Quantities of sewage sludge are not expected to increase over the next 15 years. There are 26 Water Boards providing wastewater services in the Netherlands. Recycling of sewage sludge in agriculture has been banned in the

Netherlands since 1996. Increasingly stringent standards for the application of sludge to land in the late eighties led to this ban.

A private company - GMB Sludge Processing Company has two composting plants which process about 15% of the total (dewatered) sewage sludge produced by municipal sewage treatment plants in the Netherlands, which amounts to approximately 1.5 million tons per year (with a total plant capacity of 1,370,000 PE). Since 2004, this granular product has been used as a biofuel in power stations, both in Germany and the Netherlands. The granules are used by the power stations either as an additive or as a stand-alone biofuel.

Of the remaining amount, approximately 58% is incinerated and 27% thermally dried. The product resulting from these techniques (composting, incineration and thermal drying) still requires further (final) processing.

There is no support in the Netherlands for application of sewage sludge into or onto the soil, or in agriculture. In addition, the animal manure surplus means that the farming sector is more likely to demand the exclusion of sewage sludge.

Norway

The following description is based on information provided by Blytt for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

Norway is a country with a long coastline and is dominated by forests and mountains. Arable land covers only 3% and is mostly located near bigger cities and at the bottom of the valleys. Norway has 4.5 million inhabitants. During the seventies and eighties there was a major increase in the number of wastewater treatment plants, especially in the parts of the country with discharges to inland waters and narrow fjords. There are currently about 1,400 treatment plants, of which most are very small.

The sludge from smaller plants is usually transported to larger treatment plants. In total, 62 treatment plants have registered their treated sludge to be regarded as a fertilizer product. Total quantities of sludge produced and disposal outlet are presented in tds in the table below:

Year	Total production	Total utilization	Agricultural	Green areas	Mixed soil products	Top layer on landfill	Land filled	Other
?	86,030	86,484	56,055	10,198	13,178	2,934	2,957	1,162

More than 90 % of Norwegian sludge is used for land application as a soil amendment product; where one-third goes to parks, sports fields, roadsides, the top cover of landfills, and two-thirds goes to arable land within the agricultural sector.

In order to achieve this high rate of land applied sludge, stringent standards have been set for the content of heavy metals and pathogens, and the control of the odour nuisance has been given high priority. In fact the Norwegian regulation concerning sludge is stricter than those of most of the countries in Europe. Towards the end of the 1990s', the policy to recycle organic waste increased, along with requirements to remove organic waste from landfills, in order to reduce emissions of methane and leachates. Applying sludge on arable land is considered by the Norwegian authorities to be the socio-economically acceptable and cost-effective way to utilise the sludge. This implies that farmers are willing to accept the use of sludge. The sewage sludge market is very sensitive to negative reports as farmers acceptance is influenced by many factors including opinions of retailers and consumers. Authorities and waste water treatment plants continuously work on risk communication. This helps to sort real facts from false and provides balanced information to the partners.

In the mid-seventies, a reform in the agricultural sector changed the agricultural production in the populated regions around Oslo and Trondheim from dairy farms with grassland to the production of cereals (barley, wheat, rye and oats) and oil seeds. Single-crop farming depletes organic material in the soil. Changes in the farm structure and land use are contributing factors to use of sludge on agricultural land. Sludge is not used in forests in Norway.

Several municipalities started to source separate kitchen waste for making compost. The ministries found it necessary to harmonize the parallel regulations for different types of recycled organic waste. In 2003 a new joint regulation *"Regulation on Fertilizers Materials of Organic Origin",* prepared by the Ministry of Agriculture and Food in cooperation with the Ministry of Environment and Ministry of Health was published. This covered all organic materials spread on land which was derived from materials such as farm waste, food processing waste, organic household wastes, garden waste and sludge. It was also believed that to promote and standardise waste such as sludge, higher treatment and quality control standards had to be implemented.

The 2003 regulation sets the following major requirements for organically derived fertilizers in general, with a few special requirements for sludge:

- All producers have to implement a quality assurance system.
- Quality criteria of the products include standards for heavy metal content, pathogens, weeds and impurities, in addition to a more general requirement of product stability (linked to odour emissions). There is a requirement for taking reasonable actions to limit and prevent contamination with organic micro-pollutants that may cause harm to health or the environment.
- Requirements on product registration and labelling before placement on the market;
- Special crop restrictions for sludge, including a prohibition on growing vegetables, potatoes, fruit and berries for three years, and on spreading sludge on grassland.
- Requirements for storage facilities before use. Cannot be spread on frozen soil – no later than November and not before 15 February. Sludge has to be mixed into the soil (ploughing) within 18 hours after application.
- Beside the limit values for heavy metals, the hygienic requirements are: no *Salmonella sp*. in 50 grams and no viable helminth ova. and less than 2,500 fecal coliforms per gram dry solids.

A farmer has to make a plan for all fertilizers to be spread on his fields, including sludge. The municipality has to be notified of sludge use at least three weeks before it is locally stored or spread. The wastewater treatment plant or the sludge transport company often helps the farmer with this notification. A farmer cannot apply sludge more frequently than every 10 years on the same field, but that will depend on to the sludge quantity and amount he uses.

Markets for sludge within the landscaping sector are increasing. New markets for green energy may enhance cultivation for energy crops. This may increase sludge application on these types of arable land. There are ongoing experiments and pilot trials making synthetic diesel from sludge and organic waste. It is becoming more common to co-digest sludge and food waste in order to increase the production of biogas (methane). This will lead to a sludge quality with lower metal content, but higher nutrient content.

Poland

The following description is based on information provided from a presentation by Twardowska in 2006 and a paper by Przewrocki et al 2004.

In 2001, 51.5% of population were connected to a sewage treatment plant in Poland. No recent update to this information has been supplied to the Commission.

Sludge production has steadily increased from 340,040 tds in 1998, 397,216 tds in 2001, 476,000 tds in 2004, 495675 tds in 2005 and 523,674 tds in 2006 (CEC 2006 and 2009). Compared with the 2001 figure, a doubling of sludge quantities is expected by 2015 and an amelioration of the quality of the sludge due to reduction of industrial pollutants discharged into sewers. Almost all of sludge is stabilised by anaerobic digestion or by a natural drying method,

The recycling of sewage sludge to agriculture has increased since 1998 from 8%, 14% in 2000, down to 12% in 2001 and up again to 17% in 2006 (44,819 tds in 2004, 42,558 tds in 2005 and 44,284 tds in 2006). Between 2000 - 2001 the amount of composted sludge increased from 25,528 tds to 27,591 tds (7%) while recycling to agriculture dropped slightly from 50,628 tds (14%) to 49,302 tds (12%). Industrial use (not specified) of sewage sludge increased from 19,815 tds (5%) in 1998 to 28,274 tds (7%) in 2000 and then fell to 24,220 tds in 2001 (6%). Quantities of sewage sludge sent to landfill have dropped from 191,600 tds in 1998 (56%) to 151, 618 t ds in 2000 and rose again to 198,630 tds in 2001 (50%). Quantities incinerated dropped between 1998 and 2001 from 14,389 tds (4%) to 6,937 tds (<2%).

According to a 2008 Eureau survey, sludge production in 2005 amounted to 790,900 tds; 147,000 tds (18%) sent to landfill; 80,600 tds recycled to agriculture (10%); 4,500 tds incinerated and 558,700 to other outlets (not specified).

The forecasts for sludge management routes prepared by the Ministry of the Environment are presented below:

- Proportion of municipal sewage sludge disposed of to landfill will rise to 45% in 2010 but will decrease to 39% in 2015.
- Proportion of sewage sludge incinerated should rise from 1.6% in 2001 to 5% in 2010 and to 8% in 2015. This will depend on new investments in incineration plants.
- Composting is the preferred method of sewage sludge treatment. It is estimated that 20% of sewage sludge could be composted; however, this requires building sufficient capacity of composting plants.
- Another route will be recycling to agriculture. The introduction of more effective and stringent regulations will limit the increase of sewage sludge to agriculture. In 2015, it is predicted that about 26% of sewage sludge will be recycled via this route. Sewage sludge use as fertilizers will reach 46%, including composted sludge.

Portugal

The following description is based on information provided by Duarte for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

In Portugal, there are wide regional differences in sludge production and sludge management as the number of inhabitants and the development of wastewater treatment varies greatly and soil and climatic conditions differ. Since the implementation of the UWWT Directive, there have been major upgrades of existing wastewater treatment plants (WWTP) and construction of new ones, leading to an increase in sludge production. However, by 2005, only 65% (6,572,000 inhabitants) of the total population of Portugal was served by a WWTP mainly with secondary treatment (43%); 24% had also tertiary treatment. The Southern regions (Algarve Alentejo and Lisboa e Vale do Tejo) had about 76% of the population served by a treatment plant and the Northern regions (Centro and Norte) about 58%. There are also industries discharging to these WWTPs producing a load of 50% and 70% respectively in the Southern and in the Northern regions where industry is more important. The generated load was estimated to be about 10,650,000 pe.

The available information on sludge production is scarce and dispersed. Based on field studies carried out in two different Portuguese regions: Algarve (2005) and Center Alentejo (2006), the amount of sludge produced has been estimated and is reported in the table below.

Region	pe	Daily sludge production ratio (g DM/pe.day)	Sludge production (tds/year)
Norte	3,500,300	80	102,209
Centro	2,404,800	50	43,888
Lisboa e Vale do Tejo	3,441,600	50	62,809
Alentejo	802,500	70	20,504
Algarve	499,500	40	7,293
TOTAL	**10,648,700**	**60**	**236,703**

The range assumed for the sludge range (40 – 80 g DM/pe.day) depends, mainly, on the sludge treatment process. For example, if the sludge is digested and if lime is added the upper limit is for non-digested sludge with lime addition and the lower limit is for digested sludge without lime addition. Quantities reported to the Commission are presented below:

Year	Sludge production	Quantities recycled to land	
	tds	tds	%
1995	145,855	44,000	30
1996	177,100	53,130	30
1997	214,200	64,260	30
1998	121,138	41,413	34
1999	374,147	66,547	18
2000	238,680	37,176	16
2001	209,014	69,853	33
2002	408,710	189,758	46

Until recent years, the most common disposal outlet for sewage sludge was landfill. However, this disposal option is becoming more restricted as regulations limit disposal of organic matter and the cost of landfilling is increasing. However, public opinion is against incineration and protest actions have taken place every time a waste incineration plant project has been presented. Thus agricultural use of sludge could play a major role in the future in Portugal. This is especially the case in the Centre and Southern regions of the country where soils are deficient in organic matter. Increasing numbers of operators have started to transport and apply sludge in agricultural and forest land. The main agricultural crop receiving sludge in Portugal is maize, followed by vineyards and orchards. Some sporadic applications occur in forage areas and in forestry after forest fires.

At the same time, other industries and activities such as agro-industries, municipal solid waste (MSW), manure and slurry from intensive livestock production are also relying on agricultural land for the disposal of their waste and are thus competing with sewage sludge for available land. This is especially the case in the Northern and Central regions where operators have more difficulties in recycling sludge to land for three main reasons:

- these are more populated areas, thus WWTP produce more sludge;
- the available agricultural area is reduced;
- more intensive livestock production occurs and thus production of manure and slurry competes for available agricultural land.

Future development does not support an indefinite increased of sludge recycling to agriculture, as continuous reduction of the cultivated area is happening, with wider areas devoted to forest or fallow land and consumers demanding more quality controls on agricultural products, reducing the desire in agricultural producers to use sewage sludge on agricultural land.

For our baseline scenario, we have assumed that by 2010, compliance with UWWT Directive will be achieved and that sludge production would have risen to a maximum of 420,000 tds and that recycling to agriculture will have reached 50%. The remaining sludge will be thermally treated (30%) and landfilled (20%) depending on treatment capacity. The situation is not expected to change by 2020.

Romania

Romania joined the EU in January 2007 and has been granted an extended period to comply with the UWWTD up to 2019. In 2005, 47% of generated load was collected but only 28% was treated by secondary treatment. Current sludge production has been reported to decrease between 2004 and 2006.

Year	Total production (tds/y)
2004	164,969
2005	134,322
2006	137,146

While there is currently no recycling of sludge to agriculture, it has been considered as an option for future management together with co-incineration in cement plants (Crac, 200?).

For our baseline scenario, we have assumed that by 2010, the situation in Romania will have not changed compared with 2006. We have assumed however that full compliance will be achieved by 2020 and that by 2020, sludge quantities will have risen dramatically to 520,000 tds (25*21 M inhabitants). By 2020, a significant proportion could be recycled to agriculture (at least 40%) while landfilling would be the second option unless thermal treatment capacity has been built.

Slovakia

The following description is based on information provided by Sumná for the latest version Global Atlas (Alabaster and LeBlanc, 2008).

Following the implementation of the UWWT Directive, it is estimated that sludge production will increase by approx. 20-40 % in Slovakia. During the period 2004-2006, about 55,000 tds of sludge was generated per annum.

Sewage sludge production (tds per annum) and disposal outlets in the years 2004 – 2006 (CEC 2009) is presented in table below.

Year	Total	Incineration	Agriculture 1)	Landfill 2)	Forestry	Other
2004	53,114	0	41,116	10,581	0	1,417
2005	56,360	0	34,784	17,236	0	4,340
2006	54,780	0	33,630	15,375	0	5,775

Notes:
1) While sludge was directly applied into the agriculture in 2004 and 2005, it was no longer the case by 2006 when large quantities were diverted for the production of compost.
2) Landfill also includes quantities of the sludge that were temporarily stored.

About 90 % of monitored sewage sludge production in Slovakia meets the limit values for PTEs as a result of reduction programmes for pollution due to industrial discharges to public sewers that has been implemented in Slovakia.

Recycling of sewage sludge to agriculture is the preferred option in Slovakia not only because it was relatively the cheapest option but also because it was recognised as the best environmental option for sustainable development. Direct application of sludge into agricultural land is regulated according to the Act on Sewage Sludge Application into Agricultural Land. This determines the conditions for sewage sludge application into agricultural and forest land without affecting soil properties, plants, water, or health of humans and animals. The Act authorises, under specific conditions, applications to arable land and permanent grass land and forestry (only soil in forest nurseries, in plantations with Christmas trees, fast-growing wood plants, energetic and intensive growths). It does not deal with the application to non-agricultural land or use of sludge in land reclamation.

Application of compost or soil supporting substance or growing media is regulated by the Act on Fertilizers. In this case, the product made on the basis of sludge is subject to certification and assessment whether properties of such fertilizer and its technical documentation are in line with related technical standards and generally binding legal regulations.

There are currently no suitable incineration capacities for sludge incineration. However, the national waste management plan for the year 2005-2010 is planning to increase these capacities and to promote energy recovery from waste. The capacity for waste co-incineration in two cement plants (others do not comply with the conditions of the Act on Air Protection) exists in the Slovak Republic, but currently it is reserved for the handling of industrial waste and co-incineration of animal waste. However with the decreasing production of animal waste, sludge could be considered as an alternative in the future in these facilities.

Disposal of sludge to landfill is the least favoured option for sludge management by the Slovak Government. However, due to lack of incineration capacity, it is the only alternative option for sludge disposal. It is expected that the proportion of organic waste disposed at landfills will be limited in line with the requirements of the EC Landfill Directive.

The aim of the Waste Management Programme of the Slovak Republic is to decrease the amount of landfilled waste to 13% out of the total amount of waste being generated in the SR, by the year 2010. Among the measures to be used to reach this are decreasing the quantities of sewage sludge disposed of into landfills and to increase the costs of landfill disposal of all materials.

For our baseline we have estimated sludge quantities by 2020 to amount to 135,000 tds. The proportion of sludge recycling to agriculture as compost to be 50% or more, landfilling will decrease down to 5% or less depending on the thermal treatment capacity, which could treat up to 40% of sewage sludge.

Slovenia

The following description is based on information provided by Grilc and Zupancic for the latest version Global Atlas (Alabaster and LeBlanc, 2008), a presentation given by Mayr and Zugman in 2005 and by Medved in 2006 and a paper from Vukadin and Podakar (from Environmental Agency) in 2007.

Slovenia was a part of former Yugoslavia until 1991 and in May 2004 it became a member of the EU. Wastewater treatment capacity has increased steadily since 2000 when Slovenia entered the process of accession to the EU. It is reported that, in 2005, only 53% of population was connected to a WWT plant but that 73% of generated load from agglomerations above 2,000 pe were collected; 51 % was treated by secondary treatment and 19% by more stringent treatment. Nearly 250 municipal wastewater treatment plants are now in operation, but only 10 % of them are larger than 10,000 pe capacity, (and only 5 larger than 100,000pe capacity). Their total capacity is about 2 million pe (similar to the the population of Slovenia), but part of the capacity is used to treat industrial effluents.

Sewage sludge quantities have increased from 15,000 tds in 2001 to 47,000 tds in 2006. The quantities reported by the Environmental Agency are much lower and were estimated to amount to only 20,000 tds in 2006 (see tables below).

	Gril and Zupancic, 2008	CEC, 2006	
Year	**Sewage sludge production (tds/y)**	**Sludge production (tds)**	**Quantities recycled to agriculture (tds)**
2001		8,200	500 (6%)
2002	14,767	7,000	1100 (16%)
2003	20,140	9,400	800 (9%)
2004	26,747	9,687	125
2005	39,366	13,580	71
2006	46,744	19,435	27

Figures from the Environmental Agency of the Republic of Slovenia (2007) are reported below:

Year	Sewage sludge production (tds/y)	Use in agriculture	Composted	Landfill	other	export
2000	8,800	300	1,000	7,500	Na	
2001	8,200	500	900	6,800	Na	
2002	7,000	1,100	900	5,000	Na	
2003	8,800	500	0	7,000	1,400	
2004	12,900	100	0	9,000	3,700	
2005	16,900	100	100	9,500	7,200	
2006	20,100	0	0	9,200	5,600	5,200

These figures show that the quantities of sewage sludge have increased steadily and have more than doubled over the last 4 years. The rate of increase will level off in the next few years as the construction of the largest plants is almost completed. It has been reported that by 2010, sludge production in Slovenia would amount to 40,000 tds per year.

Anaerobic digestion of sludge is relatively rare (10 plants only), mainly at larger plants, where biogas production contributes to the reduction of treatment costs. Some plants use combined input; that is, fresh sewage sludge and separately collected biodegradable municipal waste, food waste, and other similar materials. Filter presses and belt filters are mainly used at small plants, whereas continuous centrifuges are used at large plants.

Some wastewater companies dispose of the sludge on site (internally) (about 14% of total sludge produced). The main ‘internal’ outlets for dehydrated sewage sludge are land application and recycling after composting on the premises of treatment plants or of their operators (mainly non-arable land). This can only be performed sporadically. Composting is practiced on site at a small scale usually together with other types of municipal waste. The compost produced is used for maintenance of green areas around the treatment plants. Limited amounts of sludge are temporary stored, before the most appropriate (or cheap) method is found.

Disposal Methods	Internally		Externally	
	Quantities (tonnes	**%**	**Quantities (tonnes**	**%**

	DS/y)		DS/y)	
Temporary storage	321	<1	589	1
Recycling/Composting	2,831	6	4,030	8.5
Land use	3,288	7	0	0
Landfill disposal			13,967	30
Export (to incineration)			21,916	47
Other disposal types			123	2
				47,065

In 2006, the largest amount of sludge (47%) was exported abroad in granulated dry form for incineration. The reason for this method is the absence of proper incineration facilities in the country and tightening of the landfill requirements. The existing industrial thermal processes have not yet obtained permits to co-incinerate dry sludge as an alternative fuel. Co incineration in cement kilns is however not considered particularly attractive in Slovenia due to its relatively low calorific value (about 11-12 MJ/kg at 90% DM.). Sludge export for incineration abroad should, however, only be a temporary solution as new thermal treatment facilities for wastes and sludge are currently under construction.

Landfill disposal of dehydrated sludge has been the most traditional way of disposal and, is still the second route for disposal of sludge in Slovenia (30%). From 2008, sludge landfilling will decrease due to stricter waste acceptance criteria for landfilling such as total organic carbon content of less 18% DM and calorific value less than 6 MJ/kg. In particular the required TOC/DOC limit values are difficult to reach by conventional digestion/composting stabilization processes.

Composting of dehydrated sewage sludge is most often performed in combination with biodegradable municipal waste and other structural materials (bark, corn stalks). Compost is used in non-agricultural applications: for recultivation of landfill sites and land reclamation of degraded areas, public parks maintenance and other similar locations.

Agricultural use is almost inexistent due to the high content of PTEs in sludge, especially zinc, copper, chromium and lead. The available arable land in Slovenia is limited to 36% as 60% of the country is covered with forests and woods. Application of sewage sludge in forestry is prohibited.

For our baseline, the situation in 2010 will remain the same as in 2006 while by 2020 quantities produced are expected to increase to amount to 50,000tds. Over the next 10 years, the proportion of sludge being recycled to land will increase as sludge quality improves but will stay relatively low at around 15%, landfilling will also decrease to 5% while thermal treatment will remain the preferred option.

Sweden

The following description is based on information provided by Hultman et al (1999).

Sweden has a population of about 9.2 million people. The proportion of people living in urban, rural or in sparsely populated areas is about 85%, 5% and 15%, respectively. There are approximately 2,000 municipal wastewater treatment plants and 95% of the population in towns and agglomerations with more than 200 inhabitants are served by plants with tertiary treatment. Full compliance with the UWWT Directive is already achieved.

Sweden has gradually strengthened its rules concerning limiting values of metal concentrations in sludge. In addition there are also limit values for organic substances (nonyl-phenol, toluene, total PAH and total PCB).

There are also legal restrictions on disposal to landfill and, since 2005, organic wastes including sludge from wastewater treatment plants have effectively been banned from landfills. In addition, since 1 January 2000, a landfill tax has to be paid when sludge is disposed of to landfill.

Centrifuges are the most common by used dewatering equipment followed by belt presses. Other conditioning methods are used such as the KREPRO process which uses sludge conditioning by use of acids and heat. There is a growing interest to more efficiently use natural and biological dewatering methods, for example, by use of reed beds.

All large treatment plants use anaerobic digestion, while the other methods are used at small and medium-sized plants. There are also some examples of thermal drying.

Co-treatment of sewage sludge with solid wastes has been investigated in Sweden at different scales such as:

- Sludge incineration together with municipal solid wastes
- Anaerobic digestion of sludge together with other organic materials
- Large-scale composting of sludge together with other organic materials.

Sludge production has been relatively stable for the last 10 years at around 210,000 tds per annum (CEC 2006 and 2009) while quantities recycled to agriculture have fluctuated due to debate over the safety of the outlet but it seems to have reached a stable level at around 10 -15 %.

At the end of the 1980s, sludge disposal outlets in Sweden were agriculture (35%), landfill (50%), land reclamation (15%) and others (5%). Ten years later (1998) the agricultural use had declined to 25% and disposal to landfill had increased to 46 %. In 2006, the agriculture and landfill outlets had further been reduced to 15%, and 4%, respectively while other outlets (land reclamation, green spaces, co combustion, etc) were reported to have reached 81% (Eureau, 2008).

The reasons for the decrease in sludge recycling to agriculture were that, in 1990, the Federation of Swedish Farmers (LRF) recommended its members not to use sludge. A national consultation group was formed between LRF, the Swedish Water and Waste Water Works Association (VAV) and the Swedish Environment Protection Agency (SEPA) which reached agreements concerning agricultural use. However, at the beginning of 2000, LRF argued that agricultural spreading should be suspended because of the presence of brominated flame retardants in sludge and their possible negative effects on soils and organisms.

About five years ago VAV ordered a product certification system from the Swedish Testing and Research Institute (SP). The food industry requires that sludge be quality assured by a certification system. This however offers no guarantee that the sludge will be accepted for use in agriculture. A quality assurance system (ReVAQ) has been designed together by the concerned parties, water companies, farmers, nature conservation and the food industry but the future of agricultural use of sludge is still uncertain. Future use of sludges in agriculture may, however, decrease due to concerns of the food industries and the public. This is the most difficult to predict.

Landfilling had increased due to recommendations to avoid sludge in agriculture, but has now decreased to below 5% by 2005 due the legal restrictions on organic wastes going to land, the introduction of a landfill tax and the difficulties to find new land areas or getting permits for the disposal.

Incineration is a well established method in Sweden for solid waste treatment but not for sewage sludge. Co-incineration with solid wastes may be an interesting alternative to mono-incineration although it seems that most existing incineration plants for solid wastes do not have excess capacity to also burn sludge. Therefore, attention has been directed towards co-incineration with biofuels (wood, peat etc), coal power plants or plants producing building materials at high temperatures (cement, brick etc). Two factors will influence the use of incineration of sludge in Sweden: the potential introduction of a tax on incineration and the potential requirement that phosphorus must be recovered either before or after the incineration.

Other land uses of sewage sludge represent about 10-15% of sludge production in Sweden. Sludge based products and soil conditioners can be used on reclaimed land, parks, golf courses, green areas etc (there are about 400,000 hectares of green areas in Sweden). Sludge can also be used as landfill cover material. Sludge used in forestry has received some attention from forest companies. Sludge can be spread as dried sludge in pellet form on mineral soil to compensate for nitrogen losses due to soil acidification and intensive forestry.

Increased interest has been devoted to extraction of products from sludge. Two commercial systems are mainly under consideration in Sweden, namely the KREPRO and Cambi processes. The Cambi and KREPRO processes aim to see the dissolved substances as resources, either through improved methane production in the digester (Cambi) or by reuse of precipitation chemicals, production of a fertilizer (ferric phosphate), and separate removal of heavy metals in a small stream (KREPRO).

For the baseline study, sludge quantities are expected to increase slightly mainly due to population growth. By 2010, sludge quantities will remain at about 210,000 - 220,000 tds increasing to 250,000 tds by 2020. Over the next 10 years, the proportion of sludge recycled to agriculture will stay at 15% - 20% while recycling to other land uses is expected to be around 70-75%, landfilling reduced to 1% and 5%-10% for co-combustion.

United Kingdom

The following description is based on information provided by Matthews for the latest version Global Atlas (Alabaster and LeBlanc, 2008) and relates mainly to the situation in the England and Wales.

About 96% of the UK population is connected to sewers leading to sewage treatment works (DEFRA, 2002). Most of the remainder are served by small private treatment works, cesspits or septic tanks.

Sludge quantities have increased steadily over the last 15 years (see table below) to amount to 1.6 M tds in 2006. Historically, about a quarter of sludge was either dumped at sea or discharged to surface waters. This was banned from 1998 under the UWWT Directive because it was considered environmentally unacceptable.

Sludge recycling to land is encouraged in England and Wales as a contribution to the environment by recycling valuable nutrients and organic matter. It is recognised by the Government as the BPEO in most circumstances. Requirements are defined in the 1989 Sludge Regulations (derived from the sewage sludge directive) and the associated Code of Practice, and have been made more stringent by the agreement – the Safe Sludge Matrix - between the British Retail Consortium, Water UK (which represents the UK Water Utilities), and ADAS (the Agricultural Development and Advisory Service), with the support of the Environment Agency.

The most common option in England and Wales and in the UK overall for sludge disposal is recycling to agricultural land at around 70% in 2006 (see figures reported by CEC 2006 and 2009 in Table below) followed by incineration with subsequent disposal of ash to landfill. Landfill, which was always the less preferable option, is now used less due to increasing restrictions from the 1999 Landfill Directive, lack of site availability and costs. Liquid sludges can no longer be disposed of into landfill sites. In Scotland and Northern Ireland, incineration is the most preferred option treating respectively 51,000 tds in 2005 in Scotland and 22,000 tds in 2004 in NI.

	CEC 2006, 2009	**DEFRA web page**			
Year	**Sludge production (x10^3 tds)**	**UK sludge**	**England and Wales(x10^3 tds)**	**Scotland(x10^3 tds)**	**Northern Ireland(x10^3 tds)**
1995	1,120	1,124	993	93	34
1998	1,045	1,058	936	97	25
2001	1,187		1,137	-	-
2002	1,303	1,390	1,249	113	28
2003	1,360	1,422	1,280	113	29
2004	1,445	1,368	1,221	113	34
2005	1,511		1,369	140	. .
2006	1,545				

Year	**Quantities recycled to agriculture**		**Incineration**		**Landfill**		**Sea**		**Power generation**		**Land reclamation**		**Other**	
	(x10^3 tds)	%	**(x10^3 tds)**	%	**(x10^3 tds)**		**(x10^3 tds)**	%	**(x10^3 tds)**	%	**(x10^3 tds)**	%	**(x10^3 tds)**	%
1995	550	49	82	7	115		254	22	-		-		125	11
1998	504	48	185	17	115		150	14	-		-		105	9
2001	709	60					0		-		-			
2002	761	58	232	17	65		0		52	4	84	6	196	14
2003	824	61	227	16	38		0		50	4	106	7	177	12
2004	878	62	265	19	15		0		0	0	150	11	60	4
2005	1,056	70	NI		NI		0						NI	
2006	1,050	68	NI		NI		0						NI	

Untreated sludge is no longer applied in agriculture. The extent of dewatering and stabilisation varies from site to site. A variety of treatment methods might be used depending on the local treatment facilities. There is no set treatment requirement and many factors are taken into account to meet the required treated sludge quality.

A common method of treating sludge at present is anaerobic digestion to standards that meet the terms of the Matrix. After a period of doubt in the 1990's about the future of anaerobic digestion, the process now has a secure central place in sludge strategies and design and operation of plants has developed significantly. The process has been extended to higher levels of efficacy and effectiveness to meet the terms of the Matrix by the use of additional stages. These can also have the advantage improving product quality (that is, releasing ammonia, improving consistency, and reducing smell), producing gas and reducing volume. When digestion is used, the value of the energy created from the methane in the sludge gas is becoming increasingly important. Most sludges are now dewatered using centrifuges or belt presses. There continues to be an interest in other thermal processes, such as pyrolysis and gasification, but these are not currently available.

The application rate onto agricultural land depends on the crops, which can be a cereal, but on a local basis could be maize, rape, or sugar beet, (uses for growing potatoes and other root vegetable have become much less frequent in recent years). A typical application rate would be 6-8 dry tonnes/ha/year.

In the past, small quantities of sludge have been supplied to the domestic and horticultural market. The practice has not been widely encouraged for the domestic market due to the difficulties of effecting realistic controls over application and the disproportionate costs. One opportunity to supply a product would be as compost, which incorporated sludge with other materials. Investigation of this continues but, so far, products including a straw-based compost have not proved to be an attractive or cost effective product. If such products are supplied, there is a move towards the much tighter standards produced by the British Standards Institution, such as PAS 100, for composts, and details can be found on the SORP website.

Only a small amount of sludge is used in forestry and this will probably not increase in the future. Untreated sludge is no longer used for any part of the forestry cycle.

Sludge has also been applied on energy crops such as willow and poplar or miscanthus in short rotation plantations. The harvested wood can be used for a number of purposes, including use as a fuel source. The use of untreated sludge is permitted for these crops.

It is unlikely that the use of sludge on conservation and in recreational land would ever constitute more than a small fraction of the disposal of sludge. This market might be bigger than that at present if sludges were composted or dried and pelletised. The soil criteria for agricultural land apply, and it is likely that only fully treated sludge would be used, particularly on recreational land.

There is some use of sludge for land reclamation (i.e. capping landfill sites and creation of woodland on brownfield sites) However, these tend to be opportunistic and will probably never constitute a significant outlet for sludge.

In the future for our baseline scenario, the two main options will continue to be recycling to agricultural land and thermal treatment. The issues of energy consumption/production and carbon footprint will become important in assessing the sustainability of operations.

The UK is in the process of reviewing sludge use legislation. The UK Government has proposed the incorporation of the Safe Sludge Matrix into Regulations and could incorporate further changes to reflect any developments of knowledge and attitudes. If implemented, the Regulations would make many of the restrictions explicitly mandatory, rather than placed in a Code context. However as yet there are no firm indications as to when the law will be changed. Nevertheless the Companies are incorporating the principles in their operations. There is a clear awareness of the issues of risk management and accredited quality assurance programmes and many schemes have been registered under ISO 14000 or 9000.

Some of the changes to the Regulations would be:

- Use of untreated sludge would be banned
- Treatment will be in accordance with definitions of conventional treatment and
- enhanced treatment
    - Conventional treatment is 99% (2 log) reduction of E. Coli and an MAC of 100,000 per gram DS
    - Enhanced treatment is 99.9999% (6 log) reduction of E. Coli and an MAC of 1000 per gram DS and an absence of Salmonellae sp
- Ban the use of conventional sludge on grassland unless it is incorporated
- Restrict access for harvesting or grazing for conventional sludge to 12-month intervals for field vegetables and 30 months for vegetables eaten raw
- Max limit for lead lowered to 200mg/kgDS
- Max limit for zinc in soils pH 5.5-7.0 would be 200mg/kgDS and for pH values above 7 with a calcium carbonate content more than 5% would be 300mg/kgDS

For our baseline, sludge production is not expected to increase over the next 10 years from the 2006 level of 1.6 million tds. Recycling to agricultural land will also stay at a similar high level at around

65-70% over the next 10 years; incineration may increase to 20-25%; land reclamation will increase to 15-20% and landfill will remain low at about 1%.

Country	1995					2000					2005				
	total sludge	agriculture	incineration	landfill	other	total sludge	agriculture	incineration	landfill	other	total sludge	agriculture	incineration	landfill	other
	tds/a	%	%	%	%	tds/a	%	%	%	%	tds/a	%	%	%	%
Bulgaria	20,000	40		60		20,000	40		60		33,700	40	0	60	
Cyprus	7,000	10				7,000	10				7,586	47		50	
Czech Republic	146,000	20		50	40	210,000	45		30	25	220,700	10	10	10	60
Estonia												10			
Hungary	30,000					30,000					128,380	37	1	44	15
Latvia	20,000					20,000	37		38	33	23,942	37		38	33
Lithuania	48,000			90		48,000	10		90		71,252	23	0	77	
Malta															
Poland	340,040	8	8	56		397,216	14	6	50		523,674	14	1	18	70
Romania											137,145	0	2	98	
Slovakia								0			54,780	39	0	28	16
Slovenia											19,434	0	47	30	15
Austria	390,000	12	5	11		401,867	10	10	11	60	266,100	17	43	5	39.814
Belgium	87,636	32	34	32		98,936	13	76	14		102,566	12	81	3	14
Denmark	166,584	67	25			155,621	60	43	2		140,021	59	40		
Finland	141,000	33			66	160,000	15		6	80	147,000	3			90
France	750,000	66	15	20		855,000	65	15	20		910,255	58	16	20	3
Germany	2,248,647	42	30		30	2,297,460	37	34	3	20	2,059,351	30	38	2	29
Greece	51,624	0		95		66,335	0		95		125,977	0		95	
Ireland	38,290	11				35,039	40				62,147	63		17	20
Italy	609,256	26		30		850,504	26		30		1,070,080	26	7	31	40
Luxembourg	7,000	80			15	7,000	80			15	7,750	45	20		33
Netherland	550,000	0	100			550,000	0	100			550,000	0	100		
Portugal	145,855	30	0	70		238,680	16	0	84		408,710	46	0	54	
Spain	685,669	46				853,482	53				1,064,972	65			
Sweden	230,000	29		50	20	220,000	25		46	20	210,000	14	2	4	86.5
United Kingdom	1,120,000	49	7	35	9	1,066,176	55	21	5	16	1,544,919	66	19	1	15
EU12 % of total EU	8	1	0	4	1	9	2	0	4	1	12	2	0	4	5
EU15 % of total EU	92	36	19	14	12	91	34	22	11	12	88	36	21	9	18
EU27 % of total EU	100	37	20	18	12	100	36	22	15	13	100	38	22	14	23

Table 15 **Estimates of annual sewage sludge production and percentages to disposal routes, 1995 – 2005 (from data in this report)**

Country	2010 total sludge	2010 agriculture	2010 incineration	2010 landfill	2010 other	2020 total sludge	2020 agriculture	2020 incineration	2020 landfill	2020 other
	tds/a	%	%	%	%	tds/a	%	%	%	%
Bulgaria	47,000	50		30	20	180,000	60	10	10	20
Cyprus	8,000	50		40	10	16,000	50	10	30	10
Czech Republic	260,000	55	27.5	10	25	260,000	75	20	5	5
Estonia	33,000					33,000				
Hungary	175,000	77	5	11	5	200,000	58	30	5	5
Latvia	25,000	30		40	30	50,000	30	10	20	30
Lithuania	80,000	30	0	70		80,000	55	15	30	
Malta	10,000			100		10,000	10		90	
Poland	520,000	38	5	45	12	950,000	26	10	18	46
Romania	165,000	0	2	98		520,000	40	10	50	
Slovakia	55,000	50	5	5	10	135,000	50	40	5	5
Slovenia	40,000	10	50	20	15	50,000	15	70	10	5
Austria	273,000	5	64	1	25	280,000	5	85	1	10
Belgium	170,000	9	90	0		170,000	9	90	0	
Denmark	140,000	50	45			140,000	50	45		
Finland	155,000	5			90	155,000	5			90
France	1,600,000	60	17	24	3	1,600,000	65	17	15	3
Germany	2,000,000	30	50	0	20	2,000,000	30	50	0	20
Greece	260,000	10		95		260,000	5	40	55	
Ireland	135,000	75		15	10	135,000	70	10	5	10
Italy	1,500,000	50	10		20	1,500,000	70	15		20
Luxembourg	10,000	90	5			10,000	80	20		
Netherland	560,000	0	100			560,000	0	100		
Portugal	420,000	50	30	20		420,000	50	30	20	
Spain	1,280,000	70				1,280,000	70			
Sweden	250,000	10	15	4	81	250,000	15	10	1	74
United Kingdom	1,640,000	65	25	5	5	1,640,000	65	25	5	5
EU12 % of total EU	12	5	1	5	1	19	8	3	4	4
EU15 % of total EU	88	40	25	7	11	81	40	25	4	9
EU27 % of total EU	100	45	26	12	12	100	48	28	8	13

Table 16 **Estimates of annual sewage sludge production, and percentages to disposal routes, 2010 - 2020 (from data in this report)**

Environmental, economic and social impacts of the use of sewage sludge on land

Interim Report describing the first consultation

milieu
ENVIRONMENTAL LAW & POLICY

WRc

RPA

This report has been prepared by Milieu Ltd, WRc and RPA for the European Commission, DG Environment under Study Contract DG ENV.G.4/ETU/2008/0076r. The primary author was Anne Gendebien. Additional expertise was provided by Bob Davis, John Hobson, Rod Palfrey, Robert Pitchers, Paul Rumsby, Colin Carlton-Smith and Judith Middleton.

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Table of Content

1 Introduction

This report summarises the work done to date for the project “Study on the environmental, economic, and social impacts of the use of sewage sludge on land” (Contract Number: 070307/2008/517358/ETU/G4). It also summarises the responses received to the Commission's first stakeholders on-line consultation which was launched on 13 July 2009 for a 4 week period regarding possible revision of the Sewage Sludge Directive 86/278/EEC. Responses received up to 27 August have been considered.

This document presents a summary of the responses, including a breakdown by type of stakeholder. The two reports provided for the consultation provided a summary view of the current state of sludge production, treatment, use and disposal, and a view of the future amounts, treatment and disposal routes and possible influences (regulatory and public) upto the year 2020.

The report does not aim to provide a statistical survey of opinions. The consultants have responded to some comments with a short discussion, but have not intended to present a final view. The consultants do not necessarily agree with all the views expressed.

2 Scope and Objectives

The aims of the consultation were to invite stakeholders to review and comment on the two reports prepared for the Commission by the consultants. The first report summarised current knowledge on sewage sludge recycling to land. The second described sludge production, use and disposal assuming that no changes are made to the Directive up to 2020, as a baseline scenario. The Commission sought contributions from stakeholders which were structured around 3 general questions and 28 specific questions.

Respondents were invited to comment if they disagreed with the findings and/or to submit additional references to be included in the reviews. The consultation also sought to obtain more up to date information and to correct any misunderstandings or factual inaccuracies that had been reported in the descriptions of the situation in each specific Member State.

This report includes a list of respondents; a summary of their responses and a completed revised version of the country reports, main tables and figures published in the two reports. In addition, it contains additional sections to the original report when relevant additional references were provided. It does not include a revised full copy of the two reports nor the completed version of the responses. These remain available on CIRCA (http://circa.europa.eu/Public/irc/env/rev_sewage/home).

3 Facts and Figures

40 responses were received in time to include in this report. Some were joint responses and some originated from different organisations but reiterated some of the comments. 19 were received from governmental bodies, 18 from the private sector and commercial organisations or from associations with commercial interests, 2 were received from non-profit making organisations and 2 were from individual citizens with specialist knowledge.

Responses were not received from all the Member States (16 MS out of 27 + 1 non EU MS) but European representatives of commercial organisations from the agricultural, water and waste sectors as well as some of their national members were well represented. The ranking of the origin of the responses by nation is Germany, the UK and Belgium and France in the group of the top four countries. Due to the lack of response from certain organisations, the views of respondents described in this report do not necessarily represent the full range of opinions held by stakeholders within certain sectors (i.e. food manufacturers) of society or groups of the population (public citizens, environmental NGOs, etc).

Some respondents provided general comments whilst others provided detailed responses to all 28 questions and some additional material.

Table 17 Respondents to Public Consultation by Member State

Member State	Responses received	Public authorities	Organisations	General comments	Specific response to 28 questions
EU-15					
Austria	**2**	☺	☺	☺	
Belgium	**3**	☺		☺	☺
Denmark	**2**	☺	☺	☺	
Finland	**1**		☺	☺	☺
France	**3**	☺	☺	☺	☺
Germany	**6**	☺	☺	☺	☺
Greece	**-**				
Ireland	**-**				
Italy	**2**		☺		
Luxembourg	**-**				
Netherlands	**-**				
Portugal	**2**	☺	☺	☺	
Spain	**-**				
Sweden	**-**				
United Kingdom	**4**	☺	☺	☺	☺
EU-12					
Bulgaria	**-**				
Cyprus	**1**	☺		☺	
Czech republic	**1**	☺		☺	
Estonia	**-**				
Hungary	**1**	☺		☺	☺
Latvia	**1**	☺		☺	
Lithuania	**1**	☺		☺	
Malta	**-**				
Poland	**-**				
Romania	**1**	☺		☺	
Slovakia	**-**				
Slovenia	**1**	☺		☺	☺
EU	**7**		☺	☺	☺
Norway	**1**		☺	☺	☺
Total	**40**				

Table 18 Categories of Respondents

Respondent category	Total number	Sub-category	Number
Public authorities	**19**	National authority (MS)	11
		Regional authority (MS-R)	6
		Statutory advisor, agency, public institution (MS-A)	2
Organisations	**21**	International Professional association/federation (EF)	8
		National Professional association/federation (NF)	7
		Company/industry (IS)	4
		Consultancy	0
		Research/academic institute	
		NGO	1
		Other	1

Table 19 List of respondents

Name	Type	Country	Date Received
Official organisations			
IBGE-BIM (Brussels Institute for Environment)	MS-R	Belgium	14/07/2009
Leiter des Referts Vermeidung und Verwertung von Abfällen, Bayerisches Staatministerium für Umwelt und Gesundheit (Bavarian Ministry of Environment and Health)	MS-R	Germany	24/07/2009
Slovenian Ministry of Environment and spatial planning	MS	Slovenia	24/07/2009
Ministry of Environment/Waste Management department	MS	CZ	30/07/2009
Romanian Ministry of Environment	MS	Romania	06/08/2009
Danish Ministry of Environment- Environmental Protection Agency	MS-A	Denmark	07/08/2009
Baden-Württemberg - Ministry of Environment	MS-R	Germany	06/08/2009
North Rhine Westphalia Ministry of Environment	MS-R	Germany	07/08/2009
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (German Ministry of Environment)	MS	Germany	08/08/2009
UK Department of Environment, Food and Rural Affairs	MS	UK	10/08/2009
Agência Portuguesa do Ambiente (Portuguese Environment Agency)	MS-A	Portugal	10/08/2009
Lithuanian Ministry of Environment	MS	Lithuania	10/08/2009
Hungarian Ministry of Environment	MS	Hungary	11/08/2009
French authorities (secretaire general des affaires européennes- sgae)	MS	France	11/08/2009
Ministry of the Environment of the Republic of Latvia	MS	Latvia	18/08/2009
Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (Ministry of Environment)	MS	Austria	20/08/2009
Walloon Region Ministry of Agriculture, natural resources and Environment –Soil and waste department – soil protection direction (DGANRE-DSD-DPS)	MS-R	Belgium	10/08/2009
Flemish Region-OVAM (Flemish waste agency)	MS-R	Belgium	17/08/2009
Ministry of Agriculture, Natural Resources and Environment	MS	CY	26/08/2009

Name	Type	Country	Date Received
Commercial organisations			
FIWA (Finnish Water and Waste Water Works Association)	NF	Finland	10/07/2009
VEAS (Vestfjorden Avløpsselskap – Oslo water company)	IS	Norway	16/07/2009
Incopa (European coagulants producers)	EF	EU	23/07/2009
Ecosol (European producers of Linear Alkylbenzene)	EF	EU	23/07/2009
FederUtility (Federazione delle Imprese Energetiche e Idriche (Representative of local public utility companies)	EF	Italy	23/07/2009
Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA) (German Association of Water)	NF	Germany	24/07/2009
Alan Srl	IS	Italy	24/07/2009
Water UK	NF	UK	27/07/2009
DAKOFA (Danish Waste Management)	NF	Denmark	27/07/2009
FP2E (Professional Federation of Water Companies) (EUREAU member)	NF	France	27/07/2009
EUREAU (European federation of national associations of drinking water suppliers and waste water services)	EF	EU	27/07/2009
Copa-Cogeca (European Farmers and Agri-cooperatives)	EF	EU	27/07/2009
Austrian Chamber of Agriculture (Part of COPA-COGECA response)	NF	Austria	27/07/2009
Aguas de Portugal	IS	Portugal	29/07/2009
EFAR (European Federation for Recycling in Agriculture)	EF	France	31/07/2009
InSinkErator (manufacturer of food waste disposers)	IS	USA/UK	31/07/2009
EWA (European Water Association)	EF	EU	07/08/2009
EuLA (European Lime Association)	EF	EU	10/08/2009
Bundesverband der Deutschen Entsorgungswirtschaft (BDE) (Federation of German Waste Management Industries)	NF	Germany	11/08/2009
Others			
CIWEM (Chartered Institution of Water and Environmental Management)	NGO	UK	27/07/2009
CEN (European Committee for Standardization)	Other	EU	30/07/2009

4 Summary of Comments

4.1 General Comments

Sewage sludge, for the purpose of this consultation, is the product of treatment of sewage (and sludges) brought into domestic or urban wastewater treatment works and other similar sludges. This is consistent with the definition of sewage sludge given in the directive.

The boundary for the destination of sewage sludge for this consultation was agricultural land, although impacts of other routes have also been described. The desire of respondents to extend the boundary of the directive to include uses beyond arable etc. land to areas such as reclamation, recreational and energy crops, should be seriously considered.

General statements

Have all important sources been mentioned in the summary report in the existing knowledge?

Many of the respondents commented that the reports and sources used provide a good overview of the current situation. However, some respondents believe that a number of key references and relevant international but mainly national research papers have been missed. Some respondents also submitted more up to date figures especially for sludge production and outlets which were taken into account in revising the country reports. These additional references are listed in Annex 1 – some of these papers are not available in English.

Do you find the baseline projections in summary Report 2 realistic?

The majority of official respondents agreed with the baseline scenario for their relevant country or region, offered some corrections or did not have any comments.

A few, however, disagreed strongly with some of the assumptions and proposed alternative figures. Based on these comments the country reports and the tables in reports 1 and 2 were updated as well as the relevant figures. The revised tables are included in Annex 1. The figures will also be updated and included in the final report.

Other general statements

The majority of comments both from official and commercial respondents were positive and commented that both reports were well structured and presented an interesting overview of the situation encountered at EU level and had provided a thorough analysis of current and future risks and uncertainties.

The summary below is divided into 2 parts: the first part reports comments on the potential revision of the Sludge Directive and the second part includes comments on the information and analyses presented in the two reports

The following improvements to the studies were suggested and have been summarised under the main headings of the reports:

Overall comments:

- Should also describe other outlets.
- Should include industrial sludges, and sludge produced by the food and paper industries should be integrated into the baseline scenario.
- Imbalance between the presentation of benefits of sludge land spreading and risks.
- Too UK orientated.

- One respondent supports the use of the term "Wastewater Biosolids" instead of sewage sludge or "sewage bio-waste".

General comments on revision of Sludge Directive

The consultation has produced a considerable body of detailed comments and observations but little enthusiasm for major changes to the Directive. There is a general consensus amongst the respondents that the existing Directive has been demonstrably effective over many years and if they recognise a need to update the Directive, no fundamental changes to the principles used in the Directive are needed.

Most respondents support the need to revise the Directive while stressing that the current existing regime is safe and has guaranteed sufficient protection to health and the environment. However, the reasons for possibly revising the Directive and the extent of possible revisions varies greatly between respondents.

Most respondents support the recycling of sewage sludge to agriculture when carried out in accordance with appropriate standards. They stressed that the practice is safe and also represents by far the most sustainable option, particularly in the light of future challenges including climate change and declining phosphate (P) resources.

Some respondents strongly oppose the application of sewage sludge to land for precautionary reasons but favour the use of other sources of organic material such as high quality compost and the use of sludge in biogas production or other thermal treatment.

Some argue that any future policy changes should be proportionate to risk and that their potential climate change impacts should be balanced against potential benefits, others advocate the precautionary principle.

The majority of respondents support mandatory drivers such as the EC Directives as being useful, and to improve on the one hand the quality of sludges that are used on land, and on the other hand the management practices (soils to receive sludges, prohibition period before spreading and harvesting, etc.).

Several commercial respondents also stress the need for flexibility, notably with non mandatory drivers such as quality assurance schemes and different regimes for fertilisers derived from sludge: products (through the end-of-waste status), wastes; and the use of those fertilisers for food production under the waste regime should remain possible (with ad hoc standards, based on scientific risk assessment studies).

One respondent argues that as individual Member States have laid down stricter national limit values than those stipulated in the Sewage Sludge Directive this demonstrates that limit values in the Sewage Sludge Directive should be revised and extended.

Some would like a revision of the Directive to take into account technological developments (i.e. treatment processes), new research (i.e. contaminants and pathogens) and also to ensure uniformity with recent developments in European environmental legislation and policy.

Some or all of the following amendments were proposed by those who wanted revision of the Directive:

a) Extend the scope of application of this Directive to non-agricultural areas and to non-sewage sludge biowastes.
b) Revise current limit values for PTEs.
c) Introduce limit values for organic pollutants.
d) Introduce pathogen concentration limits.
e) Introduce a quality assurance system.

Scope of Directive

Several respondents argue that there is a need to extend the scope of the existing Directive, especially in the absence of a Soil Framework Directive , to take account of all land uses (both agricultural and non-agricultural). Although the use of biosolids in agriculture is regulated, there is no EU framework for the use of biosolids in forestry or for land restoration.

The revision of the Directive could also be an opportunity to harmonise existing regulatory regimes, by careful alignment with other areas, i.e. waste and resource efficiency, greenhouse gas and carbon accounting, energy, water quality and chemicals management and controls.

More than half the respondents considered that a potential revision of the Directive should also be extended to include all bio-wastes and argue that there should be a consistent framework of controls for all residuals applied to land.

The use of sewage sludge and other organic resources on land should be viewed from the perspective of the soil rather than from the origins of the materials. It is important to get away from "silo thinking" and take a holistic view of all aspects of organic resource. A recurrent argument is the fact that the spreading of manures and other residuals on land is not regulated although they can have similar environmental effects to biosolids, but they are 20 times greater in quantity than biosolids.

Sludge and soil quality

Pathogens link to health effects – only proposals that two levels OK; that reduced waiting periods for enhanced treated is appropriate.

The presence of some types of organic substances (OCs) in sewage sludge produced the greatest controversy between different respondents. Some respondents strongly promote the precautionary principle with regard to organic compounds arguing that lack of secure control on introduction of any substances into the sewage makes all sludges hazardous. The majority of those who commented did not have such strong views, and a significant proportion strongly argued that the currently applied conditions have not resulted in identifiable adverse effects on humans, agricultural animals or plants or the general environment.

The presence of potentially toxic elements (PTEs) as currently specified in the directive also led to opinion differences. Since generally PTEs have reduced, and there have been no demonstrated adverse effects, several respondents proposed that the number of controlled and reportable PTEs for sludge and soil should be reduced to two or three. The need for copper and zinc in some soils was also described and considered important not to unnecessarily limit concentrations of these elements.

Pathogens in sludge and soil were also discussed. In this case some respondents promoted the view that different standards should be harmonised, appropriate to different end uses, and that for the highest quality sludges the existing waiting periods between application and use should be reduced.

Overall there were no firmly described views on what appropriate standards should be present in a revised directive for any of organic substances, PTEs, or pathogens. There was also divergence between those who considered that a revised directive should have standards that all should meet, at a higher level than currently, and those that considered individual Member States should continue to take responsibility for setting their own individually decided standards more stringent than a revised directive.

The majority of respondents favour the option to keep sewage sludge as a 'waste' rather than a 'product' as it offers better control of the application under the waste legislation (traceability). Others are concerned that if treated sludge was defined as a product and fell under the REACH-regulation, all the requirements to fulfil the REACH regulations would be expensive.

Many of the respondents promoted the urgent need to have clear and linked legislation for combined treatment and use of manure, industrial organic waste, biowaste and sewage sludge.

Quality assurance

Some respondents favour the introduction of a quality assurance (QA) system but most do not see the need for an harmonised approach.

There are opposing views on listing treatment processes that may meet pathogen reduction requirements with some considering it necessary to list in a revision of the existing Directive possible treatment processes for the reduction of pathogens. Alternatively there is some support for HACCP[9] but not for a defined list of processes and their operating conditions. Use of HACCP to meet defined [risk-based] output standards is considered a much more robust and adaptable approach.

The double barrier principle is widely supported in which use-restrictions and level of treatment (e.g. with 2 categories: advanced treatment, and conventional treatment) are combined. This approach can be broadly regarded as a HACCP which has proven to be efficient and cost effective.

5 Comments on Reports

In this section respondents comments, discussion and criticisms of the contents of Report 1 and Report 2 are shown with short responses and observations. Example comments are included from individual responses to illustrate respondents views.

5.1 Sludge Quantity

Example respondents views include:

- *A clearer definition for the terms 'sewage sludge' and 'disposal' is needed to ensure that comparison between Member States is as accurate as possible.*
- *Concern about conflicting population estimates.*
- *Add quantities of sludge composted to the quantities reported to be spread on land to have the 'true' total of sludge recycled to agriculture and agricultural activities.*

Collating reported amounts of sludge production, and populations, from different sources led to some inconsistencies between values described in these reports. This highlights the importance of improving common definitions if it is considered important to maintain accurate ongoing publicly available statistics. Benefits would include the ability to identify the extent of differences between different Member States in production, treatment and disposal and so comprehend how EU and Member States mandatory and guidance requirements impact on different Member States, and consider what adjustments may be required to improve the route to common goals.

Although responses from respondents have enabled amendment of details, the overall impact on understanding amounts, processing and disposal routes has been small, and is not considered sufficient to revise the general conclusions. The absence of detail of some routes (composting, including use in horticulture, land reclamation, energy crops and forestry) was considered to be a defect in the report(s) which could lead to some underestimation of the total amount of sewage sludge used in beneficial soil recycling processes. In particular, reporting of the amounts of sludge used on agricultural land does not always include sludge used in composts that is then used on agricultural land (see details in country descriptions, Report 2). The reported agricultural route in 2005 used approximately 40% of

[9] HACCP – Hazard analysis and critical control point procedures – these have been prepared for some processes to identify measurement, sampling and analyses that provide information on process performance directly linked to achieving safety critical target values. For sludge treatment, control points might include temperature and retention times, to achieve treated sludge pathogen quality requirements.

EU sludge, and the reported amount of sludge that was composted was about 12% of produced sludge. From this it is clear that agricultural and similar recycling is the single largest ultimate destination for processed sludges.

There is a lack of clarity available at national summary level on the treatment history of sludges used in agricultural recycling. The purpose of the assessments was to provide an overview of routes and destinations rather than to fully account for all possible situations. Increased attention is now paid to the use of sludge for sophisticated renovation schemes, as well as for indirect uses, such as horticulture. Much of the sludge in the "other" category is used in forms of soil application not specifically described in the agriculture route. These conditions are likely to be subject to other planning or management conditions, including appropriate risk assessments or quality assurance schemes.

5.2 Sludge Quality Reporting

Example respondents views are:

- *Data on quality should cover all elements including pathogens and organics.*
- *Need to add a statement regarding the importance and purpose of presenting average sludge quality data.*
- *Lack of information in the report on the impacts of a possible revision/change of threshold values in PTE or OC in sludge. It is necessary to compare data for each country on sludge quality by size of WWTP or at least weighted taking into account the DS production. Described in this way great variations could be expected between EU 15 and EU 27 states.*
- *The range of P and N concentrations was questioned, particularly the extreme low and high values. The table did not show the designation of values (mg/kg DS, for PTEs, and % w:w for P and N).*

Comments on the relevance and importance of Potentially Toxic Elements (PTEs), Organic Contaminants (OCs) and pathogens in treated sludge and in soils are reported in sections 0, 0 and 0.

Opinions differ significantly on the importance of OCs in sludge and on the need to measure and limit them. These range from the strongly precautionary approach that would avoid risk from OCs by not using any sewage sludge on agricultural land, to the pragmatic approach that no evidence of harm from OCs has yet been demonstrated. A very wide range of OCs have been identified by different Member States, or regulatory bodies, as requiring measurement. It remains unclear what benefit has been gained by such monitoring other than a public perception that sludge quality is improved by using these controls. There may be an indirect benefit gained by ensuring that discharges from potential sources of the target OCs are better managed, leading to lower risks of damage to treatment processes.

A view was put to simplify PTE controls to limit regulation to 2 or 3 limiting elements, whilst continuing to monitor others for QA (quality assurance) purposes. Whilst this would support the principle of minimising regulatory requirements, the choice of PTEs for such regulation is unclear as there is no simple apparent link between a possible indicator PTE and the other currently measured PTEs (see Table 4, Report 1 for sludge PTE contents).

The current arrangements that require minimum standards, but allow Member States, or local regulators to create more stringent requirements have been widely accepted. Although sludge is not likely to be transported between agricultural areas to any significant extent, products from agricultural operations are increasingly moved between Member States.

5.3 Sludge Treatment and Current Practice

Example respondents views are:

- *Need to separate the proportion to "landscaping" from other outlets as it is an important route in a number of Member States.*
- *Important to distinguish between mono-incineration" and co-incineration", mainly because only mono-incineration makes it possible to recover phosphorus, from the ashes. Such recovery is increasingly important and the use of novel processes which also allow for phosphorus recovery such as super critical water oxidation should be considered.*
- *One cannot continue to present sludge incineration as a potential source of renewable energy. Sludge average dry matter content in Europe is probably circa 20 % which means that it will need energy to be burnt. Combustion of dried sludge is energy consumptive. Digestion is the only way to provide renewable energy during sludge treatment and has also the advantage of producing a final product that is easy to handle and odourless.*
- *A consideration that is elaborated upon less in the studies is the fact that the capacity for digestion and incineration in the EU-15 is expanding significantly. Encouraged by national financial incentives for the production of green electricity and green heat, the trend is that ever more sludge is digested (as pre-treatment) after which the dried sewage sludge is co-incinerated, in order to attain the European 2020 targets for renewable energy.*
- *Incomplete list of sludge treatment processes - Some treatments had not been considered or mentioned -i.e. solar drying combined with incineration which could have a positive impact – especially regarding greenhouse gases balance.*
- *Established and successful processes should be discussed equally to new processes and Annex 1 (Report 2) should describe all of the processes mentioned in the table on page 37 of Report 2.*

While several authorities and commercial stakeholders recognised the advantages of co-treatment of sludge (i.e. in co-incineration or co-digestion), some regard mono-incineration as the preferred option, in order to enable phosphorus recovery. Others disagree strongly with the statement that co-incineration in cement or coal fired powered plants should be considered as a recovery operation as ash can be used in brick or cement production.

Incineration use, costs, energy benefits and emissions are contentious with strongly held views for and against the use of incineration. Operators do use suitably prepared sewage sludge in modern incinerators to generate power, and assessments of energy balances show that appropriately chosen and operated systems are expected to provide a whole process energy benefit. Although the benefit is expected to be less than for anaerobic digestion a range of circumstances can justify use of incineration as a sludge powered generator.

In terms of any revision to the sludge directive incineration is a means of managing solids that otherwise would require unreasonably distant transport, and because sludges processed for and in incinerators are most likely to be derived from large conurbations that include surface and road drainage and industrial discharge content such disposal is an effective means of managing actual or perceived adverse contaminants. If the ash can also be used for mineral extraction (in particular, phosphorus) then an additional bonus can be gained.

There is expected to be a large increase in the amount of sewage sludge incineration, with some other thermal processes, throughout the EU to manage increasing amounts of sewage sludge, and limited availability of the agricultural recycling route in some areas. To reverse the trend towards more incineration would require either a ban on such a processing route or more substantial encouragement than could be envisaged in a revised sludge directive.

5.4 EC and Member States Legislation

Example respondents comments include:

EC legislation:

- *The lack of reference to the impact of the regulation on Animal By-products (EC Regulation 1774/2002 of October 2002).*
- *The lack of reference to the impact of the revision of IPPC Directive: the Industrial Emissions Directive.*
- *The lack of reference to the impact of an increase of sludge quantities from Landfill directive and WFD Directive and thus underestimation of sludge future quantities;*
- *Check description of Nitrates Directive.*
- *The European waste catalogue should be mentioned - urban sludge is referenced under the 190805 code.*
- *The fact that the EC Landfill Directive could have a negative impact and that the EC Incineration Directive could have a positive impact on sludge land spreading needs to be clarified. The Waste Directive could also have a negative impact on sludge land spreading if the composted sludge does not meet the end of waste criteria.*

Member States legislation

- *Some corrections and updates were provided and taken into account in the relevant country reports and summary tables and figures.*
- *Provide more detailed description of national voluntary quality assurance schemes and their multiple positive effects.*

Regulatory framework

- *A revision should maintain flexibility and give the opportunity to MS to enforce more stringent national rules to cater for the different local conditions of climate, soil conditions, and nutrient demand. For this reason, and in order to ensure sufficient soil protection, the Directive could be modified to take account of Article 175 EC.*

Respondents have suggested Directives or Regulations they consider likely to have effects on sludge treatment or disposal are either included within the reports with less than desirable detail and discussion, or are not included. This demonstrates the widespread links between existing legislation that affects sewage sludge treatment and destination, and hence the complexity involved in meeting all current or future requirements.

In Report 2 impacts of legislation have been categorised into positive or negative impacts on the amounts used on agricultural land; the impacts are not readily converted into amounts. There was some attempt in the judgements made on the amounts of sludge produced and the destinations described in Report 2 to take account of the impact of meeting the current nutrient removal requirements by all countries, as well as that of the reduction of availability of landfill.

5.5 Economics of Sludge Treatment & Disposal

Example respondents comments are:

- *Should have used more up to date data on costs.*
- *Sewage sludge use for biogas production and related renewable energy generated needs to be covered.*

- *Pyrolysis has proved so problematic so often that it is probably delusional to think that it holds promise for the future.*
- *Costs don't have to be broken down into transportation and dewatering or drying costs because decision making is on the global cost of each route. In some cases availability of farm land could be a more important criterion.*
- *Not included current costs, missing solar drying.*
- *Mono-incineration favoured for poor quality sludge to recover P.*

The costs described were used as an illustration of the effect of different treatment routes. They have been checked against WRc assessments of costs for some of the routes described and are in general agreement with the range of the costs. There are very substantial differences in precise costs related to factors that include different locations, sizes, and treatment requirements. Plant size is the most significant factor apart from the process and destination choice. The difference between a 50k pe works and a 200k pe works is likely to be in the region of x2 – x3 times more expensive (in NPC per tRwDS) for a 50k pe works. The costs shown include all parts of treatment and recovery including the value of energy recovery.

Although the costs were collated for 2002, it is WRc experience that the relative positions do not significantly change, and that adjustments for such guidance assessments can be made using inflation indices within reasonable periods of the initial assessments.

5.6 Agricultural Value of Sewage Sludge

Example respondents comments are:

- *Sewage sludge provides a predictable and reliable fertiliser response that has been well researched.*
- *Availability of P in sludges formed in bio-P removal is increased; reductions in P availability in chemical P removal sludges appear not significant.*
- *The description of P fertiliser use and availability in Report 2 has to be adapted to the EU context and shall not be limited to a global worldwide overview. It will then be possible to demonstrate that even with extended sludge land spreading only a small part of the crops needs in fertilizers will be covered.*
- *Much more emphasis on the decline in phosphate reserves is needed and the beneficial closed loop recycling sewage sludge contributes to the phosphate picture will be a vital part of the need to recycle to agriculture – it is becoming a need, not an option.*
- *A new phosphorus balance for Austria shows that P contained in sludge, meat and bone meal and not recycled biowaste can feed ~ 70 % of the whole crop area.*
- *Check P content as reported in Table 4, Report 1.*
- *The Nitrates Directive requires Member States to designate NVZs in which the limit of 170kgN/ha/year applies; other limits are set by local codes or regulations; the examples shown are for the UK using local circumstances to set limits.*

Few respondents considered that the risks considered by them to be associated with PTEs and OCs in sludge outweighed the benefits from nutrients and soil conditioning that could be achieved by using suitably chosen and treated sludge. The importance of the P content in sludge or that can be derived from sludge was described by many of the respondents. These benefits have been described in various sections of Report 1 and Report 2 (Section 2.7.1).

The amount of P in EU sludge (assuming P at 2% of dry matter) can be estimated at 11.8mt x 0.02 = 236,000 tonnes TP. Currently only about 40% of EU sludge is used on agricultural land (94,400 tonnes TP). Annual fertilizer P use in West and Central Europe is 1.381Mt TP (2006 data, IFA[10], converted to P from P_2O_5). Hence the amount of P in sewage sludge is insufficient to replace the

[10] http://www.fertilizer.org/ifa/Home-Page/STATISTICS

current demand, but making full use of sludge P would reduce the imported P requirement. Other biowastes could further supplement the P demand from recycleable sources. Respondents also commented on the value of recycling sewage sludge P in terms of reducing imported load of PTEs present in some P fertilizers, with particular reference to cadmium.

The range of P concentrations in sludge noted in Table 4 is reported to be wide and surprised some respondents. UK values are reported to be 3.5% P_2O_5 in digested cake or 1.5% as P; German values are reported by DWA as 3%-4% as P in DM. Reasons for differences have not been examined. One of the factors may be differences in the amounts of P removed from sewage.

5.7 Potentially Toxic Elements (PTEs)

Example respondents comments are:

- *Provide additional clear justification for adjusting soil metal limits for Cd and Zn and sludge limit for Pb.*
- *Dispute that the DEFRA study reported conclusion was that a precautionary change of Zn limit from 300mg/kg to 200mg/kg for soils of pH5-pH7 is appropriate.*
- *Decline in average reported PTEs (Table 4, R1) raises the question of whether it is necessary to regulate the current range of PTEs.*
- *There is a case to simplify the controls on PTEs in sludge and sludge-amended soil as concentrations of many of the elements that were important contaminants in sludge in the 1980s have declined below critical risk thresholds.*
- *One proposal is to keep in the statutory regime Zn and Cu as these are the largest concentration PTEs, and possibly Cd, whilst having just a monitoring of the other elements (e.g. Ni, Pb, Cr, Hg) for quality assurance purposes, in Member States where the concentrations in sludge are below risk thresholds, their specific regulation is no longer necessary.*
- *Any limit value for elements of copper (and zinc) in the sewage- sludge (and biowaste)-regulations must take into account the extent to which they are essential elements for plants and are deliberately added to some soils.*
- *In the identification of the costs and benefits of the Directive revision any tightening of soil limit values has to be assessed taking into account the existing data about heavy metal concentration in EU soils (particularly for nickel and cadmium).*

Many Member States have taken a more stringent approach in restricting permitted concentrations of some or all of the metals in soils and in sludges to be applied to soils. Some of the restrictions have effectively blocked sludge application to land.

No respondent offered clear proposed concentration values for limits to be set in any revised directive, other than by referring to the currently used values in individual Member States, and proposing that the Directive values should either be stricter, or relaxed for some of the metals.

5.8 Organic Compounds (OCs)

Example respondents comments are:

- *Give more detailed information on this topic and the associated risks.*
- *Chlorine solvents have been analysed over the last 20 years in Lombardy as routine and no trace of these substances has been found.*
- *Scientific evidence has not identified the need for statutory controls on organic contaminants at the European level to protect human health.*

- *Source control measures (e.g. REACH and WFD) will continue to have a positive effect on the chemical composition of sludge further reducing the risk of contamination with undesirable substances.*
- *Regulatory approaches – i.e. REACH - are not suitable to effectively control human exposure by restricting the accumulation of OCs in sewage sludge.*
- *Insufficient attention given to pharmaceuticals.*
- *Wide range of trace organic substances present in sludges whose effects are not known or substances like dioxins and dioxin-like PCBs underestimated; low concentration synergistic effects of substances not sufficiently certain to be assessed.*
- *New limit values for organic substances should be set (proposed values provided.)*
- *More thorough review of risks to humans due to leaching of contaminants from soils to groundwater, adverse effects on soil organisms and soil fertility, contaminant transfer into plants and surface water contamination. In particular, the risks associated with perfluorinated surfactants in the present study are not taken into account.*

There are strongly contested views on the need for limit values on specific organic compounds (OCs) in sewage sludge, backed by further studies submitted or referred to in the consultation responses that show risks sufficient to require limits or to support a precautionary approach of not recycling sludge to agricultural land (Rhine Westphalia, June 2005)[11], and that show risks insufficient to require any specific limits to be placed on organic contaminants (e.g. Norwegian Scientific Committee for Food Safety, August 2009)[12]. These two example contrary views are based on surveys of OCs in sludge that for many of the components appear similar in concentration.

Out of the 40 consultee responses, 8 would like OC limits, or stricter limits than currently in place in some location (with another respondent stating that any recycling is unacceptable), 5 argued that there is no evidence of sufficient risk to require limits on OCs, and another 4 that would prefer if limits are placed that they should be based on a common risk assessment and applied generally.

There were no common views amongst those responding in favour of introducing EU limits on OCs in sewage sludges on which substances should be regulated. The studies have not shown that any single or small group of substances could act as a marker for a larger range of substances.

There is no evidence that OCs currently in sludge have caused harm, and there are also indications that OCs concentrations have been reducing, possibly linked to improved discharge controls. A pragmatic approach which would retain pressure on producers to manage and minimise potential contents would be to introduce EU wide controls on one or two components, whilst retaining a principle that individual areas could impose additional restrictions on substances known in their area to have a particularly high likelihood of entering the system.

5.9 Pathogens

Example respondents comments are:

- *Although there have been many reported incidents of food-transmitted illness none has been associated with the use of sewage sludge on farmland by means that would comply with 86/278/EEC.*
- *Agricultural use of sludge treated to significantly reduce pathogens (but not necessarily to eliminate them) coupled with suitable land use restrictions, following the well established multi-barrier approach, is an acceptable and safe practice and should be maintained by the revised Directive.*

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[11] Ministry of the Environment, Conservation, Agriculture and Consumer Protection of the State of North Rhine-Westphalia, June 2005. Characterization and assessment of organic pollutants in Sewage Sludge.
[12] VKM – Norwegian Scientific Committee for Food Safety (2009). Risk Assessment of Contaminants in Sewage Sludge Applied on Norwegian Soils. ISBN 978-82-8082-338-0

- *Dispute that there are uncertainties in pathogen inactivation in treatment processes and that viable but non-culturable pathogens (VBNC) exist*13.
- *There is no evidence of land with long-term sludge application having greater background levels of a wider range of pathogens.*
- *Research is required on the impact of agricultural management practices on pathogen development in soils and consequent risk for human and animal health.*
- *Agricultural use of untreated sludge should not be permitted and is no longer regarded as acceptable practice.*
- *Waiting periods for sludge treated to eliminate pathogens are unnecessary and reduce the flexibility in end-uses of sludge processed to this standard.*
- *Support the flexibility of the existing Directive which enables Member States to set limit values (taking account of local circumstances) provided that they meet the minimum criteria established by the Directive. Whilst Member States should be encouraged to adopt a scientifically robust approach to setting standards in relation to sludge, it should be on the basis that adopting tighter standards is not only required but that there is a demonstrable benefit in terms of safety and increased environmental protection. At the same time any tighter standards should not limit the opportunities for beneficial recycling of bio-solids.*
- *It would be politically unachievable to obtain agreement on a common quality level, and subsidiarity is the best approach.*
- *A common risk management system should be used with harmonised values, and common QA requirement.*
- *All sludges to be fully safe for all handling: disproportionate and unnecessary as long as manure is used on land without similar treatment, or for that matter irrigation water.*
- *Dispute comment that "Aerosol measurements…the studies has been limited". Extensive research on this topic in the USA in all of the climate zones and with all types of sewage sludge has been carried out and has been published by Pepper, Gerber, et al. in peer reviewed journals and includes detailed risk assessments.*
- *Pathogen controls should include different levels of microbiological quality according to treatment status and end use.*
- *Food waste disposal (FWD) might increase the number of plant pathogens but they will not affect presence or absence. The steps in sewage treatment, sludge treatment and restrictions on harvest intervals and cropping will provide adequate barriers to transmission to crops.*
- *Clostridia spp are not a suitable indicator as it is 'cosmopolitan' and it forms thermo-tolerant spores, so reduction is not indicative of the effectiveness of treatment and presence is not indicative of risk.*
- *The problem of spreading of antibiotic resistance has not been adequately considered.*

There is a wide range of comments from respondents discussing or contesting matters in this section. These cannot be discussed in detail but it is not considered that they would lead to significant changes to general understanding of the current state.

Seventeen respondents specifically mentioned or discussed pathogens in sludge. Most of these either inferred or specifically described the evidence that there has been no adverse health effects on humans, animals or plants whilst using sludge for agriculture treated and recycled in accordance with the Sludge Directive requirements. Five of the respondents specifically described a desire for pathogen controls to be based on different standards for different purposes, and possibly even adjusting requirements by location as well, whilst three respondents would prefer consistent or harmonised controls.

[13] Examples of recent investigations of viable but non-culturable pathogens in biosolids and waters are reported in Alanya et al, (2009) Quantification of vbnc *E.coli* in dewatered biosolids through gene expression via RNA microarray - www.iwasludge2009.org.cn –Dunaev T, et al, (2008) Use of RNA based genotypic approaches for quantification of viable but non culturable *Salmonella* spp in biosolids Water Science and Technology 58 (9) pp1823-1828; Liu Y et al (2008) Detection of viable but nonculturable *E.coli* O157:H7 bacteria in drinking water and river water – Applied and Environmental Microbiology 74 pp1502-1507.

None of the respondents made any specific recommendations other than by referring to existing quality limits or more stringent recycling controls used in some Member States either as regulatory controls or as codes of practice.

Some countries have increased the level of controls, and a point has been made that the increased controls may have contributed to the lack of any observed adverse consequences. The precautionary approach was stressed, together with some particular concerns about antibiotic resistant bacteria pools retained in soils. On these matters, a couple of respondents have considerable concerns, stating that the risk has been greatly underestimated. Others put the counter argument that pathogen load in soils does not increase as a result of sludge recycling and that pathogens tend to be outgrown by the natural fauna.

Several respondents commented that public perceptions that sewage sludge use on agricultural land is significantly adversely influenced by odours generated during spreading operations. This can be translated into concerns about risks of contracting illnesses from pathogens in aerosols. Work on these has been carried out. One respondent considered that work carried out in the USA on health risks of aerosols has been sufficient and complete demonstrating no risk to the public. (The most recent publication from the group carrying out these studies has identified a small enhanced risk to operators, at a similar level to risks for a sewage treatment works operators (Tanner et al, 2008[14])). These reports are consistent with the lack of unequivocal epidemiological evidence of adverse health effects. The studies use good surrogates for potential bacterial and viral pathogens but inevitably suffer the disadvantage that assessment takes the form of infection rate prediction from concentrations of pathogens collected and assumptions of recipient sensitivity. It is more likely that public concerns will be managed by demonstrating that sludges distributed onto land are of a high and consistent quality, and provide real benefit to the soil.

There appears to be acceptance and desire for pathogen quality standards to be present in a revised directive. The desire expressed by some respondents for statements of suitable treatment methods may not be appropriate as it could lead to an undue reliance on the process principle rather than ensuring that the process is operated efficiently. However, that does not mean that a process could only be measured by the pathogen kill across the process. Determination of critical stages of processes required to maintain the required level of pathogen destruction and ensuring that they are met can provide sufficient management in conjunction with periodic pathogen concentration measurements.

5.10 Greenhouse Gases

Example respondents comments are:

- *The main assumptions taken into account to establish the comparison of greenhouse gas emissions need to be presented: dry matter content and the calorific value of the sludge used to establish the calculation have to be compared with the average quality of the European sludge for these parameters.*
- *Source study for Table 10 (Report 1) needs to be declared.*
- *Renewable Energy Directive should be considered.*
- *Several respondents argued that sludge recycling to land helps to reduce CO_2 emissions by building the so-called "sinks" - carbon sequestration in the soil (see Austria and Danish studies) while incineration of carbon, contained in ~25 tons (load of one lorry) of dried sludge, produces approximately the amount of CO_2 a middle class car emits by driving ~200.000 km.*
- *Greenhouse gas emission from mineral fertiliser production should also be taken into account in addition to the direct emissions from their application in the field.*

[14] Tanner BD, Brooks JP, Gerba CP, Haas CN, Josephson KL and Pepper IL (2008). Estimated Occupational Risk from bioaerosols generated during land application of Class B Biosolids. J. Environ. Qual. 37 pp2311-2321.

- *CO_2 from the combustion of biogas is short-cycle and therefore should not be counted, although obviously any release of unburnt methane does have global warming potential (GWP) 25x CO_2.*
- *The issue of N_2O seems to be exaggerated. N_2O is a 'leakage' product from nitrification (ammonia to nitrate) and from denitrification (nitrate to di-nitrogen gas). This is an 'inefficiency' of the biological pathway and unrelated to the origin of the ammonia or the nitrate. If sewage sludge supplies the fertilizer replacement equivalent of 100kg ammoniacal-N the N_2O release will be more or less the same as 100kg ammoniacal-N fertilizer. The fact that some organic N is not mineralized to ammonia in the first year and is not available to plants means that it will not be converted to N_2O either. Table 10 thus gives a very erroneous picture.*

The content of this section in Report 1 is derived from a variety of sources that include the UKWIR Carbon Accounting Workbook[15] and used by WRc in preparing comparative scenarios. Emission factors and methodology are founded on IPCC methods and emission factors.

The examples described in Table 10 are taken from a report that is not currently publicly available, but a similar scenario could be constructed for examination by respondents. The numeric examples are provided for illustration of the issues and are not designed to provide values for all circumstances within the EU. Nitrous oxide is recognised as an emission resulting from agricultural use of sludge (as well as from incineration) and measurements of the amounts have been reported (UKWIR CAW references). Estimates of these emissions are set against savings in emissions due to other fertiliser sources, as shown in Table 10.

The renewable energy directive (RED) encompasses sewage sludge as an energy resource. Assessment of the benefits of different processing and recycling options have not been carried out for this study but the examples and descriptions provided in this report, estimated in accordance with internationally accepted methodologies, are consistent with approaches described in the RED.

The amount and type of emissions from sludge treatment, recycling and disposal processes continue to be the subject of controversial discussion. There is a desire to act to minimise emissions from all stages whilst maximising energy recovery, for which anaerobic digestion is widely regarded as the most appropriate technology. There are disagreements and lack of secure comprehension of the factors that should be included in any comparative assessment. This includes the benefit that may be gained from using sludge as a carbon store in soil. If GHG assessments are to be included in a revision, definitions of the boundaries, and methods of assessments will be required.

Some respondents requested additional detail with regard to the content of the assessments summarised in this section and were unfamiliar with the concepts and values described. This was outside the scope of the section to develop to the extent that may be desirable.

5.11 Stakeholders

Example respondents comments are:

- *Policy owner to be included as principal stakeholders as well as agricultural merchants and supply chain contractors.*
- *The report should expand on this issue as food/retailer assurance schemes and customers are more reluctant to the spreading of organic waste-derived materials on land from sewage than to the spreading of organic waste-derived materials from animal origin (e.g. manure). Meanwhile media reports seem to become more sensational – all this could become a significant future risk and uncertainty so this issue is not addressed enough.*

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[15] UKWIR CAW Carbon accounting workbook - http://www.ukwir.org/ukwirlibrary/92805 -Workbook for Estimating Operational GHG Emissions (09/CL/01/9)

- *The unfolding and main conclusions of the "conference citoyenne sur les épandages de boues" held by the French ministry of the environment shall be presented.*
- *Risks should be borne by the producer not the landowner or farmer.*
- *There are examples of special interest nature groups in favour of sludge to agriculture (BUND in Germany).*

The comments above reflect the observations in a number of the responses that public perceptions and specific interest groups are major drivers in accepting or rejecting use of sewage sludge on land. Examples of large landowners who have a general presumption against use of sewage sludge have also been provided, together with municipalities (the public) where requirements on quality reduce the incentive to use sludge.

From the description of stakeholders which has been described with their different roles and interests, this consultation has not received submissions from farmers customers, food processors, retailers, the general public, or the media. Food retailers and grain merchants have had particular influence on changes in practices in the UK. Special interest groups have been limited to organisations with professional interests in processing sewage and sludges.

5.12 Future Trends and Issues

Example respondents comments are:

- *Too general. More detailed and concrete analysis of other possibilities of sewage sludge disposal and the relating legislative tasks is necessary. For example, the fact that the capacity for digestion and incineration in the EU-15 is increasing significantly, encouraged by national financial incentives for producing green energy.*
- *C-sequestration might be an upcoming driver which is rather underestimated in the Summary Report 2. Besides the foreseen lack of P might be a more increasing driver than mentioned, but difficult to say when and how powerful.*
- *Provide concrete examples/justifications for potential restrictions on the type of crops being used for sludge landspreading.*
- *Provide information on how the forecast for the "other" routes has been established.*
- *German – expect increased demand especially with improved quality & QA.*
- *Increased fertiliser prices positive impact on sludge demand.*
- *P fertiliser + practicability of P recovery from dewatering.*
- *Carbon sequestration and P shortage.*
- *Increased AD, more recycling.*
- *Nitrates directive – co-composting with green waste.*
- *More co-digestion, reduced proportion of industrial input.*
- *Pyrolysis weak or delusional future prospect.*

Six respondents made specific reference to this section, and some others made general comments that link to this section. One respondent would have liked greater development of the summary items.

Respondents suggested that in addition to the content of the section, the following should be included or enhanced:

- *Increased demand for sludge as a P source, and as a fertiliser, in conjunction with improved quality and QA systems to assure quality; and extraction of P from sludge by a variety of methods to different purities for use in fertilisers; there were no comments about availability of P in sludges linked to works in which chemical removal of P from sewage is practised;*
- *Clarifying the nature of additional sequestration of carbon in sludge, so that use of sludge in recycling is a carbon sink; this could lead to further encouragement of digestion and recycling rather than incineration;*

- *Co-treatment of sludge with other wastes is likely to increase; but needs consistent treatment across all wastes.*

The comments demonstrate that respondents have a strong sense that sewage sludge, when treated and processed to appropriate quality standards, will continue to be used in a variety of beneficial procedures, including perception as carrier of a valuable fertiliser resource. For use in co-treatment the status of both sewage sludge and other waste materials may require either regulatory clarity, including consistency with biowaste derivations and permitted uses, or specific encouragement.

5.13 Monitoring, Record Keeping and Recording

Example of respondents comments are:

- *The frequency of sampling of sludge should be adjusted according to the size of the WWTW and according to the use of the sludge.*
- *The agronomical characteristics of the sludge and of the soils of the land spreading area have to be regularly monitored. This would allow the establishment of a land spreading rate adapted to crops' needs.*
- *Nutrient management planning is necessary to ensure that all types of fertilisers being spread on land are in accordance with crops' requirements.*
- *Regarding the information required to be made available it is necessary to integrate:*
  - *The spreading rate per land unit.*
  - *The supply of total and available fertilisers spread per land unit.*
- *Information given to the final user about the origin and the quality of the sludge and agronomical advice has to be defined in detail.*
- *Better definition of analytical methods.*
- *High quality sufficient management.*
- *Mandatory QA.*
- *Flexible QA.*
- *Lack of discussion of different sludge and soil analysis methods.*
- *Identify control and monitoring in sludge treatment.*
- *Make clear total and available fertiliser used.*
- *Strengthen reporting requirements in a revised Directive so that more recent information including annual data can be available to the Commission without having to rely on other external sources and estimated data.*

5.14 Other Comments

The following are further comments made by respondents that cover more than one of the areas described in previous sections:

- *There is a need to research the effects of pharmaceuticals, endocrine disrupters, brominated flame retardents and antibiotic-resistant bacteria at EU-level as well as by individual national or regional authorities.*
- *Disagree with the comment that the application of sewage sludge in agriculture and for other land uses would be enhanced if sewage sludge was recognized as a product and stressed that it is not justified to exclude sewage sludge from the regime of the waste law.*
- *The benefits of using sewage sludge as compost was highlighted by several respondents as providing more advantages. They claimed it can contribute to reduce greenhouse gases as well as providing fertilizer value, as it can act as carbon sink and reduce methane emissions from landfills when used as landfill cover. Composting also helps in reducing collection, transport and disposal costs. This is particularly the case in developing countries where landfill gas collection systems are too expensive or technically impractical to implement.*

- *A guarantee fund should be created and risks should be borne by the producer of the biosolids and not by the landowner. Those who supply biosolids (or other organic soil treatments) for use on land should indemnify landowners for an extended period (perhaps 20 years) against the possibility of adverse effects from the biosolids until the risk of such effects emerging could be considered nil.*
- *Where sewage sludge has undergone suitable treatment, there should be no barrier to it being awarded an eco-label and that the existing Decision should be reviewed.*
- *Using LCA as a tool to determine the best solution for sludge management as long as it is done according to a uniform manner all over Europe (method, parameters, etc.) taking account of the work of the JRC on these aspects.*
- *To ensure wider acceptance a high level of quality and control seems necessary. End-of-Waste criteria might be one of more possible solutions. Should recycling be promoted (in line with the new waste directive) high quality should be the key word and sufficient management systems for sludge not meeting the criteria should be in place.*
- *EC regulations for chemicals and water protection are not always adequately recognising sludge issues although it is more cost-efficient to make actions at the source of pollution. One example of this are restrictions on using detergents with phosphorus. How will the zeolite nanoparticles affect sludge use? In many cases the restriction to use chemicals is done in legislation. It is not up to the water utilities to decide what kind chemical substances can be used in household chemicals or what kind of emissions enter the sewage work through air emissions.*

6 Responses to Specific Questions

The full copy of the responses is available on the CIRCA website http://circa.europa.eu/Public/irc/env/rev_sewage/home. The summary of the comments and the main points are presented below under each question.

The majority of official respondents have not provided responses to the specific 28 questions but have concentrated their comments on updating information pertinent to their country. Comments were submitted from the regional Flemish and Walloon authorities of Belgium, France, Germany, Hungary and Slovenia. For some specific questions, some official authorities (Germany, UK) referred to the information submitted separately by their national industrial federations.

Q1 – What are the special reasons in your country that result in a reported sludge production rate of less than 23kg/pe/year or greater than 28 kg/pe/year?

The official sludge production per Member States are presented below:

Member State	***Sludge production rate***
Belgium – Flemish region	17 kg DS/**pe**/y
France	20 kg DS/**capita**/y [a)] 16.6 -18.7 kg DS/**capita**/y [b)] 31,6 kg/capita/y [c])
Hungary	25.8 kg DS/**pe**/year.
Slovenia	10 kgDS/**capita**/y – wastewater systems not completed; 60% of population connected to 223 WWTW; 40% to cesspools.

a) The production of sludge per capita connected to the collection systems and wastewater treatment waste for a census population in 2006 of 63,235,568 inhabitants

b) By adding the theoretical sludge production from individual treatment systems

c) By adding quantities of sludge generated by industrial plants not connected to a network public collection and processing waste water

The commercial stakeholder comments are presented below:

State	***Sludge production rate***
France	18-19 kg/pe/y - lower values possibly due to old data and incompletely reconstructed treatment works.
UK	23.7 kg DS/**capita**/y
UK	The range of 23 to 28 kg/pe/year is actually quite low, equating to 63 to 76 g/hd/d. Production rates may be less than 23 kg/pe/yr where an aerobic digestion is effectively achieved during secondary treatment such as a nitrifying oxidation ditch, or where poor levels of treatment are achieved and solids are discharged.
Portugal	Estimate at WWTW of 22 – 23 kg DS/capita/y

Q2 - What change in the rate of sludge production do you expect will take place up to 2020?

The official comments on sludge production per Member State are presented below:

Member State	***Future sludge production (2020 (tds/y))***
Belgium – Flemish region	Slight increase
Belgium-Walloon region	Increase up to above 50,000 tds
France	*Increase of 17% to 1.4Mt ds*
Germany	No change
Hungary	Agree with assumptions
Slovenia	Agree with assumptions

The commercial stakeholder comments are presented below:

State	***Future sludge production (2020 (tds/y))***
Finland	The rate of sludge production will very probably grow in the future.
France	The forecast for French production seems unrealistic, and should reviewed. The estimated amount of 1,600 kt DS/year in 2010 (Table 5, p; 17) is too high, and should be lowered to 1,300 kt DS/year; this will be equivalent to a rate of 20 kg DS/capita. But this amount of 1,600 kt DS/year may be kept for 2020 (21 kg DS/capita).
Germany	A constant sludge production rate or maybe a slight decrease.
UK	Shift from 25 to 28 kg DS/capita as more sites are required to meet phosphate consents and this may be compensated by increasing solids destruction rates in sludge treatment, especially as the trend to more effective biogas production continues.
Portugal	In 2015 expect 750,000 tds/a (> report prediction of 420,000 tds/a).

Q3 - Why would any change in the reported rates of sludge production per person take place?

The official comments per Member States are presented below:

Member State	***Comment***
Belgium – Flemish region	Nutrient removal
Belgium-Walloon region	Population increase and progressive compliance with UWWT Directive

The commercial stakeholder comments are presented below:

State	***Future sludge production (2020 (tds/y))***
Finland	Onsite Wastewater System Decree (542/2003) came into force on 1.1.2004. The Decree sets minimum standards for wastewater treatment in the area outside agglomerations. The treatment of wastewater in rural areas with no centralized sewerage system will be improved greatly over the coming years due to this decree. The requirements in the Decree apply immediately to all new buildings, while wastewater treatment systems of buildings completed before 1.1.2004 must in most cases be upgraded to fulfil the new standards by 1.1.2014. To fulfil requirements a lot of new sewers will be constructed increasing the amount of wastewater and

	sludge. The number of onsite systems will also increase with a resultant increase in sludge generation. It is estimated that 90 % of the sludge from onsite systems will be transported for treatment in wastewater treatment plants. This will result in an increased sludge production per capita.
France	The improvement of treatment capacities and sewage systems will increase the sludge production.
Germany	Structural changes will continue (slowly) in Germany: Production of goods will go back in support of service industries. Thus less wastewater and sludge may be produced. Modernization in industrial production processes will lead to techniques which produce less wastewater or which are effluent free. More operators of wastewater treatment plants aim to establish new techniques to reduce the amount of sludge e.g. sludge disintegration.
UK	Increase due to implementation of WFD, EQS Directive 2008/105/EC and Landfill Directive but if legislative and economic incentives are used to encourage an increased use of anaerobic digestion this could slow the rare of increase in sludge production.
Portugal	Accomplishment of UWWTD with provision of advanced treatment.

Q4 – What proportion of total sewage sludge reported here is due to industrial sources in your country? Is this expected to change, and to what proportion?

The majority of respondents did not have that information but some were able to estimate the share between domestic and industrial sources.

The official comments per Member States are presented below:

Member State	***Comments***
Belgium – Walloon region	100% domestic
Belgium – Flemish region	No information
France	Current estimates load from domestic origin: 50 million pe compared with current received charges of approximately 75 million pe = domestic origin 2/3 and 1/3 of industrial origin. This proportion is however variable in the space and the time depending on developments in life and economic activity.
Germany	About 20% of the sludge production is due to industrial sources (no formal data, repeat estimate from commercial respondent): Total sludge production (TSP) in Germany : 2, 06 Mio t /y (ds) Raw Sludge production per inhabitant is about 80g/pe*d (ds) After digestion (>90% is stabilised by anaerobic treatment): 55 g/pe*d (ds) 82.000.000 pe * 55 g/pe*d * 365 d/y = 1,65 Mio t /y (ds) N 80% of TSP => ; 20 % of TSP is due to industrial sources.
Slovenia	No information

The commercial stakeholders comments are presented below:

State	***Comments***
Finland	At the moment many industries are connected to the sewer system. There is no reason to assume any major change to the current situation.

France	Only a small part of industrial effluents (from very small and small industries as food industries), since industries get their own WWTP).
Germany	The following estimation signifies, that in Germany about 20% of the sludge production is due to industrial sources: • Total sludge production (TSP) in Germany : 2, 06 Mio t /y (ds) • Raw Sludge production per inhabitant is about 80g/pe*d (ds) • After digestion (>90% is stabilised by anaerobic treatment): 55 g/pe*d (ds) • 82.000.000 pe * 55 g/pe*d * 365 d/y = 1,65 Mio t /y (ds) N 80% of TSP; 20 % of TSP is due to industrial sources
UK	Proportion of industrial effluent is unlikely to change however the composition may change due to improved practices and increased pre-treatment.
UK	The industrial contribution to the wastewater system is understood, but how much gets through sludge treatment and how much secondary sludge is generated from treating industrial inputs is difficult/impossible to model.
Portugal	Expect decrease in industrial wastewater.

Q5 – What proportion of your country is likely to have sewage effluent consents for: Total Nitrogen - Phosphorus ?

Information provided by official respondents is summarised below per Member States:

Member State	***Proportion of nutrient removal***	
	Nitrogen	***Phosphorus***
Belgium – Walloon region	Data not submitted.	Data not submitted.
France	By the end 2011: 90 to 95 % of the capacity of wastewater treatment.	By the end of 2011: 70 % of the capacity of stations wastewater treatment.

Information provided by commercial respondents is summarised below:

State	***Proportion of nutrient removal***	
	Nitrogen	***Phosphorus***
Finland	About 63 % of waste water nitrogen load. [a)]	Phosphorus - all country 100%.

a) Total Nitrogen removal is required in wastewater treatment plants where PE is over 10,000 and effluent is discharged to nitrate vulnerable water areas. Nitrogen removal 63% (based on assumption of 72% reduction in nitrogen removal plants, 40% (average) removal in other plants and 90% (voluntary) removal in Viikinmäki WWTP. Phosphorus 0.35 mg/l, removal 96,5 %.

Q6 – What are the likely consent values?

- ***Total Nitrogen < 15 mg/l – for what population***
- ***Total N < 10 mg/l, P < 2 mg/l – for what population***
- ***Total N < 10 mg/l, P < 1 mg/l – for what population***
- ***Total N < 10 mg/l, P < 0.2 mg/l – for what population***

Information provided by official respondents is summarised below per Member State:

Member State	***Population proportion***			
	Total N<15 mg/l	***Total N< 10 mg/l/ P<2mg/l***	***Total N<10 mg/l, P<1mg/l***	***Total N<10 mg/l, P<0.2 mg/l***
France	90 to 95% of the treatment capacity more than 2000 pe.	70 to 80% capacity treatment over 2000 pe.	70 to 80% capacity treatment over 2000 pe.	No processing unit sewage service. Some French facilities reach these results averaged annual data.
Slovenia	Requirements linked to WWTW population size			
UK	EA is regulator – consultation period insufficient to collate data			

The commercial stakeholder comments are presented below:

<table>
<tr><td rowspan="2">State</td><td colspan="4">Population proportion</td></tr>
<tr><td>Total N<15 mg/l</td><td>Total N< 10 mg/l/ P<2mg/l</td><td>Total N<10 mg/l, P<1mg/l</td><td>Total N<10 mg/l, P<0.2 mg/l</td></tr>
<tr><td>Finland</td><td></td><td>Total N < 10 mg /l – 63 % connected population = 2,8 million people.</td><td>P < 1 mg/l – connected population 15 % = 675 000.</td><td>P < 0,3 mg/l – connected population 50 % = 2,3 million people
P < 0,5 mg/l – connected population 35 % = 1,6 million people.</td></tr>
<tr><td>Germany</td><td colspan="4">Consent values are given in Annex 1 of the Waste Water Ordinance (Abwasserverordnung). An abstract is given as follows:
<table>
<tr><td>Size range
[kg/d BOD]</td><td>Total Nitrogen, sum of Ammonia, Nitrate and Nitrite
(N-total)
[mg/L]</td><td>Total Phosphorous
(P-total)
[mg/L]</td></tr>
<tr><td>< 600</td><td>-</td><td>-</td></tr>
<tr><td>600-6.000</td><td>18</td><td>2</td></tr>
<tr><td>> 6.000</td><td>13</td><td>1</td></tr>
</table>
BDE has no statistical data available on the respective proportions in Germany.
Your suggestions for demand targets on Nitrogen and Phosphorus that go below 10 mg N-total per litre and 0.2 mg P-total per litre are beyond the understanding of BDE, as these requirements seem to be rather too ambitious.</td></tr>
<tr><td>UK</td><td colspan="4">No comment</td></tr>
</table>

Q7 – What other combinations of consents may have significant impact on treatment processes?

Information provided by official respondents is summarised below per Member State:

Member State	***Comment***
UK	Requires information from EA

The commercial stakeholder comments are presented below:

State	***Comment***
UK	If regulators were to impose consents for endocrine active substances or other organic compounds they might increase or decrease sludge production; they would certainly increase the global warming potential of wastewater treatment. If consents are imposed for "heavy metals" to meet the WFD [literal] objective it would increase sludge production. Sidestream recovery of fertilisers (struvite and ammonium sulphate) from dewatering liquors seems to be fast becoming a practicable and commercial possibility that will have some impact on sludge production.
UK	Stringent BOD, suspended solids standards, ammonia standards will lead to increased sludge production. The tighter EQS Directive requirements will also lead to increased sludge production.

Q8 – How will these consents be achieved? Biological nitrogen removal Tertiary nitrogen removal using chemical addition (methanol) Biological nitrogen and phosphorus removal Chemical phosphorus removal Combination of chemical and biological removal Other likely common process combination

Information provided by official respondents is summarised below per Member State:

Member State	***Biological Nitrogen removal***	***Tertiary nitrogen removal***	***Biological nitrogen + phosphorus removal***	***Chemical phosphorus removal***	***Combination of chemical and biological removal***	***Others***
Belgium – Flemish region					√	
France	More than 90% of agglomerations ≥2000 pe	approximately 10 million pe	Exclusive biological phosphorus removal is marginal, usually coupled to chemical removal	widespread	30 million pe - typically implemented to achieve less than 2 mg/l because it minimizes sludge production and use of reagents	

Information provided by commercial respondents is summarised below:

State	*Biological Nitrogen removal*	*Tertiary nitrogen removal*	*Biological nitrogen + phopshorus removal*	*Chemical phosphorus removal*	*Combination of chemical and biological removal*	*Others*
Finland					√	
UK	All processes in use; other combinations may be required to meet the EQS Directive					

FI Practically all plants are using a combination of chemical and biological removal. Nearly all plants are using chemical phosphorus removal with ferrous chemicals. These will be used in the future as well to be able to achieve the consents for phosphorus removal. Only very few plants are using biological phosphorus removal.

Total Nitrogen removal is usually achieved trough biological nitrogen removal process. In Viikinmäki WWTP nitrogen is also removed in tertiary nitrogen removal using chemical addition (methanol). Population Equivalent of Viikinmäki is ca.1.000.000 people.

Q9 – In your country, what are the special conditions that encourage or discourage the amount of agricultural recycling?

Information provided by official respondents is summarised below per Member State:

Member State	*Encourage*	*Discourage*
Belgium – Walloon region	Political incentives. Confidence in sludge quality. Price of fertiliser.	Complexity of regulatory rules. Confidence in sludge quality. Price of fertiliser.
Belgium – Flemish region		The financial incentives for green power and heat make it financially more interesting to digest sludge (as pre-treatment) with a view to the production of biogas and then to dry and to incinerate as renewable energy.
France	Long experience of recycling sludge to agriculture. Availability of arable land. Interests of farmers for these materials. Strict regulatory framework, traceability of practices. Monitoring and expertise by qualified independent organization. Implementation of a risks guarantee fund to urban and industrial sludge application. Best economical and environment option. National support from some consumer and environmental organisations.	Negative public perception. Local lack of availability of suitable surface areas (i.e. vineyard, forestry, vulnerable zones, etc). Lack of confidence from farmers in some practices (sludge under status "product" exception to the rules). Restrictive requirements by food industry Variability of the sludge agronomical quality.
Germany	Increase in fertiliser prices	
Hungary		Ban in Natura 2000 areas. Nitrates directive requirements in vulnerable

		zones.
Slovenia	Future improvement in effluent and sludge quality; desirability of sludge fertiliser replacing cost of chemical fertilisers. Cost of exporting sludge to incineration. Ban on landfilling of sludge.	Current sludge quality with high metals content.

Information provided by commercial respondents is summarised below:

State	***Encourage***	***Discourage***
Austria	Regional differences in policy.	Regional differences in policy. Marketing programs of retailers, sugar industry, the Austrian Agrarmarketing Agency and organic farming are examples how to limit the use of sludge on land even under controlled conditions. Acceptance of sludge is low.
Finland		Environmental support includes limits and rules for phosphorus per hectare. Nitrates Directive is followed in the entire country and in some cases the nitrogen may be the limiting factor. Agricultural ministry decree 12/2007 allows maximum spreading amount of 1,5 g Cd/ha/a in agriculture as a 4 year portion which means 6 g Cd/ha/ spreading at one time. In some cases this is the limiting factor. The association of farmers is against sludge use in agriculture. In certain areas a lot of manure is available and thus there is no demand for sludge in the agriculture.
France	Stringent regulation framework accompanied by knowledge diffusion, transparency, chemical analysis and traceability of sludge recycling to land. Recent high prices of mineral fertilisers have been a very intensive driver for farmer's demand. Large land bank available.	"prohibition clause" in the terms and conditions from the Food industries, which, at regional level, may impact very negatively the agricultural recycling. Odour management is also important.
Germany	All requirements that guarantee a certain security on planning and disposal as well as enjoy the reliance of the user on NP-fertiliser products encourage the use of sewage sludge on land. Public confidence can be improved, for instance through mandatory quality assurances and quality management systems.	Requests by some pressure groups, which go beyond the legal demands, have a restrictive and thus discouraging effect on the use of sewage sludge on land. As an example, mill organisations or several potato producers in Germany generally object to the fertilisation with sewage sludge.

Germany	Policy Owners decisions (EC, Member State Governments and Regulators) that encourage or discourage agricultural recycling of sewage sludge will have the most influence on the amount of sewage sludge used as a fertiliser in future. In Germany the future amount of agricultural recycling of sludge will be decided by the legal regulations which are to be defined in future legislation, particularly with regard to the announced amendment of the German Sludge Ordinance as well as the fertilizer regulations.	Incineration appears to be a more reliable disposal route; co-incineration is economically priced even if transport of several hundred kilometres required.
Italy		Regional implementation (i.e. Emilia Romagna restricting utilisation in agriculture or the Veneto Regions which imposes severe criteria concerning WWTP sludges in compost production on a "precautionary principle").
Italy	Regional differences. Landfill Directive.	Regional differences. Nitrates Directive – supporting availability of land for livestock wastes.
UK	Stakeholder agreements of 1998	Odour - 'not causing odour nuisance' should be a legal requirement. Another weakness is that the 'Safe Sludge Matrix' has not been incorporated into the Sludge Regulations. A third weakness is that treatment and recycling of other organic residuals are regulated under different legislation and this inhibits co-treatment, which would otherwise be a good solution.
UK	Clear leadership from UK government as being the BPEO. Safe sludge matrix and involvement of key stakeholders in process of establishing the Matrix plus continuous engagement with them.	Perceived risks from supply chain particularly the grain sector.
UK	Availability of land for land spreading, suitable treatment capacity available and overall cost per tonne recycled.	Availability of land for land spreading, suitable treatment capacity available and overall cost per tonne recycled.
Norway	Lack of manure creates a demand for sludge for soils with little organic matter.	
Portugal	Unavailability of landfill. Anticipate improved processing controls and QA will improve public acceptability.	Sludge quality, lack of land bank near production sites, availability of organic materials with greater public acceptability, eco-label and restrictions on sludge recycling.

Q10 – What change do you expect to take place in the rate of agricultural recycling by 2020?

Information provided by official respondents is summarised below per Member State:

Member State	**Increase**	**Decrease**	**Status quo**	**Other**
Belgium – Walloon region	+ - reversing current trend			
France	Up to 75-80%			
Germany				Increased extraction of nutrients from sludge to apply with reduced contaminants
Hungary	+ (increase arisings and better quality)	- due to digestion and composting		
UK	Agree predicted effects and trends			

Information provided by commercial respondents is summarised below:

State	**Comment**
Austria	No change
Finland	It is very difficult to predict the future in agricultural use. The association of farmers is against sludge use in agriculture. At the moment only 3% of sludge is used in agriculture, but few years ago use was 10 - 17%.
France	Increase of sludge landspreading due to decrease of landfill disposal for which additional taxes are going to apply. Total amount of sludge recycled to land, and so the agricultural surfaces concerned, will increase but the proportion for agricultural recycling, will decrease to around 50%.
Germany	Following adoption of revised and more stringent German Sludge Ordinance, the amount of sludge marketed for agricultural uses will most probably decrease to 20% or less.
Italy	Stable situation regarding the agricultural landspreading.
Italy	Increasing difficulty in agricultural recycling.
UK	It will remain the same in ds terms but increase in tonnage terms as drying is phased out.
UK	With increased anaerobic digestion of bio-waste, and incentives on renewable energy and heat recovery, we would anticipate agricultural recycling to increase.
UK	The current 71% to agriculture will stabilise or reduce as utilities attempt to reduce exposure to the agricultural route.
Portugal	Medium term sustainability of agricultural recycling is small with competition from other organic wastes, reduced agriculture, and increased incineration capacity.
Norway	No change, increased QA and controls on pollution prevention.

Q11 – How will the existing regulations noted above affect your recycling and other disposal routes?

Information provided by official respondents is summarised below per Member State:

Member State	**Landfill Directive**	**Incineration Directive**	**IPPC**	**Waste Directive**	**Renewable energy**
Belgium – Walloon region	+				
France	Positive: reorientation of flows to agricultural recovery and incineration.			Negative: due to loss of traceability to the plot related to the output of the status of waste.	Neutral: Increase in the quantities of sludge processed by digestion (estimate) (delicate).
Belgium – Flemish region	Flemish legislation prohibits use of sludge in agricultural applications, from 2006.				
Germany	The EC and national regulations on sewage sludge will have a bigger impact than any of the mentioned directives.				

Information provided by commercial respondents is summarised below:

State	
Finland	European legislation does not have much influence in Finland since sludge use is mainly limited by national legislation and rules.
France	Landfill directive will not have a negative impact on sludge landspreading. The incineration directive will not have a positive impact as its implementation will globally increase the costs of the different sludge outlets. Composted sludge shall be integrated in the thinking about the end of waste criterion establishment for compost as it is currently considered as a product in France.
France	End-of-waste (EoW) status for compost is a key point for France, where, about 15% of the recycled sludges to land are composted. The existing EoW status (mandatory standard NFU44-095) for composted sludges has clearly been a driver for the development of composting ; in parallel, because composted sludges are without odours when spreading, because demand for soil improvers is increasing, and because storage is easy, composting has taken a key role in France. The IPPC regulations may affect not the development for composting or anaerobic digestion, because more stringent conditions have been set up for France in the past. But this could change the evolution of process for the new plants, according the future definition content for the “waste treatment BREF”.
Germany	The existing European regulations will have no additional impact in Germany, as the requirements imposed by European law are already completely met. No correlation with IPPC, as sewage sludge is not subject to the Directive.
Italy	Large increase in the cost of the different ways of sludge disposal (3-5 more in the last 5 years).
UK	RED and WFD will have a beneficial impact The Industrial Emissions Directive (old IPPC) will lead to unnecessary increased

	treatment cost and have a detrimental effect on recycling.
UK	There will be very little impact other than if lower PTE levels for soils are adopted.
Norway	No significant demand for eco-labelled sludge.
Portugal	Difficult within 86/278/EC to recycle sewage sludge to agriculture.

Q12 – Will the Nitrate Directive and the WFD have a significant effect on restricting or reducing the availability of land for agricultural recycling of sewage sludge? How much of an effect?

Information provided by official respondents is summarised below per Member State:

Member State	**Nitrate Directive**	**WF Directive**
Belgium – Walloon region	Difficult to evaluate but a slight decrease may occur at local level with maybe some increase in transportation costs.	
France	No as only approximately 3% of the available area is necessary for the application of sewage sludge. Some reductions locally, in vulnerable areas.	
Germany	Sewage sludge in Germany has to meet all the regulations laid down for fertilizers in general – so there will be no special effect of the nitrate directive for sewage sludge.	The discussions about the effects of the WFD are in Germany still in progress.
Hungary	Some impact on the rate of application of sludge per hectar.	Rules on the surface-, and groundwater protection contain territorial limits for the use of sludge.
Slovenia	Could have a significant effect on restricting and reducing the availability of land for agricultural recycling of sewage sludge. Also compete with manure and compost utilisation.	Could have a significant impact and reduce/restrict land availability for sludge recycling.

Information provided by commercial respondents is summarised below:

State	**Nitrate Directive**	**WF Directive**
Finland	In place so no further effect.	Current use of sludge in agriculture is very little and thus WFD is not going to affect it.
France	Has already impacted the sludge landspreading outlet mainly by the reduction of spreading rates and spreading periods. We do not expect additional impacts.	For the WFD see our remark above.
France	No real impact.	No real impact.
Germany	Has had the effect of reducing the available landbank but this reduction did not lead to serious reduction of the rate of sludge recycling to land.	Could lead to reduced localised sewage sludge application rates due to high soil phosphorus from artificial fertilisers. We do not expect this reduction to be widespread.

Germany	No additional changes for the agricultural recycling of sewage sludge.	No additional changes for the agricultural recycling of sewage sludge.
Italy	Reduction in availability of land in Northern Italy for a precise political decision to support and to facilitate the use of animal effluents although the landspreading represents < 5% of the available lands.	The application of the WFD will increase the production of sewage sludge in Italy.
Italy	Will be a negative effect on agricultural recycling. The indicated trends in local legislation are a clear signal.	Will be a negative effect on agricultural recycling. The indicated trends in local legislation are a clear signal.
UK	UK already operates within the Nitrate Directive restrictions and thus it will have no further impact. There is a real danger that the misinterpretation of Nitrogen application levels (Total versus Available) limits application rates to nonbeneficial levels when the negatives of soil compaction and low levels of Phosphate addition are taken into account.	
UK	Has significantly affected the availability of agricultural for sludge application.	Has to a degree affected the availability of agricultural for sludge application. The impact in relation to P requirements remains uncertain. This could lead to localised lowered sludge application rates due to high soil phosphorus content.
UK	May drive technology down the route of composting sewage sludge with green waste to produce a compost with low nitrogen availability. Will influence the return frequency to a particular piece of land and also the application rate, but it will not prevent sludge use.	Will influence the return frequency to a particular piece of land and also the application rate, but it will not prevent sludge use. The WFD is in a number of instances in conflict with the overall concept of sustainability by driving wastewater treatment solutions to ever more energy-consuming technologies.
Portugal	Reduce use as the ND only applies to organic fertilizers like sludge.	
Norway		More balanced use of fertilizers required linked to crop; further research on management practices to avoid excess P & N.

Q13 – In your country what are the most significant local restrictions on sewage sludge quality that affect the availability of land for sewage sludge recycling?

Information provided by official respondents is summarised below per Member State:

Member State	***Local restriction***
Belgium – Walloon region	PAHs and restrictions on sludge originating from STW that have treated leachates from landfills.
Belgium – Flemish region	Limit values on heavy metals, PAHs and other organic substances.
France	Metal content.
Slovenia	Heavy metal content in sludge.
Hungary	Extended metals list, plus limit values on PAH, PCB, TPH.

Information provided by commercial respondents is summarised below:

State	***Local restriction***
Austria	As stringent regulations have already significantly help in improving quality of sludge more stringent regulations would not affect the availability of land so much. Only copper could cause problems because of increasing contents.
Finland	Quality is not a limiting factor.
France	Spreading rates are mainly determined by the agronomical value of the sludge and are in very limited situations driven by PTE flows over 10 years. Soil heavy metal concentrations due to background level can affect the availability of land and lead to the establishment of a derogation file submitted to the local authorities as specified within the French regulation.
France	Some possible restrictions imposed by food industries or food retailers. Either on pollutants (for crops) or pathogens (for meat or cheese production) especially on grazing lands.
Germany	The revised version of sludge ordinance will most probably distinguish between three different types of soil: clay, loam/silt, and sand. That distinction will limit the use of sewage sludge in the near future. The main limiting factors in Germany include lead and cadmium.
Italy	Soil heavy metal concentrations due to background level can affect the availability of land and other general restrictions issued by national and regional authorities (such as distance from houses or from rivers and lakes or public wells). Strict regional limits on As reduce the use of some sludges.
UK	Nitrate Vulnerable Zones, Phosphorus Indices and Odour are the most significant local restrictions affecting availability of land for recycling in the UK.
UK	Rate of application is governed by N content determined by NVZ controls and crops requirements. Increased regulatory pressures from waste legislation on sludge application Specific restrictions from grain merchants.
UK	Sludges that have raised PTE levels (very rare nowadays) and soils with naturally occurring high PTE levels (e.g. Mendip Hills).
Norway	Soil phosphorus limits.
Portugal	Requirements for sludge pasteurisation, industrial effluents contamination of sludge, high odour.

Q14 – What changes to local statutory or practice requirements do you expect up to 2020 (in terms of limits on quality, etc.)?

Information provided by official respondents is summarised below by Member State:

Member State	***Change***
Belgium – Walloon region	Maybe introduction of P index for soils. Improvement of sludge quality due to better waste prevention and selective collection. Improvement in industrial discharge – increase sludge confidence. New rules in water protection zones.
Belgium – Flemish region	New limit values.
France	Increased control, tracking and information on sources, processing and disposal of sludge and materials used in forming the sludges.
Hungary	No comments.
Slovenia	No change.

Information provided by commercial respondents is summarised below:

State	***Change***
Austria	There are a lot of statutory and practice requirements and changes will be only marginal.
Finland	Legislation for fertilizer products, also for composts, soil improvers, growth medium or other type of materials made from sludge, was renewed in 2006. Any new changes are not expected locally.
France	None
Germany	The Sewage Sludge Regulation is currently under revision; the Fertiliser Regulation has been revised in 2008 and includes limiting values and restrictions for sewage sludge. If these requirements remain existent, we will face in Germany a shift towards thermal treatment of sewage sludge - simply for reasons of secured planning.
Italy	We expect new limits on organics pollutants by regional authorities.
UK	Implementation of WFD. Increase competition from industrial biowastes, composts and digestates following diversion of biodegradable waste from landfill. End of waste status could increase the range of opportunities and market outlets.
UK	By 2020 there might at last be quality assurance and independent audit, which were two of the promises in the 1998 stakeholder agreements.
Norway	Quality limits already strict, with already low organic micropollutant concentrations, so no major change expected.
Portugal	National limits on quality will become more stringent, including organic compounds and dioxin limits, and sludge pasteurisation requirements.
EU	Pathogen free sludge, use of recovered contaminant free P.

Q15 – To what extent do the current requirements in the EU sludge directive affect the availability of land for sludge recycling? To what extent are the requirements believed to be unsuited to current farming and public needs?

Information provided by official respondents is summarised below per Member State:

Member State	***Impact***
Belgium – Walloon region	Limited as regional regulations is more stringent than 86 Directive. Intermediate storage and quantity of N allowed to be applied are the real constraints.
Belgium – Flemish region	Existing limit values are not stringent enough to meet food standards.
France	Soil quality limits on nickel and soil pH in particular areas, but these are regarded as suited to current needs.
Hungary	Limited as additional restrictions are imposed under the national regulation, and current directive limits are the minimum required.
Slovenia	No change.

Information provided by commercial respondents is summarised below:

State	***Impact***
Austria	No impact as more stringent regulation in Austria than the current EU sludge directive. A new EU sludge directive should give more stringent requirements but also a need for enabling the use of sludge on land.
Finland	No impact on the availability of land for sludge recycling as sludge is recycled as compost used in landscaping or as soil improver outside the scope of the Directive. Revision of the EU legislation should include sludge compost and use in landscaping use.
France	Not enough requirements on the sludge quality control and on the traceability and monitoring of the sludge landspreading operations.
France	The current sludge directive does not reduce the availability of land in France.
Germany	No impact as stricter requirements under German regulations. A quality assurance is urgently needed as part of revision of the Sludge Directive.
Germany	No effect. However, previous pronouncements about imminent revision has created doubts in the supply chain if the current Directive is fit for purpose. This we believe may have led to some local erosion of confidence and the landbank. We believe that the current Directive is sufficient to prevent pollution/contamination from occurring when treated sludge is recycled to agricultural land thus preventing any long term damage.
Italy	Further reduction has been expected in 2009 as new rules will be applied on regional basis.
UK	No problem with land availability under current sludge Directive. However, potential revision has led to some uncertainty among stakeholder – need public statement from EC that the current Directive is fit for purpose.
UK	The only significant improvements needed in the sludge directive are a) to oblige ‘no odour nuisance’ when sewage sludge is stockpiled or applied to land and b) to revise the pathogen reduction requirements similar to the ‘Safe Sludge Matrix’ and require treatment to be based on HACCP. It would be foolish to introduce requirements to monitor organic substances of

	concern because surveys and risk assessments have shown that they do not pose risk to humans, crops, animals or the environment. It would be a waste of money to analyse for these substances routinely. However, occasional surveys and risk assessments of the results should continue.
UK	The omission of pathogen controls and cropping restrictions (as laid out in the UK Safe Sludge Matrix) does not allow full public confidence in agricultural sludge use.
Norway	Norwegian requirements are more stringent than the Directive requirements.
Portugal	The Directive allows different national interpretations on contaminant levels. There should not be national differences.

Q16 – In your country what changes to the concentrations of metals in sludges do you expect up to 2020?

Information provided by official respondents is summarised below per Member State:

Member State	***Comment***
Belgium – Walloon region	Slight decrease
Belgium – Flemish region	Slight decrease
France	Better control following implementation of WFD
Germany	Slight decrease

Information provided by commercial respondents is summarised below:

State	***Comment***
Finland	Major changes are not likely but some improvement and lower concentrations can be achieved locally.
France	Slight decrease, but it is likely we are reaching the background concentrations in sludges.
France	Slight decrease.
Germany	Any further reductions on current levels of metals are unlikely to be significant.
Germany	Some further potential to decrease for some metals. Nevertheless, due to diffuse and non-point sources, copper and zinc may increase, as they are still used as construction materials or in gardens.
UK	Continued decrease at a slower rate than the past 10-15 years. A more pro-active approach to small / medium industrial sites would reduce concentrations further.
UK	Improvement is possible but it will not happen unless there is encouragement, for example by publishing the sludge analysis data (anonomysed) so that companies (and stakeholders) can see how they perform.
UK	There is no scientific or agricultural evidence to suggest the lowering of any PTE soil levels but there seems to be an intention to do this.
Norway	Minor decreases as concentrations already very low.

Q17 – What changes to concentrations of the nutrients nitrogen and phosphorus do you expect up to 2020? Will changes to sewage effluent phosphorus concentration requirements affect the balance of nutrients in sewage sludge?

Information provided by official respondents is summarised below per Member State:

Member State	*Information*
Belgium – Walloon region	N content stabilised since 2005. However due to some treatment (i.e. liming) N content could decrease (due to dilution). Same for P as effluent quality improves but some treatment could have the opposite effect.
Belgium – Flemish region	Removal of nutrients (N and P) is mandatory in the Flemish region for wastewaters of agglomerations > 10.000 population equivalent (Flanders is 100% vulnerable area). Since 2006, all sewage stations in Flanders are equipped for nutrient removal.
France	No clear trends – Prohibition of use of phosphates in detergents should offset, in terms of national balance, the increase in requirements of treatment of phosphorus.
Slovenia	With improved waste water treatment system the concentrations of the nutrients nitrogen and phosphorus should continuously decrease (in sewage).

Information provided by commercial respondents is summarised below:

State	*Information*
Finland	New nitrogen removal wastewater treatment plants will be built. Phosphorus removal requirements will be more strict in the future for wastewater treatment plants. However, any major changes in sludge nutrient concentrations are not expected.
France	Higher concentrations of phosphorus are expected.
Germany	We do not expect major changes in nitrogen and phosphorus concentrations.
Germany	Since 1995, the concentration of Nitrate (N-total) in municipal sewage sludge increased from 34 to 44 mg per kg of sewage sludge dry substance. Regarding Phosphorus, the increase happened to be from 21 to 24.5 mg. It is assumed that the concentrations will also increase in the future. As Phosphorus is a highly valuable and finite resource, a future use of the resource through sewage sludge recycling is reasonable.
UK	Increase P removal will see increased P in sludge from those sites and this is likely at some locations to reduce the rate of application. An increased N removal is unlikely to lead to any significant increase in N content in sludge.
UK	As anaerobic digestion increases, the availability of nitrogen (N) will increase. Assuming that digested sludges will generally be dewatered, nitrogen as ammonia shall require either side-stream or main-stream treatment. Depending on the liquid effluent discharge standard, nitrogen will be released into the atmosphere as di-nitrogen via denitrification. Where chemical P removal is used, volumes of iron and phosphate-rich sludges will increase. Where advanced sludge treatment is used at P removal sites, iron dosing will have to be replaced to remove the risk of vivianite formation. Chemical P removal will have to be replaced with biological P removal, and forced struvite harvesting will have to be used to prevent recycling of phosphate rich liquors. In other words, N will be lost to the atmosphere. P will be bound as struvite in sludge, or harvested as struvite as stand-alone slow release fertiliser. Of course if drinking water were not dosed with P, if laundry and dishwasher detergents did not contain P and if P were recovered [as struvite] from dewatering liquor, the P concentration in sewage sludge would decrease.

Norway	No major changes.

Q18 – What are the proportions of your sludges that are treated with the following main processes: Anaerobic digestion (AD) / Advanced anaerobic digestion / Drying / Lime treatment

Information provided by official respondents is summarised below per Member State:

Member State	*Anaerobic digestion*	*Advance anaerobic digestion*	*Drying*	*Lime treatment*
Belgium – Walloon region	ND	ND	ND	ND
Belgium – Flemish region	49% anaerobic digestion (pre-treatment)		88% drying for incineration	
Slovenia	Agree with report estimations. Main process currently is drying.			
Germany	Refer to DWA paper on proportions of sludge treatment processes.			

Information provided by commercial respondents is summarised below:

State	*Anaerobic digestion*	*Advanced anaerobic digestion*	*Drying*	*Lime treatment*
France	60 to 70 plants (sources vary) and produce 345 GWh.th + 45 GWh.e	Not widespread	No data.	In 1997, the amount of sludge mixed with lime was estimated at 250,000 t DS, i.e. 30% of the French production (ADEME, 2001). No up-dated data is available, but on a sample of 600 WWTPs, a ratio of 15-20% is reported.
Norway	20%	20%	4%	42%
Germany	Detailed statistic data is given in: • Statistisches Bundesamt – Fachserie 19 Reihe 2.1 "Umwelt – Öffentliche Wasservesorgung und Abasserbeseitigung - 2004 " See Annex 1. DWA-Themen: „Stand der Klärschlammbehandlung und –entsorgung in Deutschland- Ergebnisse der DWA-Klärschlammerhebung 2003", see Annex 4.			
UK	Where possible anaerobic digestion (AD) should be used as almost the default sludge treatment process. Most, but not all AD sites will benefit from Advanced AD. Where there are existing spare assets, or there are low levels of primary sludge, Advanced AD appropriate. The overall may not be sustainability of Advanced AD over AD needs to be assessed on a site-by-site basis. Co-digestion would be very desirable if the [unnecessary] barriers to co-treatment were removed. Drying can be used to give a robust disposal route where an advanced treated sludge is required (under the sewage Sludge Matrix). Otherwise the sustainability of drying is questionable and it is likely to decrease because of the cost of energy and better dewatering of advanced AD sludge. Liming will decrease because of the cost of lime and the odour involved. Exceptions may be small rural sites, or emergency liming only.			

Q19 – What are the proportions of sludge converted or disposed of using: Incineration / Landfill / Other thermal processes (gasification, pyrolysis, wet oxidation)

Information provided by official respondents is summarised below per Member State:

Member State	***Incineration***		***Landfill***		***Other thermal processes***	
	Current	**Future**	**Current**	**Future**	**Current**	**future**
Belgium – Flemish region	88%	No increase	12% as landfill cover			Other techniques will be used such as wet oxidation. The use of sludge in agriculture will decline even further.
Germany	50		0			
Hungary			24	5.5	10	35.2(a)
Slovenia	25		50			
a) including incineration, biogas and renewable energy.						

Information provided by commercial respondents is summarised below:

State	***Incineration***		***Landfill***		***Other processes***	
	Current	**Future**	**Current**	**Future**	**Current**	**future**
Finland	Small amount	May increase			7% ***	
Sweden					3.5% ***	
France	18		12		nd	
Germany	49.4*		0.2		**	
UK	17		1		0	
Portugal	0	50			0	0
Norway	0		<1		0	
* thermally treated ** Gasification, pyrolysis and wet oxidation are no common techniques in Germany for sludge treatment. *** Kemicond process – not thermal						

Q20 – What are the likely impacts of the Nitrates Directives on the current sludge recycling proportion in your country? By how much?

Information provided by official respondents is summarised below per Member State:

Member State	***Impact of Nitrates Directive***
Belgium – Walloon region	Medium impact only in some areas.

Belgium – Flemish region	Large impact as the whole of Flanders has been designated as a vulnerable area – no application of sewage sludge in agriculture.
France	Marginal impact.
Hungary	The Nitrate Directive in itself does not limit the size of the agricultural lands suitable for sludge use, however other rules on the surface-, and groundwater protection contain territorial limits for the use of sludge. The Nitrate Directive has impact on the quantity of spreadable sludge. In Hungary the 170 kg nitrogen ha/year restriction is also applied for sludge.
Slovenia	The Nitrates Directive could be a significant restricting factor for the application of sewage sludge to land locally, in regions where nitrates vulnerable zones have been identified and intensive animal production zones, due to the fact that Slovenia has an intensive animal production.
UK	Detailed study required for definitive answer.

Information provided by commercial respondents is summarised below:

State	***Impact of Nitrates Directive***
Austria	No effect by ND because sludge and sludge compost are not considered a manure. Time and N limits exist since ~ 20 years by the national water regulation.
Finland	No impact.
France	No impact.
France	Very limited impact except potentially a slight increase of the spreading areas.
Germany	The Fertiliser Ordinance limiting rate for the use of sewage sludge is 40 kg NH_4-N or respectively 80 kg N-total in autumn, when the sewage sludge includes reasonable amounts of Nitrogen; there is a retention period for application in the winter.
UK	Unlikely to have an overall impact on the proportion and quantities of sludge recycled to land observed in the past 5 years. The main impact will lead to increase the distances travelled to application sites.
UK	The Nitrates Directive will drive the industry to produce thicker, drier sludges to minimize storage capacity outside of the closed period in nitrate vulnerable zones.
UK	No impact.
Norway	Little impact.

Q 21 – What local codes of practice or other restrictions related to land use have the greatest impact on sludge recycling to agricultural land in your country?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	Ban on sludge recycling on land growing vegetables.
Belgium – Flemish region	The administrative provisions in the Flemish waste legislation.
France	The obligation for sludge producers to plan applications and monitor the agronomic factors has the most impact on the sludge route. This is positive since this has

	improved confidence in sludge application.
Hungary	Range of statutory restrictions on use locations and crop restrictions including measures designed to avoid groundwater contamination or nutrient or toxic element enrichment.
Slovenia	The legal restrictions and public acceptance.

Information provided by commercial respondents is summarised below:

State	
Austria	Different regulations in federal countries, production contracts by food industry, retailers and Austrian Agrarmarketing Agency, organic farming.
Finland	Environmental support includes limits and rules for phosphorus per hectare for all fertilizers and also for sludge. According to the rules of environmental support 40 % of phosphorus in sludge is considered to be available to the plants and allowed amount of sludge to be applied to the fields is calculated accordingly. Typically amount of phosphorus is the limiting factor in agricultural use of sludge. Also nitrogen directive is followed in the entire country and in some cases the nitrogen may be the limiting factor. The decree issued by the Ministry of Agriculture 12/2007 allows maximum spreading amount of 1,5 g Cd/ha/a in agriculture as a 4 year portion which means 6 g Cd/ha/spreading at one time. In some cases this is the limiting factor.
France	Soil threshold value in heavy metals. Specifications of production contracts set out by food industries or retailers.
France	Additional restrictions from food industry on contaminants or/and pathogens.
Germany	Further restrictions imposed by e.g. marketers (i.e. potato producers) and land owners (i.e. the church) affect the use of sewage sludge on land. As already stated in the report, further restrictions exist for organic farming.
Italy	Sludge limits regarding As and other organic contaminants like MBAS and NPE.
UK	Safe sludge Matrix, Code of Good Agricultural Practice (2009), Code of Practice for Agricultural Use of sewage sludge (1996); The Application of HACCP procedures in the Water Industry: Biosolids treatment and use on agricultural land (Water UK 2004).
Portugal	Decree 118/2006 revised the transposition of the Directive into Portuguese law.
Norway	Measures to restrict soil erosion and loss reduce land available as sludge must be ploughed in after spreading.

Q22 – What changes in land use are likely to affect sewage sludge recycling?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	Same rules apply to recycling of sludge to agricultural and non agricultural land so no impact.
Belgium – Flemish region	The prohibitions to use sewage sludge for market vegetable, beet crop, etc.
France	An increase of agricultural land used for organic farming is expected, to reach 6 % by 2012. Sewage sludge cannot be used on this land. The impact is limited as the area required sewage sludge recycling in France is only about 3 % of the available

	agricultural area.
Hungary	Increase in forestation could reduce the agricultural areas suitable for sludge application. Organic farming may increase in smaller extent which can lead to narrowing of agricultural areas can be used for sludge application.
Slovenia	There are no changes in land use expected which are likely to affect sewage sludge recycling.

Information provided by commercial respondents is summarised below:

State	
Austria	Areas with high percentage of organic farming cause higher requirements on sludge treatment and extended transport distances.
Finland	Considerable amount of sludge is used as a landfill cover nowadays. In the future many landfills will be closed and new incineration plants will be built for municipal waste. In the future there will be no demand for sludge as a landfill cover.
France	Limited effect with the development of organic farming (up to 20% of agricultural land by 2020) as only 4%-5% of available land is used for sewage sludge and industrial wastes.
Germany	In the fruit and market gardening, on permanent grassland and in the forest, the application of sewage sludge is in Germany generally forbidden. With a different share in the cultivated land, namely more forest rather than arable land, the use of sewage sludge can theoretically be influenced, although changes are rather unlikely to happen. Organic fertilisers can be applied to the 2 million hectares of land used for energy crops in Germany.
Germany	We expect that changes in land use, e.g. increased cultivation of energy crops or more organic farming will only have minor effects on the rate of sewage sludge compared to the effects of future legislation.
UK	No changes foreseen that might influence agricultural recycling.
UK	The unlikely increase in organic farming area.
Portugal	Any change in land use will dramatically influent the rate of agricultural recycling.

Q23 – Will the lack of eco-label qualities (including organic farming) affect the use of sewage sludge in your country? By how much? Would other standards improve desirability?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	No effect as there are already certication in place.
Belgium – Flemish region	No effect.
France	The current level of recycling sludge in agriculture in France indicates that the presence or absence of ecolabel does not significantly affect use.
Germany	The effect of an ecolabel is expected to be limited. Rather promote quality assurance labels and quality assurance institutions.
Hungary	Products made of sewage sludge can only be marketed with permission in

	Hungary. By improvement of the quality of sludge it is easier to fulfil the requirements of product parameters.
Slovenia	The high quality standard of sewage sludge as the product is the only aspect which can improve interest and public acceptance.

Information provided by commercial respondents is summarised below:

State	
Finland	This is not an important issue in Finland.
France	The lack of eco-labels (on product containing sludge) does not impact reduce sludge recycling in agriculture. The main standard for improving desirability is the EoW (End of Waste) status for composted sludge.
Germany	As the eco-label excludes sewage sludge, no cause for concern. Quality assurance systems for sewage sludge have been developed and have led to a increased user confidence in the quality of the organic fertiliser; once established in the market they will have a positive impact on the use of sewage sludge.
UK	Current eco-labelling schemes or controls on organic farming have no impact on agricultural recycling in the UK. There are proposals to develop a BSI/ISO accredited standards for sludge and this would have a positive influence.
Portugal	Improving sludge quality standards will increase agricultural use.
Norway	Organic farming rules that prevent use of sewage sludge are opposite to a sustainable system.

Q24 – Are further restrictions needed on types of crops and or specific land areas (i.e. forest) or longer harvesting intervals?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	No additional restrictions are required as local regulations more stringent than the Directive.
Belgium – Flemish region	Yes. In Flanders there is no real quality assurance system in this regard.
France	Sludge recycling in forestry is currently under review. The use of sludge in land reclamation projects or recovery of soil is also envisaged. National restrictions in place for application before and during growth of food crops, with reduced restrictions if the sludge is pasteurised.
Hungary	Ban on sludge application in forests in Hungary. Set longer waiting periods as specified in Hungarian legislation (i.e. use of sewage sludge is prohibited in the year of growing and the previous year on the ground intended for the cultivation of vegetable crops and fruit which are in direct contact with soil. The Directive set a period of 10 months preceding the harvest of the crops and during the harvest itself. We find reasonable to maintain our national legislation taking into consideration the food-safety implications.
UK	Member States have produced their own further restrictions and are expected to continue to do so. It is better to share knowledge and experience.

Information provided by commercial respondents is summarised below:

State	
Austria	Crop production has to be based on fertilization plans and nutrient balances. Restrictions by special conditions (sandy soils, steep slopes, close to open water, etc.) have to affect every fertilizer.
Finland	One interesting option in the future would be using sludge in the forest fertilization. This is studied at the moment. Forests cover more than 70 per cent of the land area of Finland. A total of 20.3 million hectares is available for wood production. In Finland hygienization is required and other quality parameters are already in place for fertilizers and soil improvers also when used in forests. Thus there is no need for further restrictions.
France	No, the current requirements at EU level are quite good. Flexibility should be left to Members States to set up more stringent conditions, based on farming practices (grazing, etc), climate conditions, types of soils, local crops, etc.
France	No unless if there is a well demonstrated threat for human being or animals health.
Germany	The regulations in Germany are already quite strict and to some extent excessive. A loosening of these regulations would be desirable, especially with regard to an established quality assurance system (control of discharger and sewage sludge treatment, product analysis and application control) that would enable - under the respective local conditions - an opening for some restrictive areas**.**
Germany	The German sludge Ordinance already specifies several restrictions on types of crops and specific land areas in § 4 "Application bans and restrictions" (see Annex 5). We believe those restrictions should be revised employing scientific risk assessment methods and restrictions should be lifted or at least modified for sludge that has undergone advanced treatment to reduce pathogens.
UK	This is an area where the Directive could be strengthened and developed. Appropriate land use restrictions should consider the extent of sludge treatment and the microbiological status of treated sludge (in a similar way to how the current Directive differentiates between treated and raw sludge). Sludge treated to an enhanced standard to remove pathogens could be used without restriction, whereas that treated to a conventional standard would keep to the 10 month waiting period currently stipulated for all treated sludges (irrespective of the extent of sludge treatment). There is a need for better definition and explanation of the uses and types of crops that are suitable for the application of different sludge types and this should incorporate an expansion of the end uses of sludge to include land restoration and forestry. The UK Safe Sludge Matrix could provide a suitable framework for adapting the harvesting intervals; the adaptation would need to consider the range of conditions across the EU.
UK	There is no evidence that further restrictions are required.
UK	No
Norway	Any restrictions should be based on sound science and risk assessments.

Q25 - Should formal risk management methods be consistent throughout the EU?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	Not necessarily; subsidiarity should prevail.
Belgium – Flemish region	A quality assurance system (and corresponding appropriate environmental standards for input sludge) should be made mandatory before allowing the use of sewage sludge in agriculture.
France	Maybe relevant. A uniform system could include the 3 level: -Level 1: controls on the introduction of pathogens or hazardous substances in sewer networks. -Level 2: monitoring wastewater treatment plants and regular analyses of the specified substances in sludge. -Level 3: traceable activities from production of sludge till recycling to agriculture development, with strict technical guidance for application.
UK	Risk management methods need to be tailored to individual Member States. It is difficult to see how a fully harmonised approach could be designed or appropriate. Exchange of information with a view to dissemination and sharing of best practice in this respect is likely to be most helpful.
Hungary	Considering the different agro-ecological situations between the Member States, we do not prefer a formal common risk management approach throughout the EU.
Slovenia	The formal risk management methods should be consistent throughout the EU.

Information provided by commercial respondents is summarised below:

State	
Austria	Risk management has to be done by a quality assurance system. CEN/TC 308 should create a standard as a basis for a consistent regulation throughout the EU.
Finland	Risk management can be handled in a various ways. In Finland the focus is on the quality of the final product. Quality control has to be in place but it is up to the plant owner to decide points of monitoring and the implementation. Since quality control is used there is no need for new systems. New formal risk management methods would probably just add bureaucracy and work without real benefit. Information and guidance for risk management is useful, but any formal requirements would just add a new layer of regulations on the top of the existing ones.
France	Yes, it should be the basis for setting up thresholds on pollutants and pathogens concentrations in sludges, on dosage permitted per ha, on practices, restrictions, etc.
France	Yes and it has to be the basis used for the determination of threshold values.
Germany	As soon as European-wide criteria for the use of sewage sludge on land are set up it is definitely reasonable to adhere to uniform evaluations and standards.
Germany	Risk management is carried out differently throughout in the EU at the moment. National legislation and local regulators have approved current practices. If quality control is in place there is no need for new systems and new formal risk management methods. This would probably just add bureaucracy and costs without real benefits. Information and guidance for risk management is useful, but any formal requirements would just add a new layer of regulations on the top of the existing

	ones.
UK	Some guidance could be useful but it should be flexible enough to provide a consistent basis for assessment while allowing Member States to make their own decisions based on their own situations.
UK	There should be consistency at least to the extent that biased risk assessments are not used as justification for unnecessary or disproportionate controls.
UK	Yes, to avoid the unnecessary restrictions the oft used Precautionary Principle imposes.
Portugal	Management methods should be the same throughout the EU, but the risk assessments should take into account differences in climate and soils. The importance of public health and the environment is the same for all states.
Norway	Yes.

Q26 – Is sewage sludge likely to be used as a replacement for inorganic fertilizers? To what degree is the use of sewage sludge influenced by the market for inorganic fertilizers? Are the qualities of sewage sludge as a replacement for inorganic fertilizers sufficiently well understood to increase the demand for sewage sludge recycling onto agricultural land

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	Yes, sewage sludge is likely to be used as replacement for mineral fertilizer. Market prices for fertilizers has a great influence on the use of sewage sludge in agriculture.
Belgium – Flemish region	No, sludge cannot function as a substitute for artificial fertiliser. Artificial fertiliser works quickly and targeted, but its effect does not last long. Sludge shows results on the longer term (comparable to compost). Sludge and artificial fertiliser are therefore complementary rather than replacement for each other.
France	Only partial replacement of mineral or other organic fertilisers. Only partial impact of price of mineral fertiliser as sewage sludge contribute to about 1% for N and 5% for P of annual nutrient needs in France. Regular information on sludge production and application is collected and published.
Germany	The increasing prices for inorganic fertilizers will have a positive effect on the demand of plant nutrients from sewage sludge.
Hungary	Sewage sludge use – taking into consideration its compounds – will probably not replace the use of fertilizers, maybe can reduce it in a smaller extent. In Hungary farmers usually do not pay for the sewage sludge, but may cover the transportation costs. Bulk of costs is financed by the sewage plant. In spite of this sewage sludge use has minimal impact on the fertilizer market. The need using sewage sludge for agricultural purposes is emerging from the sewage plant and not from the farmers. Therefore several plants seek to make such kind of sludge which can be sold the compost as a product. In our view use of fertilizers can not be replaced by greater sewage sludge use because they have to meet different agrotechnical requirements and needs. Because of the quality and technological requirements certain intensive cultures require the use of inorganic fertilizers.
Slovenia	Sewage sludge could be used as a replacement for inorganic fertilizers if high quality standard for the product are enforced. In Slovenia in the last years the use of mineral fertilizers decreased due to the Nitrate Directive entered into force in

	2004 and Rules concerning good agricultural practice for fertilizing. The mineral fertilizers were replaced with farm fertilizer. The qualities of sewage sludge as a replacement for inorganic fertilizers are not sufficiently well understood in order to increase the demand for sewage sludge recycling onto agricultural land.

Information provided by commercial respondents is summarised below:

State	
Austria	Sewage sludge is one of several fertilizers to deliver nutrients and organic matter required by soils and plants. Fertilization plans and nutrient balances give exact information about limitations or the amount to be combined with manure or mineral fertilizers. Limitations by high nutrient contents in soils can be detected with analyses. High nutrient loads by high animal stocks or alternative waste fertilizers (compost, residues from food production, etc.) can be detected by nutrient balances.
Finland	There has been growing interest to use sludge in agriculture due to the increase of fertilizer prices.
France	Sludge is used as a replacement for inorganic fertilizers and is influenced by the price of inorganic fertilisers. To enhance the understanding of the agronomical value of the sludge by the farmer it is necessary to provide him with more information on: the sludge quality, the total and available quantity of fertilizing elements brought by sludge spreading on each plot of land, soils analysis results integrating fertilizing elements.
France	The use of sewage sludge in agriculture is based on its fertiliser value: without such a value, and without having proved it, it doesn’t make sense to use it on land. The price of mineral fertiliser is of great impact on sludge demand: see the past-period 2007-2008. The higher is the price of N and P, the higher is the demand. More research should be done in order to improve the technical knowledge on agronomical value of sludge (organic matter, N, P, K, CaO, MgO, SO3, etc.), with special attention on the impact on the real bio-availability for crops (or soil) according the process (thermal drying, composting, liming, etc.). The more we advise farmers to manage their N fertilisation, and so manage the right dose of N-mineral, the better it is for the credibility of sludge use in agriculture as a fertiliser.
Germany	Sewage sludge is already used as organic NP-fertiliser in agriculture and replaces the use of mineral fertilisers. At the same time, there is no competition between those fertilisers, as the need for fertilisers in Germany is much higher than it could be covered by sewage sludge alone. According to calculations, phosphorus that is available in the total amount of municipal sewage sludge/wastewater can cover 20 to 30 percent of the need of phosphorus in the agriculture in Germany. Establishing a comprehensive concept for quality assurance helps to increase the acceptance for sewage sludge fertilisation.
Germany	In Germany, according to fertilizer regulations, sewage sludge that fulfils legal requirements for agricultural use is classified as a normal fertilizer. The contents of nutrients must be considered in the same way as those of inorganic fertilizers. Thus any sludge application to agricultural land must be regarded as a replacement of other kinds of fertilizers, including organic fertilizers. The nutrient content of sewage sludge is well known and appreciated by farmers.

UK	Sewage sludge is always used as an inorganic fertiliser replacement and the sales value responds to inorganic fertiliser price movements. The replacement value of sewage sludge compared to inorganic fertilisers is thoroughly understood and only normally qualified fertiliser practitioners (FACTS scheme) sell sewage sludge to agriculture.
UK	Yes, sewage sludge is used primarily as a replacement for fertilisers. Increasing inorganic fertiliser costs will undoubtedly increase farmer interest in using sludge as an alternative cost-effective source of nutrients. Extensive field and laboratory based research has defined the agronomic properties of the principal conventional and enhanced treated sludge types recycled to farmland and this information has formed the basis of detailed fertiliser guidance available to farmers and operators. In the UK, for example, data from recent research programmes on the agronomic value of sewage sludge has been used to update the fertiliser guidance on sludge in a revised Fertiliser Manual to be published shortly.
UK	Sewage sludge should be used as an alternative; indeed it is already used as a (partial) replacement for mineral fertilisers. There is already good information on fertiliser value. Due to different nutrient balances, quaternary treatment processes such as forced struvite harvesting may have to be used to produce a good quality product as an alternative as slow release ammonium phosphate fertilizer. With a good reliable product, sewage sludge should be capable of driving the market of inorganic fertilizers, instead of the market of inorganic fertilizers driving the use of sewage sludge. Complete fertilizer replacement may not be achievable because of the balance of nitrogen to phosphate.
Portugal	Probably not as inorganic fertilizers are more efficient and do not have contaminants. As organic material has no market value farmers will only accept sludge at zero cost. There will be very large competition with compost after 2011.
Norway	Biosolids field trials have demonstrated their potential to replace inorganic fertilizers to some extent. The increases in price of inorganic fertilizers has increased demand for sludge; rising awareness of P as a finite resource will increase value of sludge. There is good understanding in the agricultural community of sludge qualities, but too many misunderstandings of safety of sludge.

Q27 – How will public opinion in Member States that currently send high levels of sludge to landfills (e.g. EU12) react to greater use of sewage sludge on land?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	Landfilling of organic waste is banned since 2007.
Belgium – Flemish region	This depends on the quality of the sewage sludge and on the quality assurance system in place.
France	No comment.

Hungary	According to the Act on Waste Management No. 2000 of XLIII.) until 1st of July 2009 the biodegradable municipal waste going to landfills must be reduced to 50 % of the total amount (by weight) of biodegradable municipal waste produced in 1995 and to 35 % until 1st of July 2016. Taking into consideration the reduction of organic compounds contained in other waste flows we do not plan the co-treatment of sludge with municipal solid waste.
Slovenia	The acceptance for use the sewage sludge on land could be achieved with high quality of the product, public awareness, presentation of good practices, etc.

Information provided by commercial respondents is summarised below:

State	
Austria	In all areas where sludge is used on land under controlled conditions, the public acceptance is very high. People who are informed that sludge is compost derived from their wastewater accept the use on land when the benefits for protecting resources and reducing energy consumption by short transport distances and standard treatment are shown properly.
France	The public is generally not aware of the exact quantity of sludge spread on land. Increase of sludge quality control and deeper monitoring of sludge landspreading operation is the best means to increase public confidence.
France	No comment.
Germany	Sewage sludge contains fundamental nutrients that should be made available and that should be used also for reasons of resources protection. In Germany, only high quality sludge is in fact disposable for recycling, and successful concepts on how sewage sludge qualities can be improved are already in place. The use of sewage sludge of lower quality for thermal treatment is desirable, as it embodies two main advantages: 1. Generation of energy (heat and electricity) from renewable sources. 2. Recovery of valuable resources out of the incineration ashes (currently only realisable after mono-incineration and with high financial burdens).
Germany	If the switch from landfill to agriculture in EU12 is correctly managed and compliance with process/protocols is maintained, then it will be perceived as the ‘right thing to do’ and the best practical environmentally option and be seen as a fully sustainable solution.
UK	Not relevant to the UK. In countries where landfill is currently the dominant disposal route for sludge, consumer acceptance of agricultural recycling will require a suitable education programme, investment in upgrading treatment processes to control odours and pathogens, measures to reduce contaminant inputs and field scale demonstration to farmers.
UK	It is difficult to gauge the overall likely public opinion across Member States that currently send high levels of sludge to landfill and it is likely that there will be marked differences. Public perception of the use of sludge on agricultural land is considered to be a key challenge which must be addressed in the future. Use of more appropriate terminology (“biosolids”), the use of quality assurance schemes and education regarding the benefits of harnessing renewable energy, and supplementing fertilizer usage has to be maximised. Odour is also a key issue and must be addressed. If the sludge “stinks”, the public will be hostile. If it does not smell objectionable and if the benefits are explained (i.e. that instead of squandering P, it is going to be conserved) then the public will be likely to accept.
UK	Initially there will be resistance but with education there will be acceptance.

	The decline in phosphate resources needs emphasising as does the damage landfill emissions cause the environment.
Portugal	Public acceptance of sludge use in agriculture is low mainly because of poor stabilisation, odour release and poor practices.
Norway	It is a challenge to communicate and build confidence on these matters.

Q28 – Will the co-treatment of sludge with municipal solid waste become an important path for the future?

Information provided by official respondents is summarised below per Member State:

Member State	
Belgium – Walloon region	Yes co-treatment via co-digestion or co-incineration will increase.
Belgium – Flemish region	In Flanders, co-incineration of sewage sludge with high calorific waste represents 40% of the treatment of sewage sludge via incineration.
France	Co-treatment would be one option for specific situations. Quality control of all inputs and through all the process route is necessary particularly with variability of other solid wastes.
Hungary	There is no plan for co-treatment of sludge with municipal solid waste.
Slovenia	Co-treatment of sludge could become an important path, when composted with biodegradable waste (quality management!) or in anaerobic digestion plants with energy recovery. It would be necessary to distinguish between sewage sludge from the municipal sewage plant and from industry or combined sewage plant which strongly influence the product quality.

Information provided by commercial respondents is summarised below:

State	
Finland	Finland is a country with scattered dwellings and small population. It is very natural due to these circumstances to develop co-treatment projects to have enough input material to have economically and ecologically viable solutions. Co-treatment of manure and sludge and co—treatment of sludge and municipal or industrial waste are relevant in Finland. We believe this is an important path and should be encouraged in EU regulations.
France	Interesting in order to reduce cost of capital (waste treatment plant as composting e.g.), to develop a real territorial waste management approach and to combine technical synergies (optimal CHP for energy recovery, optimal humidity for AD, etc.). In order to develop, some barriers have to be broken: – Financial burden: because sewage sludge and municipal solid wastes (MSW) are often managed by different authorities, innovative entities have to be set up, as public private partnerships (PPP) in order to gather and to make contribute all the stakeholders to the capital cost for treatment plants. – Administrative burden: the regulation framework is currently too conservative and brings artificial borderlines (for example, the proposed biowaste directive excludes sewage sludge from its scope, even when sludges are recycled according the same principles of other organic

	fertilisers as biowastes). – Technical burden: from the past experiences we know, co-treatments which have been implemented have to over pass technical barriers linked to the mix of inputs having different characteristics (calorific power mainly).
Germany	Mainly depend on the regional conditions and the respective waste targeted for cotreatment. For separately collected biowaste, the co-treatment in WWT digesters is often too complex, and also other efficient treatment practices have been established (e.g. composting, digestion). Not expected to be a reasonable development in the future. Cost-effectiveness can especially be given for paste-like organic wastes. General interest of the operators is of course to exhaust their full capacities and thus to co-treat adequate waste streams. In Germany, a separate authorisation is hereby needed, as the added waste then underlies water laws rather than waste legislation.
Germany	Co-digestion of food and other adequate organic wastes is an ecologically worthwhile method to significantly improve energy balances of wastewater treatment plants. Unfortunately very complex legal requirements (in particular Directive 1774/2002 concerning animal by-products) handicap a widespread implementation of co-digestion.
Italy	No, we don't think that this will be an important path for the use of the sludge in agriculture.
UK	Co-treatment of sewage sludge and biowaste is a critical path for the future and can play an important role if unnecessary regulatory barriers in the UK are removed. It is already practised in some other Member States (most notably Denmark), but the UK inhibits co-treatment by different barriers, which could be removed with no detriment to the environment. The potential volume of biowaste sludge by far exceeds the volumes of sewage sludge. Bio-sludges without the badge 'sewage' will compete for recycling routes making recycling of sewage sludge harder. The treatment of sewage sludge in the water industry is well established, and there is a high degree of expertise already operating. The water industry needs to use its skills, and take advantage of the opportunities presented by the co-digestion of sewage sludge and bio-waste. Sewage sludge contributes a good nutrient medium and carrier / dilution medium to be used in conjunction with commercial bio-waste.
UK	Co-treatment, particularly co-digestion and to a lesser extent co-composting are likely to increase in future. Co-digestion could maximise use of the existing infrastructure operated by the Water Industry for waste treatment and increase renewable energy production and co-composting could produce soil improver products that may meet end-of-waste criteria. The threat to these co-treatments lies in a regulatory regime which continues to see treated sewage sludge as a waste to be tightly controlled rather than as a resource to be used.
Portugal	Yes, co-treatment in some circumstances is the best available solution. Co-incineration with energy recovery will be practised in Portugal after 2013.
Norway	Seems unlikely.

13 Annex 1 – Additional references suggested by respondents

The following references are listed as supplied by respondents. Relevent references have been reviewed and will be included in the final report.

Alborg University (2002) Center for bæredygtig arealanvendelse og forvaltning af miljøfremmede stoffer, kulstof og kvælstof; det strategiske miljøforskningsprogram 1997-2000 slutrapport - http://info.au.dk/smpsmp_dk/Publikationer/Slutrapport/KH%20-%20Slutrapport.pdf
Budewig (2008)

Kerst, M. and Körner, W. (2003): Untersuchung und Bewertung von Proben aus verschiedenen Umweltkompartimenten auf PCDD/PCDF sowie PCB unter Berücksichtigung der neuen WHO-Toxizitätsäquivalenzfaktoren. Abschlussbericht zum FuE-Projekt Nr. 7000 (01.12.2000 – 28.02.2003). LfU Augsburg.

Körner, W., Kerst, M., Waller, U., Köhler, J.,van de Graaff, S. Schädel, S. (2007) Untersuchung und Bewertung von Proben aus verschiedenen Umweltkompartimenten auf PCDD/PCDF sowie PCB unter Berücksichtigung der neuen WHO Toxizitätsäquivalenzfaktoren. Abschlussbericht zum FuE-Projekt Nr. 7000 (01.03.2003 – 30.11.2005). Bayerischen Staatsministeriums für Umwelt, Gesundheit und Verbraucherschutz, Augsburg, April 200711. The report can be found at: http://www.lfu.bayern.de/analytik_stoffe/forschung_und_projekte/untersuchung_bewertung_proben/index.htm

Mogensen, B., Bossi, M., Kjær, J., Juhler, R., Boutrup, S. (2008) Lægemidler og triclosan i punktkilder og vandmiljøet. DMU nr. 638, 2008. NOVANA-Screeningsundersøgelse af det akvatiske miljø. http://www2.dmu.dk/pub/FR638.pdf.

Barkowski, D., Machtolf, M. and Raecke, F. (2007) Vorläufige Bewertung von PFT in Klärschlamm. FKZ 3707 33 308 – Abschlussbericht. Umweltbundesamt, Projekt-Nr.: P 207132, November 2007

Barkowski, D., Günther, P., Machtolf, M. and Raecke, F. (2007) Characterization and assessment of organic pollutants in Sewage Sludge from Municipal Wastewater Treatment Plants in the State of North Rhine-Westphalia. Ministry of the Environment, Conservation, Agriculture and Consumer Protection of the State of North Rhine-Westfalia. Düsseldorf, June 2005. –

LfU (State Institute for Environmental Protection Baden-Württemberg) (2003). Contaminants in arable soils in Baden-Württemberg fertilised with sewage sludge. Concise Report, 0949-0256, No.16, Landesanstalt für Umweltschutz, Baden-Württemberg, Karlsruhe 2003

http://circa.europa.eu/Public/irc/env/soil/library?l=/biowastesandssludge/noncommissionsbackground&vm=detailed&sb=Title
LfU (2006) Neue Entsorgungeswege für den bayerischen Klärschlamm- Technische Möglichkeiten und Erfahrungsberichete – Bayerisches Landesamt für Umwelt, Augsburg, 2006. http://www.bestellen.bayern.de/application/stmugv_app000003?SID=2093186121&ACTIONxSESSxSHOWPIC (BILDxKEY: lfu_abfall_00134, BILDxCLASS: Articles, BILDxTYPE: PDF) = X to &quot

Esperanza, M., G. Herry, F. Manciot, J.M. Laîné (2006) Analysis of Estrogenic Hormones in Natural Waters, Wastewater and Sludge. Results from the First International Round Robin Test, Water Practice & Technology, vol 1, no 2. IWA Publishing 2006, doi10.2166/wpt.2006.033.

Bachmann Christiansen L., Winther-Nielsen M. and Helweg, Ch. (2002) Feminisation of fish. The effect of estrogenic compounds and their fate in sewage treatment plants and nature. Environmental Project No. 729, 2002, Miljøprojekt. Danish Environmental Protection Agency. http://www2.mst.dk/Udgiv/publications/2002/87-7972-305-5/pdf/87-7972-306-3.pdf)

Stoumann Jensen (2008) Presentation - http://www.dakofa.dk/downloads/Konferencer/080515,%20seminar%20om%20Slam,%20affald%20og%20CO2/1100,%20Lars%20Stoumann%20Jensen,%20KU%20Life.pdf

Ramboll (2008) Livscyklusvurdering af disponering af spildevandsslam. Sammenligning af forskellige behandlingsmetoder. September 2008, Ref 08727406 I00028-4-PRP(2)

http://www.dakofa.dk/downloads/Arbejdsudvalg/slam/Moede%20081118/LCA,%20slamdisponering,%20Ramboll%202008.pdf

Leschber (2004) Evaluation of the Relevance of Organic Micro-Pollutants in Sewage Sludge and Proposal of Appropriate Limit Values for Sludge Application on Agricultural Soils. EU-JRC, 2004:

CEC (200?) Workshop - Session 2 Pollutants and nutrients in sludge and their effects on soil, vegetation and faunasee also: http://ec.europa.eu/environment/waste/sludge/pdf/workshoppart3.pdf

The reports published by the French national veterinary health monitoring unit on sewage sludge land spreading (put in place in 1997) (http://www.ademe.fr/Collectivites/bois-energie/pages/Filiere/cellule_veille/default.htm).

The following CEN reports :

- CR 13846:2000: *Recommendations to preserve and extend sludge utilization and disposal routes*

- A report on risk assessment related to sludge management, published in 2007 :
CEN/TR 15584: 2007: *Characterization of sludges - Guide to Risk Assessment especially in relation to use and disposal of sludges*

The following CEN technical reports might also be of particular interest for your study.
All three belong to a series of guidelines of good practice for sludge management (see also Fig.1 p.4).

- A guideline of good practice for hygienisation of sludge (also known as Guide 10):
CEN/TR 15809: 2007: *Characterization of sludges – Hygienic aspects – Treatments*

Two CEN guidelines of good practice for sludge management have been reviewed and their revised version will soon be submitted to validation.

- The first of them, utilisation in agriculture is already listed in Table 14 in its current published version (CR 13097: 2001, also known as Guide 4):
prCEN/TR 13097: *Characterization of sludges - Good practice for sludges utilisation in agriculture*

- The second is not yet listed in Table 14, it touches all use & disposal routes:
prCEN/TR 13714: *Characterization of sludges - Good practice for sludges management in relation to use or disposal* (current published version: CR 13714: 2001; also known as Guide 2).

Arthur Andersen (1999) - Audit environnemental et économique des filières d'élimination des boues urbaines Audit environmental and economic channels urban sludge disposaltudy water Inter-agences

WOLFF (2000) Relation entre micropolluants organiques (2000 échantillons), éléments traces metalliques (4000 échantillons), paramètres agronomiques, pH et matière sèche des boues de station d'épuration d'effluents urbains (données de 1998 à avril 2000)

AGHTM (2002) Impact du futur projet européen sur la valorisation des boues en agriculture, campagne d'analyse sur 60 boues de stations d'épuration (ETM, MPO),

Anjou recherche & Suez environnement - février 2006 - Présence et devenir des perturbateurs endocriniens dans les stations de traitement des eaux résiduaires urbaines.

INERIS, ADEME, SYPREA, SPDE octobre 2007 méthodologie d'évaluation des risques sanitaires des filières d'épandage des boues urbaines et industrielles

INRA et Université d'angers - mars 2005 Faisabilité de la quantification dans les boues de *Listeria monocytogenes* et des entérocoques par les techniques de biologie moléculaire, en comparaisons aux méthodes culturales

IRH environnement – février 2007 - Contamination potentielle des échantillons de stations d'épuration (eaux brutes, eaux traitées, boues) et effluents d'élevage par des molécules pharmaceutiques à usage humain et vétérinaire.

Programme HORIZONTAL programme de recherche financé par l'UE (DG ENV) caractérisation des sols, des boues et des composts. Pour plus d'informations : http://www.ecn.nl/horizontal/index.php

Guide technique élaboré par un groupe de travail **"Dérogations relatives à la** réglementation sur l'épandage des boues de stations d'épuration - Comment formuler une demande pour les sols à teneurs naturelles élevées en éléments traces métalliques ? " (mobilité et la biodisponibilité des éléments traces dans les sols)

Pesticides dans les boues. le rapport en français est disponible à l'ADEME

Base de données ANADEME qui est disponible, et le rapport qui sera publié l'année prochaine. Le tout peut servir pour évaluer les impacts des valeurs "seuils" choisies pour les sols, en fonction du pH. Cette base de données regroupe les données d'analyse de sols effectuées dans le cadre du décret boues de 1997 (notamment ETM) et représente environ 11 000 échantillons géoréférencés pour la plupart. Le rapport présente de nombreuses statistiques et cartographies, issues des traitements des données à différents niveaux (départements, national). pré-rapport final à disposition

ADEME/SOGREAH: mars 2007 Bilan des flux de contaminants entrant sur les sols agricoles de France métropolitaine – Bilan quantitatif de la contamination par les éléments traces métalliques et les composés traces organiques et application quantitative pour les éléments traces métalliques http://www.ademe.fr/Collectivites/bois-energie/pages/Filiere/cellule_veille/default.htm

SIGEMO (Système Informatisé de Gestion des Epandages de Matières Organiques) Les ministères en charge de l'agriculture et de l'écologie ont confié au CEMAGREF la conception d'un outil de suivi des épandages d'effluents organiques (boues de stations d'épuration urbaines et industrielles, effluents d'élevages, composts), inter opérable et appuyé sur un système d'information géographique – SIG, et ouvert à des utilisateurs variés (administrations, collectivités territoriales, bureaux d'études …) via le réseau Internet

http://www.cemagref.fr/le-cemagref/lorganisation/les-centres/le-centre-de-clermont-ferrand/ur-tscf/systemes-d2019information-agri-environnementaux-communicants/sigemo-systeme-informatise-de-gestion-des-epandages-de-matieres-organiques

Plaquette de présentation communicable au format pdf.

ERESFOR– mars 2007 - Epandages expérimentaux de produits résiduaires sur parcelles boisées – Bilan et synthèse des expérimentations menées en France et recommandations techniques

14 Annex 2 – Country files

Reviews of individual EU countries are presented, with summary tables of annual sludge production and percentages to different disposal routes shown as Table 1 (1995-2005) and Table 2 (2010-2020).

Austria

The following description is based on information provided by Kroiss for the latest version Global Atlas (LeBlanc *et al*, 2008) and a presentation given by Doujak in 2007. *This report has been revised following comments received from the Ministry of Environment during an on-line consultation in August 2009.*

At the end of 2006, there were about 1,500 agglomerations including 641 agglomerations ≥ 2000 pe in Austria with a generated load of 19,712,580 pe. At the end of 2006, the rate of collection and treatment improved up to 98.8% of the total generated load and 95.6% had more stringent treatment. The remaining population has individual treatment systems (for example, septic tanks, cesspits). A 100% connection rate is not considered realistic in Austria (BMLFUW, 2008 as reported in Olivia *et al*, 2009).

The annual sludge generation is reported to vary between 11 to 32 kg DS per capita per year (Doujak 2007). In the period 2001 to 2007, municipal sewage sludge quantities increased at an average rate of 1% per annum. This can be related to population growth, increased sewer connection and higher standard of living. The quantities of industrial sludge increased at an average rate of 2.3% per annum over the same period.

In 2005, municipal sewage sludge production in Austria amounted to 266,000 t DS in 2005 including 28,000 tds of imported sludge ; 47% were incinerated; 18% was recycled to agriculture, 1% sent to landfill and 34% by other routes such as composting (77%); landscaping (12.3%), intermediate storage (2.4%) and unspecified. In addition, there was also 155,000 tds of sewage sludge from industries mainly cellulose and paper industry being produced in 2005, mainly incinerated (83%) or sent to landfill (13%); 3% was recycled to agriculture and 1% to other outlets.

	2001	**2005**
Total sludge produced (tds)*	399,000	420,000
Agriculture (%)	10	12
Landfill (%)	12	1
Incineration (%)	43	60
Other (%)	35	27

Note: * Include municipal sludge, exports and industrial sludge.

The most recent set of figures for Austria has been published by the Ministry of Environment for the year 2006 (Olivia *et al*, 2009). The figures are reported below for municipal sewage sludge, industrial sludge and imports/exports respectively. In 2006, total sludge production in Austria amounted to around 430,000 tds; including about 252,800 tds of municipal sewage sludge and 177,000 tds of industrial sludge (mainly from the cellulose and paper industry).

In 2006, about 40% of municipal sewage sludge was incinerated; 16% was recycled to agriculture, less than 1% sent to landfill and 44% disposed by other routes such as composting; landscaping, intermediate storage and other unspecified outlets. Industrial sludge was primarily incinerated (62%), disposed of to other outlets (32%), recycled to agriculture (3%) or disposed of to landfill (less than 1%).

Quantities (tds/y) of municipal sewage sludge in 2006:

Region	Sludge production	Agriculture	Incineration	Landfill	Other (inc. composting, landscaping, intermediate storage and unknown)
Burgenland	7,957	4,900	ND	ND	ND
Kärnten	12,600	850	ND	ND	ND
Niederösterreich	44,400	8,000	4,800	ND	ND
Oberöstereich	47,240	17,700	8,500	ND	ND
Salsburg	13,300	0	ND	ND	ND
Steiermak	27,100	3,900	ND	ND	ND
Tyrol	23,900	ND	ND	ND	ND
Voralberg	10,200	2,800	100	0	5,200
Vienna	66,100	0	66,100	0	0
Total	**252,800**	**38,400 (16%)**	**96,600 (40%)**	**24 (>1%)**	**106,100 (44%)**

Quantities (tds/y) of industrial sludge in 2006:

Region	Sludge produced	Agriculture	Incineration	Landfill	Others
	I	I	I	I	I
Burgenland	2215	ND	ND	ND	ND
Kärnten	ND	ND	ND	ND	ND
Niederösterreich	ND	ND	ND	ND	ND
Oberöstereich	80,231	0	74,430	0	5,800
Salsburg	ND	ND	ND	ND	ND
Steiermak	ND	ND	ND	ND	ND
Tyrol	ND	ND	ND	ND	ND
Voralberg	ND	ND	ND	ND	ND
Vienna	0	0	0	0	0
Total	**177,000**	**4,800 (3%)**	**106,700 (62%)**	**200 (>1%)**	**61,500 (35%)**

Quantities (tds/y) of sludge exported/imported in 2006:

	Export	**Import**	**Export-import**
Municipal	15,100	3,400	11,700
Industrial	3,700	0	3,700
Total	18,800	3,400	15,400

Doujak (2007) estimated that, by 2010, the connection rate will have increased to 92% rising to a maximum of 94% by 2015. Annual municipal sludge production is estimated to rise to 273,000 tds by 2010, reaching 280,000 tds pa by 2015 and remaining at that level as 100% connection is not expected. Total sludge production including municipal and industrial sludge is estimated to reach 440,000 tds by 2015.

For our baseline scenario, we have accepted the assumptions from Doujak as realistic and that by 2010 in Austria, the quantities of municipal sewage sludge will amount to 273,000 tds and that the proportion going to the different outlets will remain stable – i.e. 15% recycled to agriculture; 45% composted to be recycled to land reclamation projects or treated in MBT plants and 40% thermally treated followed in some cases by phosphorous recovery.

By 2020, municipal sludge production will amount to 280,000 tds per annum and proportion going to agriculture will decrease to 5%; 10% will be treated by MBT and 85% will be thermally treated with subsequent phosphorous recovery. Sludge from industries will amount to 160,000 tds and be entirely thermally treated by 2020 (100%).

The development of sludge disposal routes in Austria is strongly influenced by the regional regulatory framework for sludge and waste management.

There are stringent restrictions on the application of sewage sludge and compost on agricultural land specified in the Austrian regulations. These requirements vary according to the federal state: three of the 9 federal states have, for example, banned sewage sludge application in agriculture. Where it is allowed, sludge has to be treated and at least dewatered. At the treatment works, up to 6 months storage capacity is necessary to fulfil the requirement that sludge must not be applied during late autumn and winter. Direct application of sewage sludge on grass land has little relevance today in Austria. The use of sludge on forestry in Austria is forbidden by law.

There are additional restrictions imposed on the use of sewage sludge and compost in agriculture due to product quality requirements for different markets (for example, organic farming, eco-labelling, and retailer requirements).

As the legal prescriptions and the restrictions for use of sludge and compost for land reclamation or landscaping are less stringent; an increasing part of sewage sludge, mainly after composting, is used for this purpose especially where the agricultural reuse is no longer accepted.

In recent years, there has been an increase of sludge-drying facilities with different processes (drum dryers, solar drying) to reduce storage volume and transport load. On a national scale this method still has low relevance. There is also an increase of adding other organic wastes into anaerobic sludge digestion to increase biogas production. Mechanical Biological Treatment plants (MBT) have been proposed as a suitable option for sewage sludge composting in combination with other organic materials. The output from MBT plants is than landfilled.

While in the past 11% of sewage sludge was sent to landfill for disposal, since 2004, material must meet the following criteria for landfill disposal:

- Less than 5% TOC related to total dry solids
- Less than 6000 MJ/kg dry solids.

These criteria cannot be met by conventional sludge treatment and stabilization processes; only the output from MBT plants and the ashes after incineration meet the requirements which means that sludge disposal on landfill sites is effectively banned and no longer has a major role in Austria.

During the last 10 years, waste incineration capacity in Austria has increased. The overall capacity is still dominated by the fluidized bed incineration plant on the site of the Vienna Main Treatment Plant where about 25% of the total sewage sludge production in Austria is incinerated. For the remaining, sludge is mainly co-incinerated with other wastes in coal-fired power plants and cement kilns. Mono-incineration is however favoured by the authorities in order to enable subsequent phosphorus recovery.

The current debate in Austria on sludge disposal is dominated by soil and food protection from potentially hazardous organic micro-pollutants and sustainable phosphorus management.

In Austria there is general requirement for treatment plants > 1000 pe for P-removal which results in a ~80 to 85% transfer of P from wastewater to sewage sludge. It has been estimated that the P-load in sewage sludge could replace up to ~40% of P-market fertilizer imports to Austria.

There are two clear options in the debate on sludge disposal. The first favours incineration as organic pollutants are destroyed. The second favours sludge application in agriculture as this is the least-cost solution for recycling phosphorus and favours mono-incineration of sewage sludge with P-recovery from the ashes. It does not favour co-incineration with cement coal and wastes as it interferes with P-recovery.

Under waste legislation, energy recovery from sewage sludge has a lower priority compared to nutrient and organic material recycling. However, the Austrian authorities commented that incineration of sewage sludge could be justified when it constitutes the best option for the environment, health and for phosphorus recovery. The political discussion on sludge treatment and disposal is increasingly focused on possible risks for soil and food due to application of sewage sludge that may contain organic micro-pollutants. Thus public acceptance of incineration is increasing.

Belgium

The situation in Belgium has to be described separately for the 3 regions. The description below is based on information provided by DGRNE 2005, IRGT 2005 and from a presentation given by Leonard in 2008. *This report has been revised following comments received from the relevant authorities from the 3 regions during the first on- line consultation in August 2009.*

At the end of 2005, there were 384 agglomerations ≥ 2,000 pe in Belgium with a generated load of 9,701,500 pe. 97.5% were reported to be collected; 66% treated by secondary treatment and 49% by more stringent treatment while 0.3% were reported to have individual treatment and 2.2% were reported to be not collected and not treated.

<u>Wallonia</u>

Since 2000, a public water management company (SPGE) has been coordinating and financing wastewater treatment in Wallonia. About 80% of the population are located in agglomerations ≥ 2,000 pe and are connected to sewer; about 9% are in agglomerations less than 2,000 pe also connected to sewer while about 12% of the population (400,000 inhabitants) live in areas without municipal sewer connection.

In 1999, only 38% of wastewater was treated in Wallonia, however at the end of 2008, 146 treatment plants (≥ 2,000 pe) were in operation with a total treatment capacity of 3.1 M pe or about 75% of the 2005 UWWT target (i.e. 4.2 M pe). In addition 44 plants were under construction and 57 were being designed. In addition, 209 small plants (<2000 pe) had been constructed, 8 were being built and others were being designed. It is estimated that full compliance will be achieved by 2011 with the construction of 428 plants (≥2000 pe) and 600 small plants (<2000 pe) with a combined total capacity of 4.561 M pe.

In 2008, 62% of the 146 plants were small or medium-sized (2000≤pe≤10,000 pe) with only 7 plants with a capacity ≥ 100,000 pe, most having secondary treatment. Treatment capacity is reported to be over designed by 20% to allow for population and industrial growth. From 3,413,978 inhabitants in 2006, population is expected to grow up to 3,450,555 by 2011 and to 3,551,351 inhabitants by 2020.

The whole territory has been designated as a sensitive area which means that all the plants with a capacity of more than 10,000 pe have to have been equipped with tertiary treatment by 2008 at the latest.

According to CEC (2006) and regional authority (DSD/DPS) (2009, personal communication), municipal sewage sludge production amounted to 18,514 tds in 2001, 20,300 tds in 2002 and 23,520 tds in 2003 and reaching 31,380 tds in 2007 (see table below).

It is expected (IRGT, 2005 and Leonard, 2008) that, by 2010, when Wallonia will have completed investment for the UWWT Directive, sludge production will rise to 45,000 tds. This is significantly lower than an estimate of 80,000 tds based on 25kg per capita, 3.5 M inhabitants and 88% connection to sewer.

The regional authority commented that a sludge production rate of 25 kg per capita seemed unrealistic for the Walloon situation. Based on the official predictions proposed below; the maximum sludge production rate will only be at about 15 kg per capita. The two different official estimates are presented below:

- Constant linear increase: 35,204 tds by 2010 and 50,140 tds by 2020
- SPGE study (2004): 404 treatment plants producing 50,370 tds of sewage sludge by 2010 and 428 treatment plants producing 52,101 tds of sludge by 2020.

For our baseline scenario, we have adjusted our estimate to the official figures of 35,000 tds by 2010 and a total sludge production of 50,000 tds by 2020 as population growth and industry expansion is expected to be limited.

In Wallonia, recycling to agriculture has traditionally been the preferred option although the quantities recycled have stayed constant since 1999 at around 10,000-11,000 tds per annum. The proportion of total sludge recycled has dramatically decreased over the last 10 years from 75% in 1995 to 60% in 2000 before stabilising at about 35%.

Quantities sent to landfill have increased from 18% in 1998 to a maximum of 45% in 1999 before decreasing to 34% in 2000 and 0% as landfilling of organic waste was prohibited in 2007.

The proportion of sludge sent to MSW incinerators has dramatically increased since 1999 from 2% to 64% in 2007. This was a direct consequence of the dioxin crisis (1999) which damaged farmer’s confidence in sludge quality at the time, despite the high quality of the sludge. The quality of sludge has continued to improve (see table below) and a study (Valbou 2004) has shown that 85% of sewage sludge meets the regional standards (defined as B2 class) and could be recycled to agriculture. Other outlets such as long-term storage are also used (less than 1%).

In addition, in 2007, 47,947 tds of sludge from industrial treatment plants was also recycled to land (DSD/DSP, 2009, personal communication) (see table below). These quantities seem to have decreased since 2003. It is reported that this was due to problems with compost quality, changes to legislation and lack of installations available.

Leonard reported there to be a growing interest in drying facilities and methods to improve dewatering of sludge.

In the future, the agriculture outlet (after composting) should continue to play an important role in sludge management and is expected to increase again despite some fear and opposition from the population. When recycling to agriculture is not possible, energy recovery will be favoured through anaerobic digestion with biogas production or co-incineration of sewage sludge and municipal solid waste. There are also plans to dispose of sludge in cement works, power plants or to dedicated incineration plants.

For our baseline scenario we have assumed that the proportion of sludge recycled to land will increase for the next 15 years to reach 45-50% by 2020 and thermal treatment for the remaining 45 to 50% including co-incineration with MSW and cement plants.

Wallonia - Municipal sewage sludge arisings and outlets (from 1995 till 2007):

Outlets	**1995**	**2000**	**2005**	**2007**
Total sludge produced (tds)	14,330	18,228	30,285	31,380
Agriculture	10,686 (75%)	10,773 (59%)	10,506 (35%)	10,927 (35%)
Landfill	3,644 25	6,236 (34%)	3,486 (11.5%)	0
Incineration	-	1,127 (6%)	16,217 (53.5%)	20,134 (64%)
Storage-other	-	132 (>1%)	76 (>1%)	319 (1%)

Wallonia - Quantities of industrial sludge recycled to agriculture (tds per annum):

Industrial sector	**2003**	**2006**	**2007**
Slaughterhouse	987	1,053	945
Food	2,426	2,802	3,046
Beverage	167	137	63
Brewery	2,940	3,193	2,586
Limestone	3,521	1,398	1,670
Dairy	1,340	1,124	949
Paper	36,240	35,947	32,832
Potatoes	1,473	1,221	1,387
Drinking water	3,810	4,195	3,956
Tannery	553	394	513
Total	**5,3456**	**51,463**	**4,7947**

Wallonia - Trends in quality of municipal sewage sludge recycled to agriculture:

Parameter	**2001**	**2003**	**2006**	**2007**
Cd (ppm DM)	1.5	1.4	1.5	1.2
Cu (ppm DM)	174	162	167	159
Ni (ppm DM)	29	28	25	24
Pb (ppm DM)	116	102	79	72

Zn (ppm DM)	947	848	688	672
Hg (ppm DM)	1.6	0.9	1	0.8
Cr (ppm DM)	62	56	54	45
N (%DM)	3.7	3.7	2.9	2.8
P (%DM)	2.6	2.5	2	2.3

The general organic waste management in Wallonia is organised through the Waste Plan published in 1998 which was updated in 2006. The plan supports the development of separate waste collection for organic waste and treatment technologies (i.e. incineration with energy recovery, composting, anaerobic digestion, drying processes). There is political support for recycling to agriculture but due to the lack of infrastructure, incineration is currently the predominant outlet.

The legislation regulating the recycling of sewage sludge to agriculture is the Order of 12 January 1995. Although there are no limits for organic contaminants, the authorisation for spreading sewage sludge depends in practice on the results of monitoring of some organochlorines (BTEx, styrene, PAH, PCB, AOX, LAS, DEHP, NPE, PCCD/F, EOX, pesticides, chlorobenzene, chlorophenols, cyanides). Similarly, monitoring of pathogens (*Salmonella* sp) is carried out and the authorities may impose stricter restrictions if present. There are also restrictions imposed such as spreading at a minimum distance of 10 m from wells, springs and drinking water storage or irrigation water. Sludge cannot be spread on frozen ground

There is also a decree pending on compost and digestates which sets rules for better traceability and defines different classes of compost according to origin (open or closed streams) and quality. The decree will restrict the recycling to agriculture for compost of the highest quality (class A and B). This system is already applied through the delivery of certificate of use for compost and other organic waste (AGW of 14 June 2001).

<u>Flemish region</u>

In the Flemish Region, in 1990, approximately 78% of the wastewater from households was collected via sewer systems, but only 30 % was treated in a wastewater treatment plant. By 2002 collection and treatment rates had increased up to 86% and 60% respectively. By the end of 2005, treatment levels amounted to 64.4% (VMM, 2006) and by the end of 2006, the level of collection and treatment had reached 80.6% (short by 1.4% of the 2005 target) and 66.6% (2.2.% short by the 2005 target) respectively. There were 216 treatment plants in operation in the Flemish Region including 107 plants for agglomerations > 10,000 pe; 68 with 2,000<pe<10,000 pe and 41 for agglomerations less than 2,000 pe. As the whole region has been designated as a sensitive area all 107 plants > 10,000 pe have nutrient removal treatment in place.100% collection is not expected by the Flemish region.

From the figures submitted to the Commission, sludge production amounted to 81,351 tds in 2001, 82,871 tds in 2002 and 76,072 tds in 2003 (CEC 2006). From the latest reports (CEC 2009, personal communication), sludge production was reported to amount to 87,382 tds in 2004, 76,254 tds in 2005 with no figure available for 2006. From the latest figure submitted via the consultation the total sludge production is reported to have increased steadily since 2003 to amount to 101,913 tds in 2006 (equivalent to 16.7 kg per capita per year) (see table below).and is estimated to reach 107,600 tds in 2008 (equivalent to 17.35 kg DS per capita) (OVAM 2009, personal communication). The sludge production ratio is low due to preventive measures.

Flanders - Trends in municipals sewage sludge production (tds) and disposal outlets (CEC, 2006 and OVAM 2008)

	Total production	Recycling to agriculture	Landfill	Incineration	Other
1995	73,325	13			
2000	80,708	0			
2005	92,504	12		72	16 *
2006	101,913	0	0	88	12*

Note: * As landfill cover

According to OVAM (2009, personal communication), it is expected that when Flanders should have completed investment for the UWWT Directive by 2010, sludge quantities will increase to about 110,500 tds which is lower than our estimates of 135,000 tds based on 25kg per capita, 6.1 M inhabitants and 88% connection. It is expected that the sludge production will remain constant till 2020.

Due to very stringent legal restrictions on PTEs, quantities of sludge recycled to agriculture have decreased sharply since 1998 from 22% down to 7% in 1999, 0% in 2000/2001 and 2 % in 2002. In addition, since 2006, untreated sewage sludge was no longer allowed to be recycled to agricultural land and the recycling of treated sludge was not economically viable. It is reported that 95% of sewage sludge did not comply with the stringent limits set in the Flemish legislation (see table for sludge quality). In addition, it is reported that the toluene and mineral oil content in sludge is a problem. There is an on-going study looking at possible new limit values for sludge recycled to land and estimates being made of the proportion of sewage sludge which could meet the new criteria.

Quantities of sludge sent to landfill have decreased steadily since 1998 from 35% down to 3% in 2002 while quantities sent to incineration have risen, from 43% in 1998 to 95 % in 2002 and up to 88% in 2006. 40% of sludge is co-incinerated with MSW. Other outlets such as landfill cover represented 12% in 2006. The financial incentive for the production of green energy is reported to make it more beneficial to digest sewage sludge (as a pre-treatment) and produce biogas (49% of sludge) and then to dry (88%) and to incinerate with energy recovery. In the future, it is reported (OVAM, 2009 personal communication) that incineration is unlikely to increase and other techniques such as hydrostab will be used.

Flanders-Trends in average quality of all municipal sewage sludge between 2000 and 2006 (OVAM 2008):

Parameter	**2000**	**2002**	**2003**	**2004**	**2005**	**2006**
Cd (mg/kg ds)	3.8	4.2	4.6	3.7	4	4.1
Cu (ppm DM)	310	308	345	354	329	317
Ni (ppm DM)	45	39	70	48	40	33
Pb (ppm DM)	177	171	164	173	166	160
Zn (ppm DM)	1,174	1,150	1227	1258	1,255	1,383
Hg (ppm DM)	1.6	1.4	1.3	1.2	1.2	1
Cr (ppm DM)	77	74	118	84	74	72
N (%DM)	3.5	4.4	5.3	5.2	4.6	4.5
P2O5 (%DM)	4.6	4.5	5.1	5.7	4.8	5.6

For our baseline scenario we have assumed that there will be no sludge recycled to agriculture in 2010 and in 2020 all sludge will be thermally treated.

<u>Brussels region</u>

In the Brussels region, it is currently estimated that 90% of inhabitants are connected to the sewage system. It is expected that, by 2015, 100% of inhabitants will be connected. The first (and only) wastewater treatment plant with a capacity of 360,000 pe started operation in 2000. The second treatment plant with a capacity of 1.1 M pe started operating in 2008.

Sludge at the Northern plant is treated by thermal hydrolysis/anaerobic digestion followed by wet oxidation reducing sludge quantities by 99%. The final product is sent to landfill or used in construction materials. Information submitted by the regional authority (IBGE/BIM 2009, personal communication) on the quantities of sewage sludge produced in the Brussels region is reported below:

Brussels region - Annual quantities of sewage sludge arisings and outlets in 2006 (tds)

	Production	**Incineration**	**Landfill**	**Agriculture**	**Other**
Southern plant	2,967	1,720 (58%)	1,247 (42%)		
Northern plant	0	-	-	-	-
Total	2,967				

In 2002, sludge produced at the first works was recycled to land (32%), sent to landfill (66%) and incinerated (2%). However, by 2006, with no recycling of sewage sludge in agriculture, 58% was incinerated and 42% was landfilled.

For our baseline scenario we have assumed that there will be no increase in sludge arisings by 2010, there will be no recycling to agriculture and sludge will be treated by wet oxidation and disposed of for other uses, and that the situation will not change by 2020.

Bulgaria

The following description is based on information provided by Paskalev for the latest version Global Atlas (LeBlanc *et al*, 2008) and various other reports including MoEW 2003 and UNDP/GEF Danube Project 2004.

The population in Bulgaria was around 8.1 M in 2000 decreasing to 7.8 M in 2002. The forecast is for continued decline: from 7,785,091 inhabitants in 2003 to 7,323,708 inhabitants in 2014 that is a 6% decrease of population (MoEW, 2003).

Bulgaria joined the EU only recently (January 2007) and has been granted an extended deadline until December 2014 to comply with the UWWT Directive. The transition period for implementing the Directive 91/271/EC in Bulgaria is as follows:

- By 1 January 2011 - construction of sewerage systems and WWTPs for settlements with more than 10,000 pe;
- By 1 January 2015 - construction of sewerage systems and WWTPs for settlements with 2000-10000 pe.

In 2002, the proportion of the population connected to a public sewer network and to a wastewater treatment plant was 68.4% and 38.6%, respectively. There were 55 existing treatment plants of which 43 plants had biological treatment while the remaining had only mechanical treatment. Half of these are in need of reconstruction and modernisation.

The Government plan to connect an additional 2.4 million people and to build about 1,000 new treatment plants to treat up to 85% of wastewater generated by the population as part of the plan to meet the EU UWWT Directive between 2003 and 2015. 80% of these new treatment plants will be of medium size (2000-10,000 pe) with the rest larger than 10,000 pe. (MoEW 2003 reported by UNDP/GEF 2004).

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
New WWTPs >10,000 pe:	1	2	7	22	43	53	48	33	0	0	0	0	209
New WWTPs for 2,000-10,000 pe;	0	0	0	0	0	19	87	129	177	196	154	87	849
WWTP for completion	6	8	7	9	8	5	2	2	0	0	0	0	47
WWTPs for reconstruction and modernisation	6	16	18	29	30	32	20	23	4	2	0	0	180

At the end of 2005, there were 429 agglomerations ≥ 2000 pe with a generated load of 10,265,153 pe.

Sludge production was reported to amount to 31,300 tds in 2004, 33,700 tds in 2005 and 30,000 tds in 2006. This is equivalent to only 4 kg DS per capita (CEC 2009, personal communication).

Based on the above table, by the end of 2010, Bulgaria is expected to have completed 50% of its construction of new treatment plants (mainly above 10,000 pe) and to have upgraded existing plants. Thus sludge production is expected to increase by 50% compared with 2004, amounting to around 47,000 tds. By 2020, compliance should be achieved and sludge production has been estimated to reach 151,000 tds (85% of 7.1 M @ 25 kg/capita and per year).

In Bulgaria, there is a National Plan for sewage sludge which recommends the development of a programme for recycling of sewage sludge in agriculture and forestry, as well as in land reclamation projects. The Plan requires that sludge be at least, mechanically dewatered for treatment plants with more than 10,000 pe; and treated by anaerobic digestion for treatment plants with more than 150,000 pe. It is also planned to incinerate sludge using fluidized bed furnace units for treatment plants with more than 500,000 pe.

The majority of sludge is currently sent to landfill after stabilization, usually by mesophilic anaerobic digestion. Aerobic digestion is rarely used. Current practice for landfilling is to partition special cells for sludge at the landfills. There are no sewage sludge incineration plants in Bulgaria. A project for the incineration of waste produced in Sofia is under development. This could potentially also handle sewage sludge.

Although there was no experience of recycling sludge on land in Bulgaria in 2006, 40% of sludge was reported to be used in agriculture. There have been only a few cases of sludge recycling in land reclamation and it is considered in Sludge Management Plans. There are no special regulations for the use of sludge in land reclamation and there are other possibilities of reuse on non-agricultural land.

For our baseline scenario, we have assumed that by 2010, the outlets for sludge will be 50% recycling to agriculture; 30% going to landfill and 20% to other outlets. By 2020, recycling to agriculture will increase together with recycling to land reclamation at a rate of 60% and 20% respectively. Disposal of sludge to landfill will decrease to 10% and incineration and co-incineration will increase to 10%.

Cyprus

The following description is mainly based on information provided from different presentations by Anonymous in 2000, Mesimeris in 2004 from the Ministry of Agriculture, National Resources and Environment (MANRE). *This report has been revised following comments received from the Ministry of Agriculture, Natural Resources and Environment during the first on- line consultation in August 2009.*

Cyprus joined the EU in May 2004 and has been granted an extended period until 2012 for full implementation of the requirements of the UWWT Directive. At the end of 2005, there were 57 agglomerations equal or above 2000 pe with a total generated load of 860,800 pe. 49% of these were reported to be collected and treated by at least secondary treatment while 34% received more stringent treatment. It is expected that by 2012 Cyprus would have completed its implementation programme for wastewater connection and treatment. In 2007, wastewater treatment plants were in operation for the 4 largest agglomerations on the coast of Cyprus.

It was reported that previous to 2004, no data were available on sludge production and disposal routes and that only limited quantities were recycled to agriculture. The quantities produced and recycled to land as reported to the Commission for 2004-2006 (CEC 2006) are presented below:

Year	**Total production**	**Agriculture**	
	Tds/annum	**Tds/annum**	**%**
2004	4,735	3,134	66%
2005	6,542	3,427	52%
2006	7,586	3,116	41%

The future sludge production estimates reported by the official authority (2009, personal communication) are presented in the table below. They are based on a survey of the sewerage boards of Cyprus and the Water Development Department. Total sludge production will amount to about 10,800 tds in 2010 and 17,620 tds by 2020. This is equivalent to a sludge production rate of 12 kg per capita in 2010 and 18.5 kg per capita by 2020. We have used these figures for our baseline scenario.

WWTP	**Future sludge production (tds/y)**	
	2010	**2020**
Vathia Gonia	2,000	2,000
Nicosia (Vathia Gonia WWTP)	800	720
Limassol	2,500	4,700
Nicosia (Anthoupolis WWTP)	800	2,400
Larnaca	1,100	2,100
Agia Napa/ Paralimni	1,000	1,700
Paphos	2,600	4,000
Total	**10,800**	**17,620**

Some studies have considered alternative disposal outlets for sewage sludge such as use as an alternative fuel at cement kilns. Trials have started at Vassiliko Cement Plant (Cyprus)

(Zabaniotou and Theofilou, 2008). Reclamation of disturbed mine land with sewage sludge has also been investigated (Kathijotes, 2004).

For our baseline scenario, we assumed that the proportion of sewage sludge being recycled to agriculture will stay at around 40 to 50% in 2010 and 2020 and that the remaining quantities will mainly be co-incinerated in cement plants.

Czech Republic

The following description is based on information provided by Michalova, 2004 and Jenicek for the latest version Global Atlas (LeBlanc *et al*, 2008) and reports submitted to the Commission. *This report has been revised following comments received from the Ministry of Environment during the first on-line consultation in August 2009.*

The Czech Republic joined the European Union in 2004. There are about 2000 municipal wastewater treatment plants in operation and compliance with the UWWT Directive is expected to be achieved by 2010,

Estimated sludge production has increased by about 50% from 146,000 tds in 1995 to 220,000 tds in 2006 (see table below based on data from Michalova, 2004, CEC 2006, CEC 2009, personal communication).

Compliance with the UWWT Directive is expected to be achieved by 2010, and future sludge production is estimated to increase by about 20% by 2010 and to stabilise at that level (263,600 tds per annum) for the next 10 years as population growth is predicted to be limited during that period.

Year	**Annual sludge production ($x10^3$ tds)**	**Quantities recycled to agriculture**		**Quantities sent to landfill**	
		($x10^3$ tds)	**(%)**	**($x10^3$tds)**	**(%)**
1995	146	35	24	70	50
2001	146	62- 70	42-48	40	19
2002	206	0.2	>1	45	22
2003	211	0.3	>1	25	12
2004	206	33	16	Ni	
2005	211	8-35		Ni	
2006	221	8-25		Ni	
2007	231	60	26	NI	

Ni – no information

Historically, sludge was typically sent to landfill (40%) and recycled to agriculture (25%).

Direct sludge application to land has decreased in recent years due to stricter rules concerning sludge quality in terms of heavy metal and pathogens content. At the same time the, application of composted sludge has increased. While in 2001, more than 60,000 tds of sewage sludge produced was reported to be recycled to agriculture, there was nearly no recycling in 2002 and 2003. From the latest report to the Commission (CEC 2009, personal communication), since 2004, the quantities recycled to agriculture have risen again to 60,000 tds (26%) in 2007. However, it is reported that about 2/3 of sewage sludge produced is ultimately recycled to agriculture, mostly after composting.

The amount of sludge landfilled in the Czech Republic has steadily decreased over the last decade from 50% to 10-15 % of annual production.

A negligible amount of sludge is incinerated. At present, only one municipal wastewater treatment plant has such technology. Sludge is also incinerated in cement plants. A slow increase in the market share of more expensive technologies, such as incineration or other thermal treatment methods can be expected. However, this increase will probably be lower than in Western Europe.

For our baseline scenario, we consider that recycling of sludge to agriculture will remain high at about 75% mainly after composting and that by 2020, landfilling will only cover 5-10% and thermal treatment will rise to 15-20 % of annual production.

Denmark

The following description is based on information provided by Jensen (2004), the Commission report (CEC 2006) and via the Eureau survey (2008). *This report has been revised following comments received from a commercial stakeholder during the first on- line consultation in August 2009.*

Denmark has achieved high level of compliance with the UWWT directive. At the end of 2005, there were 415 agglomerations ≥ 2000 pe with a generated load of 11,769,028 pe; 100% collected and 99.8% treated by more stringent treatment.

By 2010, based on a sludge production of 25kg/capita, the increase in annual sludge production should be limited to 141,500 tds. As population growth is limited, sludge quantities should not change between 2010 and 2020. No recent figures on sludge quantities have been submitted to the Commission for Denmark, but past records (see table below, CEC 2006) showed that sludge production has decreased significantly since 1995 from 167,000 tds down to around 140,000 tds in 2002. This is reported to be due to different ways of reporting content of dry matter rather than an actual reduction in production. According to Eureau survey, in 2008, sludge production only amounted to 77,530 tds. Similarly, sludge quantities and proportion recycled to agriculture have also decreased from 67% in 1995 to 59% in 2002.

Year	Annual sludge production ($x10^3$ tds)	Quantities recycled to agriculture	
		($x10^3$ tds)	(%)
1995	166,584	109,369	67
1996	161,717	104,095	64
1997	151,159	94,250	62
1998	153,780	96,200	62
1999	155,621	95,500	61
2000	-	-	-
2001	158,017	83,292	53
2002	140,021	82,029	59

There was a target for 2008 for 50% recycling through agriculture, 45% incineration corresponding to 25% incineration with recycling of ashes in industrial processes and 20% “normal” incineration. However, it was reported during the consultation that the 25% of sludge treated by incineration with recycling of ashes in industrial processes were based on a new technology which did not succeed which may lead to a reduction of incineration. On the other hand, the Government has recently changed tax on incineration which will mean that, by 2010, lower tax will apply for ‘normal’ incineration of sludge which could lead to an increase of incineration.

For our baseline scenario, we have assumed that sludge production will remain constant at about 140,000 tds in 2010 and 2020 and that recycling to agriculture will remain at around 50% for 2010 and 2020 and incineration at around 45%.

Estonia

Limited information was found for Estonia. Sludge quantities recycled to agriculture reported to the Commission (CEC 2009, personal communication) amounted to 2,640 tds in 2000; 3,575 tds in 2004 and 3,316 tds in 2005. No figure was provided for total quantities produced.

At the end of 2005, there were 46 agglomerations ≥ 2000 pe with a generated load of 1,488,789; 89% were reported to be collected and at least treated by secondary treatment and 64% with more stringent treatment. Based on 20 kg/pe and 90% collection and treatment, sludge production in 2005 was estimated to amount to 26,800 tds. This means that recycling to agriculture accounts for 12% of estimated sewage sludge production.

For our baseline scenario, we have assumed that future sludge production would increase to around 33,000 tds and that recycling to agriculture would remain low at around 10-15% while the remaining going to other unspecified outlets.

Finland

The following description is based on information provided by Rantanen for the latest version Global Atlas (LeBlanc *et al,* 2008) and data provided to the Commission. *This report has been revised following comments received from a commercial stakeholder during the first on- line consultation in August 2009.*

Finland (as of 2005) has a small population of 4.4 M inhabitants living in scattered dwellings (Santala *et al*. 2006). More than 70% of its territory is covered by forests, equivalent to 21.3 M ha.

Finland has achieved a high level of compliance with the UWWT Directive. At the end of 2005, there were 177 agglomerations ≥ 2000 pe with a generated load of 4,984,100 pe; 99% was collected and treated by more stringent treatment while the remaining 1% relied on individual treatment systems. Following the implementation of the UWWT Directive in Finland, 63% and 100% of population will have N and P removal respectively. Decree No542/2003 on individual wastewater system came into force in 2004 and sets minimum standards for wastewater treatment in rural areas where there are no centralised wastewater treatment plants. There are plans to transport 90% of the sludge produced by these on-site systems to centralised plants.

The total amount of municipal sewage sludge produced in Finland was about 150,000 tds in 2004 and 2005 (see table below). Quantities seem to have decreased since 2002.

Although 17% of sludge was recycled to agriculture in 2003, by 2006 only 3% was used in agriculture the rest being used in landscaping including landfill cover (Syke, 2007). Although the concentrations of heavy metals have decreased and were well below the limit values specified in the Sludge Directive and the more stringent Finnish requirements, the proportion of sludge recycled to agriculture has diminished and has shifted to landscaping operations. The most common sludge treatment process in Finland is composting. 73% of the wastewater treatment plants compost their sludges in open pile or windrows and 21% in closed reactors (Sänkiaho and Toivikko, 2005). Mesophilic anaerobic digestion is common in the largest cities. The use of other methods such as lime stabilization, thermal drying, incineration, thermophilic digestion and chemical treatment are marginal.

Future sludge production is expected to increase to 154,000 tds by 2010 with proportions for the two main outlets remaining constant, with less than 5% recycled to agriculture and 90% recycled to other land after composting. Recycling in forestry is currently being investigated as a possible new outlet, and incineration of sludge could also become more popular.

Year	Total amount of municipal sewage sludge (tds per annum)	Sewage sludge used in agriculture	
		(tds per annum)	%
1995	141,000	47,000	33
1996	130,000	49,000	38
1997	136,000	53,000	39
1998	158,000	23,000	14
1999	160,000	23,000	14
2000	160,000	19,000	12
2001	159,900	25,000	16
2002	161,500	22,000	14
2003	150,000	26,000	17
2004	149,900	11,600	8
2005	147,700	4,200	3

In 2006, Finland passed new legislation, [Government Decree (539/2006)], concerning the use of organic fertilizers including sludge. The Decree regulates potentially harmful elements, pathogens and pathogen indicators by setting limit values in products as well as rates of application. The amounts of nutrients are also regulated. The Decree also stipulates which treatment methods are suitable for producing products of high hygienic quality. For sludge treatment these are thermophilic anaerobic digestion, thermal drying, composting, lime stabilization and chemical treatment. Other methods can also be validated if they can be demonstrated to produce a product with a consistently good hygienic quality.

Previous legislation regarding the national implementation of Sludge Directive is still enforced. More can be found in *http://www.finlex.fi/fi/viranomaiset/normi/400001/28518,* in Finnish and Swedish.

France

The following description is based on information provided by papers published by the Agences de l'Eau (2004), by ACONSULT (2007), data provided to the Commission (CEC 2006) and by Eureau (2009, personal communication). *This report has been revised following comments received from the French Authorities during the first on- line consultation in August 2009*.

France has a large population, estimated at 63,235,568 inhabitants in 2006. In 2004, it was reported that there were 16,400 treatment plants with a capacity of 90M pe. 19% of the population was not connected to sewer and 17% relied on individual treatment systems (i.e. cesspool) (IFEN 2008). At the end of 2005 (CEC 2009), there were 3,004 agglomerations ≥ 2000 pe with a generated load of 67,180,943 pe; 100% was collected with 93% treated by at least secondary treatment with 54% undergoing more stringent treatment. At the end of 2008, there were 17,500 treatment plants including 3,083 above 2000 pe, of which 36% apply secondary treatment, 61% apply more stringent treatment and. 268 are not in compliance with the UWWTD. A national action plan is in place to ensure full compliance by 2011. About 67% of effluent is from domestic origin.

In 2002, (CEC 2006) sludge quantities amounted to about 910,000 tds of which 60% was recycled to agriculture. According to the Agences de l'Eau, the quantity of sludge produced in 2004 amounted to 807,000 tds per annum; 62% being recycled to agriculture, 20% disposed of to landfill, 16% to incineration and 3% to other outlets. According to Eureau (2009, personal communication), in 2008, there were 963,800 tds of sludge produced in France; 55% being recycled to agriculture; 24% sent to landfill; 17% incinerated; and 3% disposed of to other outlets.

More recent figures submitted by MoE during the consultation (2009, personal communication) showed that, in 2007, sewage sludge production amounted to 1.12 M tds of which 69% was recycled to agriculture; 18% incinerated and 12% sent to landfill. Since 2002, there has been a steady increase in the quantities recycled to agriculture, a proportion of which being composted (21% in 2006; 24% in 2007 and 28% in 2008).

Although the land area receiving sludge has increased to about 240,000 ha per annum, which represents about 3% of the total arable land, the rate of application has decreased to about 2.5 tds per ha per annum.

The improvements in treatment capacity and level of connections have and will continue to lead to an increase in sludge production which has been estimated to amount to (FP2E, 2009 personal communication) 1.3 Mtds/annum for 2010 (i.e. 20 kg/pe) and 1.6 Mtds/y by 2020 (i.e. 21 kg/pe). Although the quantities recycled to land will increase as sludge production increases, the proportion will probably decrease from 70% down to 50% by 2020 as volumes sent to incineration increase especially for new large treatment plants located in large agglomerations. In addition, it is reported that the potential sludge production from individual treatment systems could amount to 21,000 tds per annum.

The official authority estimates (MoE 2009, personal communication) that, by 2020, sludge production will increase by 17% to about 1.4 M tds as compliance with the UWWT Directive is achieved. This takes into account improved wastewater treatment (increase of sludge production) and increased sewage sludge treatment (decrease of sludge production). That is anaerobic digestion for treatment plants >20,000 pe which is expected to reduce sludge production by 30% as well as the installation of advanced treatment at one of the largest treatment plants in Achère, treating wastewater from Paris, which is expected to reduce sludge quantities by 50%.

The levels of sludge recycled to agriculture is expected to continue to rise up to 75-80% in the future (MoE, 2009 personal communication). There are also some on-going trials looking at recycling of sludge to forestry.

Data submitted to the Commission (CEC 2006) are presented below:

Year	**1995**	**1998**	**1999**	**2001**	**2002**
Total production (tds/y)	750,000	858,000	855,000	893,252	910,255
Recycled to agriculture (tds/y)	494,000 (66%)	554,000 (65%)	552,000 (65%)	509,250 (57%)	524,290 (58%)

Data from the Agences de l’Eau survey (2004) are presented below:

Region	Sludge production (x10^3 tds)	Agriculture (%)	Landfill (%)	Incineration (%)	Other (%)
Artois picardie	57	90	10	0	0
Rhin Meuse	82	46	23	24	7
Loire Bretagne	160	68	19	13	0
Seine Normandie	192	81	4	9	6
Adour Garonne	70	63	22	8	7
Rhone Mediterranee Corse	246	36	34	28	2
Total	**807**	**62**	**20**	**16**	**3**

Data from the Ministry of Environment (2009, personal communication) are presented below:

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008 ***
Total production (tds/y)	946,700	989,054	1,021,472	1,027,168	1,118,795	1,166,048
Recycled to agriculture (tds/y)	537,387 (57%)	573,889 (58%)	633,812 (62%)	624,923 (61%)	776,305 (69%)	846,004 (73%)
Including composted (tds/y)				210,781	263,377	322,129
Area needed (ha)	223,392	233,889	249,937			
Incinerated (tds/y)	188,991 (20%)	197,658 (20%)	215,684 (21%)	203,031 (20%)	204,592 (18%)	215,328 (18%)
Landfilled (tds/y)	193,494 (20%)	180,345 (18%)	132,255 (13%)	199,214 (19%)	137,898 (12%)	104,716 (9%)

- preliminary figures

Trends in quality of sludge recycled to agriculture between 2003-2005 is presented below:

Parameter	2003	2004	2005
Cd (mg/kg ds)	1.8	1.5	1.3
Cu (ppm DM)	305	280	272
Ni (ppm DM)	24	23.5	21
Pb (ppm DM)	64	57	50
Zn (ppm DM)	641	632.5	598
Hg (ppm DM)	1.3	1.2	1.1
Cr (ppm DM)	48	36	43
Tot N (%DM)			6.4
Tot P (%DM)			5.5

Since 1998, there have been strict regulations in place for recycling of sewage sludge to agriculture (Order of 8 January 1998, Circulars 14 March 1999 and 18 April 2005). For example, the limit values in sludge and for soil treated sludge are usually lower than the minimum values specified in the 86 Directive and there are limits for some organic contaminants. There is a detailed system of traceability in place. There is a guarantee fund (Decree of 18 May 2009) to pay compensation to farmers if their land became unsuitable for agriculture due to recycling of sludge.

For our baseline scenario, we have considered that future sludge production will continue to increase and should amount to 1.3 million tds by 2010 with levels stabilising at 1.4 M tds by 2020. The proportion of sludge recycling to agriculture will continue to increase at around 75-80% over the next 15 years while landfilling continues to decrease down to 5% by 2010. Incineration is expected to remain at around 15% with the remaining sludge being recycling to other non-agricultural land.

Germany

The following description is based on information provided by Schulte for the latest version Global Atlas (LeBlanc et al, 2008). *This report has been revised following comments received from the Federal Ministry of Environment and three of the Regional competent authorities and commercial stakeholders during the first on- line consultation in August 2009*.

In 2008, about 10,000 municipal wastewater treatment plants were in operation in Germany with a total capacity of 82 M pe. 250 of the biggest plants (with design capacities of more than 100,000 pe) treat about 50% of the wastewater, while a further 7,000 small sewage works (with design capacities less than 5,000 pe) contribute less than 10% of treatment capacity. About 94% of the wastewater volume is treated to a high standard that comprises biological treatment with nutrient removal. It is reported that 20% of effluents were from industrial origin. At the end of 2005, there were 4,2002 agglomerations ≥ 2000 pe with a generated load of 114,691,778 pe; 98.7% was collected and treated at least by secondary treatment and 97.2% by more stringent treatment .

The latest figures published by the Commission (CEC, 2006) showed that, in 2003, about 2.1 million tonnes of sewage sludge (dry matter) were produced in Germany and that 33% was recycled to agriculture. More recent figures from the German Association for Water, Wastewater and Waste (DWA) (BMU 2009, personal communication), show that total sludge production was 2.06 M tds in 2007, with; 29% recycled to agriculture; 18% in landscaping; 50% being thermally treated and 3.5% via other recycling methods. The reported sludge production rate is about 80 g ds pe per day for raw sludge and 55 gds pe per day after digestion.

No change in sewage production is expected in the future due to the existing high connection rate to the sewerage system and thus to wastewater treatment, and the expected decrease in population, modernisation of industrial production processes and the development of new techniques reducing the amount of sludge produced.

In Germany, sludge quality has improved dramatically over the last 20 years.

Over the past few years, thermal processes have become more significant for sludge management, at the expense of landfilling and recycling to land (agriculture and landscaping). This was primarily due to the following developments:

3. Disposal of sludge to landfill is no longer possible in Germany, as materials with a total organic content (TOC) of more then 3% have been banned from landfill since 2005; and
4. The political debate during the past few years about sludge recycling to land in Germany caused a lot of uncertainty. The debate focused mainly on organic contaminants which are not yet regulated, such as phthalates, pharmaceuticals or perfluorinated compounds. These discussions proposed not only the introduction of more stringent requirements such as lower maximum permissible values for heavy metals and limits for additional organic compounds and stricter hygienic quality, but also a complete ban on sludge recycling. In consequence, some operators of sewage treatment plants felt that sludge recycling to agriculture might not

be a reliable disposal option in Germany and therefore viewed thermal treatment as a more sustainable choice.

The German Sludge Ordinance of 15 April 1992 specifies stringent requirements in terms of quality limit values, restrictions on types of crops and land areas. Some federal states (Bavaria, Baden-Wurttemberg, North Rhine-Westphalia) do not support the application of sewage sludge to agriculture based on the precautionary principle. This has led to a sharp decrease in quantities of sewage sludge recycled to agriculture. For example in Baden Wurtenberg, between 2001 and 2008, the proportion of sludge recycled to agriculture fell from 20 % to 2% while the proportion of sludge incinerated increased from 31% to 87%.

Even though the use of sewage sludge has been strictly regulated by the 1992 Federal Ordinance in terms of limit values for heavy metals and some organic compounds, many experts considered that the maximum permissible values were too high. In November 2007, the Federal Environment Ministry published a new draft sludge ordinance. The draft ordinance proposes a significant reduction in existing limit values for heavy metals and limit values for additional organic substances.

The proportions of sludge going to the different disposal outlets for sewage sludge in Germany are presented in the table below.

Year	Total sludge production ($x10^3$ tds/y)	Agriculture (%)	Land-scaping (%)	Thermal treatment (%)			Landfill (%)	Inter-mediate storage (%)	Other /unspecified (%)
				Mono-incineration	Incineration in cement or power plants	MSW incineration			
1995	2,249	42		28					30
2000	2,297	37		34			3		20
2003	2,172	32	25	20	14	3	3	3	
2005	2,106	31		38			2		29
2007	2,056	29	18	22	25	1.5	>1	3.5	

Since 2003, there has been a voluntary quality system – VDLUFA-QLA - in Germany (Budewig, 2008) which introduced additional requirements regarding input, products (i.e. more stringent limit values) and utilisation of sewage sludge. About 8% of sewage sludge produced in Germany is currently certified by QLA.

Our baseline estimates for 2010 and 2020 assume that municipal sewage sludge production will remain at around 2 million tds per annum. For our baseline scenario, for 2010 and 2020, we assume the proportion of sludge recycled to agriculture may decrease slightly to around 25 to 30%, the proportion being used for landscaping will remain stable at around 25% and the proportion treated thermally will increase to about 50%.

Greece

The following description is based on information provided in a presentation from Karamanos et al (2004) on implementation of the UWWT Directive.

In 2004, it was estimated that 95% of households were connected to the sewerage system and that about 60% of the permanent population was served by 350 municipal wastewater treatment plants. The remaining population is in small villages and remote areas for which individual sanitation technologies should be used. According to the Commission, there are around 100 agglomerations above 2,000 pe in Greece with a total generated load of about 10 M pe.

Following the implementation of the UWWT Directive, large-scale sewage treatment plants have been constructed in recent years. However, as of 2009, Greece has not yet fully complied with the UWWT Directive requirements. About 56% of generated load from agglomerations discharging into sensitive areas was compliant, while about 90% of generated load from agglomerations discharging into normal areas was compliant

In Greece, sludge production dramatically increased from 52,000 tds in 1995 to 83,400 tds in 2004, 116,800 tds in 2005 and about 126,000 tds in 2006 (CEC 2006 and CEC 2009, personal communication). There are currently only small trials of recycling of sludge to agriculture (less than 100 tds per annum) and the majority of sludge produced is sent to landfill. This is in agreement with figures provided from a recent Eureau survey (2008), which reported that sludge production amounted to about 126,000 tds; the majority being disposed of to landfill with only minor trials of sludge recycling to agriculture (100 tds).

Year	**Sludge production (tds per annum)**	**Agriculture (%)**	**Landfill (%)**	**Others (%)**
1995	51,624	0	95	5
2000	66,335	0	95	5
2005	116,808	<1	95	5
2006	125,977	<1	95	5

For our baseline scenario, we have assumed that by 2010, Greece will be complying with the UWWT Directive and that sludge production will have more than doubled to amount to 260,000 tds (25 kg * 95% of 11.1 M inhabitants). By 2010, recycling to agriculture will remain low (5%) and landfilling will remain the main outlet at 95%. By 2020, sludge production will remain at around 260,000 tds but landfilling will have decreased to 55-60%,replaced by thermal treatment (35-40%) while agriculture will remain low at about 5%.

Hungary

The following description is based on information provided by Garai for the latest version Global Atlas (LeBlanc *et al*, 2008) and from a presentation by Toth (2008). *This report has been revised following comments received from the Hungarian Ministry of Environment during the first on- line consultation in August 2009.*

Hungary joined the EU in May 2004. It has a population of around 10 million and a total area of 93,000 km^2. Budapest has a population of 1.85 million with 96% connected to sewer but only 49% are served by the 2 existing wastewater treatment plants and thus untreated sewage is discharged into the Danube. A new plant (Central) has been commissioned and should be operational in 2010. In the rest of the country the situation is worse with only an estimated 68% of population connected to sewer and less than 1/3 of 3000 settlements having adequate wastewater treatment. At the end of 2005, there were 404 agglomerations ≥ 2000 pe with a generated load of 9,643,155 pe; 80% was collected and treated by secondary treatment and 20% relied on individual treatment systems.

The priority is to tackle sewerage problems from industry and 10 large cities. There are smaller investments for settlements of less than 15,000 people and by 2015, it is planned that all agglomerations of more than 2,000 pe will have a modern sewage treatment system.

The most commonly applied wastewater treatment technology is activated sludge. Sewage sludge is usually dewatered by filter belt press or centrifuge to a typical dry solids content of 18-20%. At the largest treatment plant in Hungary (North-Budapest Wastewater Treatment Plant), membrane presses are operated and sludge dry solids content is between 36-38%. A small proportion is dried.

At the larger plants, sludge is usually treated by mesophilic anaerobic digestion. At some plants, electricity is produced by biogas engines. Composting of sludge is reported to be on the increase (Ministry of Environment, 2009, personal communication).

Agricultural recycling is controlled by two regulations: the first covers compost products and the second one is for use of sewage sludge in agriculture. The bans imposed on sewage sludge recycled to land by the Government Decree 50/2001 (IV.3) are listed below:

- Protected areas (i.e. Natura 2000)
- Meadow or pasture
- Along the banks of surface waters or agricultural areas subject to flooding
- Drinking water protection zones
- Karst areas or in areas with limestone, dolomite, lime- and dolomite marl formations found 10 m below surface
- Forests
- Organic farms

Longer waiting periods are set in the Hungarian legislation with no application allowed in the growing year and in the previous year on lands used for growing of vegetables and fruits in contact with the soil.

There are no incinerators for sewage sludge in Hungary. The capacity of hazardous waste incinerators is not sufficient to receive a significant amount of sewage sludge, and the cost of processing is too high. Some cement factories are authorised for sludge incineration and trials have been performed, but it is not used on a regular basis (Garai, 2008).

From 1 July 2009, the proportion of biodegradable MSW going to landfill has to be reduced to 50% of total quantities produced in 1995 and to 35% from 1 July 2016. This will have an impact on the proportion of sewage sludge going to landfill.

While the quantities produced as reported to the Commission for 2004-2006 (CEC 2009) increased from 120,741tds to 128,400 tds, respectively the proportion recycled to agriculture decreased from 30 to 24%, respectively. According to the Ministry of Environment (2009, personal communication), the current sludge production rate is 25.8 kg/pe/year. According to a 2008 Eureau survey, the total sludge production in 2007 was about 119,000 tds/year. Sewage sludge was predominantly sent to landfill (72,000 tds, 61%) or recycled to agriculture (47,000 tds, 39%). Figures reported by Toth (2008) for 2005 also differ significantly from the ones reported in the Eureau and Commission surveys; quantities produced amounted to 105,000 tds; quantities recycled to land including recycling to agriculture and land reclamation directly and after composting amounted to 70,000 tds (67%) while quantities sent to landfill were only about 25,000 tds (24%) and about 10,000 tds to other/unknown outlets (9%).

Sludge quantities as reported to the Commission (CEC 2009):

Year	**Sludge production (tds per annum)**	**Agriculture (tds)**
2004	120,741	36,105 (30%)
2005	125,143	42,329 (34%)
2006	128,379	32,813 (24%)

The current and future estimates for sludge disposal outlets are presented below (Ministry of Environment 2009, personal communication):

Outlets	2006-2007 (%)	2020 (%)
Agriculture	65	59.3
Landfill	24	5.5
Others (biogas, incineration, renewable energy)	10	35.2

According to Toth (2008), total sludge production will rise to 175,000 tds by 2010 and reach a plateau of 200,00 tds by 2020. The proportion of sludge recycled to agriculture will increase until 2010 up to 135,000 tds (77%) and then decrease to about 115,000 tds (58%) by 2020. Quantities sent to landfill will steadily decrease to 20,000 tds in 2010 reducing further to 10,000 tds by 2020. Quantities sent for incineration will increase from 2010 until 2020 to reach about 60,000 tds per annum. The quantities sent to other/unknown will not change.

According to Garai (2008), the government aims is to decrease landfilling and increase the proportion of sludge being recycled to agriculture. By 2015, the proportion of landfilling is expected decrease to 33%.

According to the Ministry of Environment (2009, personal communication), Toths's estimate of 77% for the proportion of sludge recycled to agriculture for 2010 is probably too high, but the 58% expected for 2020 is realistic. The future proportion of sludge recycled to agriculture is expected to increase mainly using composted sludge.

For our baseline scenario, we have used figures presented by Toth (2008). We have assumed that by 2010 sludge production will amount to 175,000 tds reaching 200,000 tds by 2020. The proportion of sludge recycled to agriculture will increase until 2010 up to 70 % and then decrease to about 60% by 2020. This will include a proportion of composted sludge. Quantities sent to landfill will steadily decrease to 20% in 2010 and 10% by 2020 while quantities sent for incineration will dramatically increase from 5% in 2010 to 30% by 2020.

The nutrient content of sewage sludge used in agriculture between 2004 and 2007 (MoE, 2009, personal communication) is reported below:

Year	N (kg/tds)	P2O5 (kg/tds)
2004	34.2	18.2
2005	30.4	24/7
2006	30.4	31.3
2007	26.2	30.4

Ireland

Information has been extracted from an EPA reports on urban wastewater discharges in Ireland (EPA 2005, 2007 and 2009) as Ireland has not submitted recent reports to the Commission on sewage sludge.

In Ireland, in 2007, there were 482 agglomerations with populations greater than 500 pe, which collectively represent a total of 5,835,495 pe (EPA 2009). This includes 313 agglomerations ≤ 2000 pe which represent 5.6% of total load; 113 agglomerations from 2,000 to 10,000 pe representing 9.3% of total load; 19 agglomerations from 10-15,000 pe representing 4.1% total load, 35 agglomerations from 15-150,000 pe representing 26.3% of total load and 2 ≥ 150,000 pe which collectively represented 55% of the waste water discharges for 2007 .

There have been delays in providing the required treatment plants at a number of locations throughout the country. Although there have been large investment between 2000 and 2007 and improvements have been achieved since the previous reporting period, in 2006/2007, full compliance with the UWWT Directive is not expected to be achieved by 2010.

It is reported that, in 2007, 4% of wastewater received no treatment compared with 11% in 2005; 5% of wastewater received preliminary; 1% only primary treatment; 77% of wastewater received secondary treatment compared with 70% in 2005; and 15% of wastewater received nutrient removal in addition to secondary treatment compared with 12% in 2005. Out of the 158 agglomerations requiring secondary treatment or more by December 2005, a total of 28 did not have the required level of treatment in place. By 2010, this number should have been cut by 50% and by 2020, full compliance will have been achieved.

Sludge quantities produced by treatment plants with population equivalent greater than 500 pe have significantly increased over the last 10 years from 34,500 tds in 1997 to 86,400 in 2007 (see table below - EPA 2005, 2007 and 2009). The largest quantities (20,600tds) originate from Dublin. These figures slightly differ from those reported to the Commission (1997: 38,290 tds (11%); 2000:35,039 tds (40%); 2003: 42,147 tds (63%)).

The proportion of sludge recycled to land has also increased dramatically from 10% in 1997 but has decreased since the last report to 70% in 2007 compared with 76% in 2004/2005 (CEC 2006, EPA 2009) while proportion being disposed of to landfill have decreased to 11% went to landfill. Twenty five percent went to other outlets as composted and in forestry (EPA 2009).

Year	**Sludge production (tds per annum)**	**Agriculture (%)**	**Incineration (%)**	**Landfill (%)**	**Sea (%)**	**Other (%)**
1997	34,484	9.8	0	43	42	0
1999	35,595	23	0	45	33	0
2001	33,559	45	0	54	0	1
2003	42,298	63	0	35	0	2
2004	61,923					
2005	59,827	76	0	17	0	7
2006	77,648	77	0	11	0	12
2007	86,411	70	0	5	0	25

References: EPA 2005,2007 and 2009

We have estimated that by 2010, sludge quantities will have continued to increase and will reach up to twice the current amount with full implementation of the UWWT Directive, to around 135,000 tds. It will remain at that level until 2020. By 2010, we have assumed that proportions recycled to agriculture and disposed of to landfills and other outlets would be at the similar level as in 2005 – i.e. 75%, 15% and 10%, respectively and that by 2020, while agriculture would still be the major outlet at about 65-70%, incineration would steadily increase to replace landfilling.

Italy

The following description is based on information provided by Spinoza and Canzian for the latest version Global Atlas (LeBlanc *et al*, 2008).). *No changes to this report were made following comments received from two commercial organisations during the first on- line consultation in August 2009.*

According to the Italian National Institute of Statistics (ISTAT, 2006), the total population equivalent (urban + industrial) in Italy is estimated to be around 175 million pe, of which the urban fraction is as much as 102 million pe (55.9% resident population, 14.9% tourists, 16.6% commercial sites, 12.6% crafts and small enterprises). At the end of 2005, there were 2,436 agglomerations ≥2000 pe with a generated load of 70,578,677 pe. Some 299 towns and cities (>15,000 pe) have been listed as not yet being in compliant with EU standards.

Based on an average annual production of dry solids per capita (after aerobic or anaerobic digestion) of 30 kg ds/annum/pe, the total sludge production in Italy can be estimated at around 5.25 million tds/annum, of which about 3 million tds/annum is linked to the urban population. This is a three-fold increase compared with the current sludge production when all the population would be served by sewerage and subsequent appropriate treatment.

Sludge management in Italy varies widely as far as local disposal or reuse options are concerned due to different geographical, geological, technical, economic and social contexts. Some Italian Regions have revised the regional legislation on sludge utilisation in agriculture. For example, the Region Emilia-Romagna, in Northern Italy, published a new Regional Decree 2773 on 30 December 2004, modified and completed by Decree 285 on 14 February 2005.

Monitoring of sludge recycled in agriculture in the Region of Emilia-Romagna showed a consistent occurrence of toluene and hydrocarbons so a research programme to define limits values for the above components was started in April 2007. Preliminary theoretical evaluations indicated possible safety limits of 500 mg/kg-ds for toluene and 10,000 mg/kg-ds for hydrocarbons.

In 2004, it was estimated that annual production of sewage sludge was about 4.3 Mt, corresponding to about 1 Mt of dry solids at a solids concentration of 25%, with an increase of about 10% with respect to years 2001-2003 (ONR, 2006). This is in line with the figures reported to the Commission which are presented in the table below.

Year	Sludge production (t DS per annum)	Agriculture	
		(t DS per annum)	%
1995	609,256	157,512	26
2000	850,504	217,424	26
2004	970,235	195,161	20
2005	1,074644	215,742	20
2006	1,070,080	189,555	18

According to ONR (2006), disposal of sludge to landfill accounts for only 24% of the total quantity of sludge produced, and agricultural recycling including co-composting and land reclamation, has increased to 69%. About 2% of sewage sludge is incinerated and 5% kept in temporary storage basins.

Sewage sludge is usually thickened and digested before being recycled to agriculture or sent to landfill. Sludge post-treatments, such as pasteurisation and thermal drying, are seldom practiced. Increasingly, combined composting is performed by treating sewage sludge with other organic fractions, for example municipal solid wastes, food wastes, wood chips from broken pallets, cuttings from gardening and forest maintenance, and other similar materials.

When the quality of the compost is poor, mainly due to heavy metals exceeding the limits for unrestricted use, the resulting material can be used in land reclamation or as landfill cover. In 2005, wastes treated in composting plants amounted to about 3 million tons, with an increase of 125% from 1999. Plant inflow consisted of 70% of organic fraction derived from separate collection and green wastes, 16% of sludge (+7% with respect to 2004) and 15% of other organic wastes, mainly from the food industry. In some cases, sewage sludge is added in small amounts (up to 5%) to lime and clay in thermal processes to produce inert materials, such as expanded clay for construction.

Incineration or co-incineration with municipal solid waste is the most common thermal sludge disposal route in Italy. Sludge pyrolysis with gasification is currently under evaluation by a few water service companies.

Sludge composition is reported to be highly variable in Italy because almost all treatment plants serve urban areas where industrial activities contribute to the organic pollution load. Furthermore, many medium and large sized plants are located in industrial districts, such as (i) the wool district (Biella, Piedmont), (ii) the silk district (Como, Lombardy), (iii) other textile finishing district (Prato, Tuscany), (iv) tannery districts in Veneto and Tuscany, (v) metal surface finishing districts in Piedmont and Lombardy, and other minor districts.

It is expected that, at least in Northern Italy, where co-management with municipal solid wastes due to the integration of public services (energy, waste and water), could become a real possibility for the future, anaerobic co-digestion of sludge and wet fractions deriving from separate collection of municipal solid wastes would increase. This is still a limited practice in Italy but some examples of this type are listed below:

- Treviso: 3,500 t/annum of solid waste wet fraction and 30,000 t/annum of sewage sludge are co-digested.
- Cagliari: 40,000 t/annum of solid waste wet fraction and 15,000 t/annum of sewage sludge,
- Camposampiero: 12,000 t/annum and 12,000 t/annum, plus 25,000 t/annum from zootechnical wastewaters,
- Bassano: 16,000 t/annum of MSW and 3,000 t/annum of SS,
- Viareggio: 5,000 t/annum of MSW and 50,000 t/annum of SS.

The co-incineration of sewage sludge and solid wastes in incineration plants appears feasible if a drying step for sludge is introduced. Some trials are being carried out in Sesto San Giovanni, near Milan, involving co-operation with two public companies and results are encouraging.

For our baseline scenario, we have assumed that by 2010, Italy will have complied with the UWWT Directive, that sludge production will have reached its maximum at about 1.5 M tds and will remain at that level for the next 10 years. By 2010, recycling to agriculture will remain at around 20-25% but will increase by 2020 to about 25-30%. A large proportion will also be recycled to land reclamation projects (20-30%). Most of the sludge recycled to land will first be co-composted. Thermal treatment (including co-incineration) will increase to 20 % in 2010 and 30% by 2020. A large proportion will still be landfilled in 2010 (25%) but quantities will continue to decrease down to 5% by 2020.

Latvia

Information is mainly extracted from a report produced by GHK (2006). *Following on-line consultation in August 2009, the Ministry of Environment agreed with information given in the summary report below.*

Latvia is a small Baltic state with an area of 65,000 km^2 and 2.5M inhabitants. Agricultural land occupies 39% and forestry 44% of Latvia's territory. In the last decade, with the dismantling of collective farms, the area devoted to farming decreased dramatically -farms are now predominantly small. Latvia joined the European Union in May 2004 but Latvia had started a programme of improving wastewater treatment in 1995.

Regulation 362 regulates the use of sewage sludge and compost on land. Limits of heavy metals in sludge used in agriculture are more stringent than the limits set in the EC Directive.

At the end of 2005, there were 84 agglomerations ≥ 2000 pe with a generated load of 1,893,999 pe. The whole territory of Latvia has been classified as a sensitive area under the UWWT Directive. In 2005, it was reported that 71% of the population was connected to the sewer system (almost all connected to a treatment plant). The availability of a centralised wastewater infrastructure varies from town to town. In towns with a population above 10,000 it typically reaches 70-85% of the population while in towns with a population below 10,000 it can be as low as 30% of the population.

In 2007, there were 924 biological, 6 chemical and 306 mechanical wastewater treatment plants. Out of 71 agglomerations that have a wastewater treatment plant, only 7 were complying with the UWWT Directive standards whilst 64 had a treatment plant which was not fully compliant.

Numerous wastewater projects have been planned for implementation during 2006– 2015. By the end of 2008, Latvia should have finished improvements to wastewater collection in the largest cities above 100,000 pe. Investment will continue until 2015 to construct about 60 new treatment plants with a total capacity of 1.9 M pe and upgrade existing non-compliant treatment plants with a capacity of 1.17 M pe.

Most wastewater treatment plants do not have adequate sludge treatment. The most common final disposal routes for sewage sludge are agriculture and compost.

Wastewater volumes have more than halved between 1990 and 2000, as have the quantities of sewage sludge. It was estimated that about 20,000 tds were produced in 2000, about 29% was recycled to agriculture, 38% stored, 26% used for other uses and 7% composted. No incineration was reported (EIL, 2002). Sludge production continued to decrease between 2004 and 2006 from 36,000 tds in 2004, to 28,900 tds in 2005 and down to 24,000 tds in 2005 (CEC, 2009, personal communication). Quantities recycled to agriculture have fluctuated from 7,700 tds (31%) in 2004, 6,500 tds (22%) in 2005 and nearly 9,000 tds (39%) in 2006. It was mentioned that the high level of heavy metals sometimes restrict the recycling of sludge to agriculture.

Year	**Sludge production (t DS per annum)**	**Agriculture**	
		(t DS per annum)	**%**
2004	36,164	7,684	21
2005	28,877	6,545	23
2006	23,942	8,936	37

For our baseline scenario, we have assumed that by 2010, Latvia will not have finished installing new treatment capacity and thus sludge quantities will not have increased substantially compared with those in 2006. However by 2020, compliance with the UWWT Directive will have been achieved and sludge quantities will have more than doubled to 55,000 tds. In 2010, we consider that recycling to agriculture will remain at around 30 %, landfilling at 40% and 30% to other unspecified outlets. By 2020, whilst agriculture remains at around 30%, landfilling will have decreased to 20% and incineration will have increased by 5% to 10%. It was reported by the Ministry of Environment (2009, personal communication) during the consultation that the incineration of sewage sludge will not be one of the main priorities in the near future.

Lithuania

The following description is based on information provided from a presentation by Ciudariene in 2007 and Cepelè in 2008. *This report has been revised following comments received from the Ministry of Environment during the first on- line consultation in August 2009.*

Lithuania has a population of 3.4 million inhabitants – its territory is divided into 10 counties and 61 municipalities with regional differences in economic development and treatment connection rates. It joined the Union in May 2004. Lithuania designated the whole territory as a sensitive area under the UWWT Directive. It had until 31 December 2007 to provide collection of wastewater and more stringent treatment for agglomerations of more 10,000 pe (i.e. 38 agglomerations) and until 31 December 2009 to fully comply with the requirements of the UWWT Directive (collection and secondary treatment for all agglomerations between 2,000 and 10,000 pe, i.e. 57 agglomerations). It is reported that there are about 75 agglomerations with more than 2,000 pe generating a total load of 2,445,100 pe; 93.3% was collected while 6.7% was reported to be treated by individual treatment systems. 82% was treated by secondary treatment and 61% by more stringent treatment.

In 2006, 60% of the population was connected to a centralised wastewater treatment plant and at least 32% of wastewater received at least secondary treatment. Sewerage systems and wastewater treatment plants are reported to be in need of upgrade and further investments have been identified for the period 2007 - 2013. The latest Commission report on the implementation of the UWWT Directive (UBA 2009), states that in 2005/06, 93% of the generated load of all agglomerations >2,000 pe was reported to be collected with 82% of the total generated load treated by secondary treatment and 61% undergoing more stringent treatment.

Between 2004 and 2006, sludge production increased from 55,350 tds to 76,450 tds per annum (see table below- MoE, 2009, personal communication). The main outlet for sewage sludge is reported to be long-term storage. Quantities recycled to agriculture have however increased during that time.

Year	**Total sludge production (tds/y)**	**Agriculture**		**Other land**		**Landfill**		**Storage**	
		(tds)	**%**	**(tds)**	**%**	**(tds)**	**%**	**(tds)**	**%**
2004	60,579	15,919	29	2,230	4	3,920	7	33,280	60
2005	65,680	16,243	25	2,226	3	3,839	6	43,371	66
2006	71,252	24,716	32	7,454	11	8,598	11	35,682	47

Due to a lack of digestion capacity, most sludge is currently only dewatered. There is however a national plan for biowaste (also covering sewage sludge) which aims to prioritise biogas production and preservation of nutrients (composting). It is planned to set up 10 regional sludge treatment centres between 2007 and 2013, to include digestion, drying and composting plants. There are 3 existing centralised plants for anaerobic digestion of sewage sludge, and an additional 7 plants planned. There is currently one private composting plant for sewage sludge. Nine more composting plants for sewage sludge are planned to be built between 2007 and 2013 using EU funding. There are currently no municipal waste incineration plants.

For our baseline scenario, we have assumed that Lithuania would have reached compliance with the UWWT Directive by 2010, that sludge production will have reached its maximum by then and amount to 80,000 tds with no further change to 2020. In 2010, recycling to land may increase to 30% as landfilling is restricted and incineration capacity will not yet be available. By 2020, landfilling will have decreased further to 30%, agricultural recycling increased to 50-60% and incineration and other thermal treatments increasing to 10-20% of produced sludge solids.

Luxembourg

Limited information was available. The following description is based on information provided from a Interreg project by Kneip *et al* published in 2007 and other reports published by the Luxembourg Administration in 2005 (AEV 2005) and the Commission (CEC 2006).

According to the latest figures from the Commission (UBA 2009), at the end of 2005, there were, in Luxembourg, 42 agglomerations ≥ 2000 pe with a generated load of 1,035,350 pe and a collection rate of 97.8%. Ninety four % of the generated load was treated by secondary treatment and up to 80% to a more stringent level. Luxembourg has wastewater treatment capacities for approximately 950,000 pe;

80% of this treatment provided by 10 biological wastewater treatment plants with capacities ≥10,000 pe. Half of these treatment plants do not comply with the EU standards with regard to organic discharges and 6 out of 10 do not comply with the emission limits for nutrients.

The limited information submitted to the Commission by Luxembourg on sludge quantities and disposal is summarised in table below. According to official figures, from 29 out of 34 treatment plants ≥ 2,000 pe equivalent to 594,444 pe, sludge production amounted to 8,037 tds in 2004 which is equivalent to 13.5 kg MS per pe; 44% were limed; 11% composted; 6% treated by aerobic thermophilic digestion and 39% were not treated or treatment was not specified. Sludge production was reported to amount to 8,200 tds in 2005 (AEV 2005). In 2008, works started on a solar drying unit.

Forty percent (3,229 tds) were recycled to agriculture (98.8% in Luxembourg and 1.2% in Germany); 36% (2,925 tds) composted (73% in Luxembourg; 27% in Germany); 18% (1,433tds) incinerated (93.5% in Germany, 6.5% in NL) and 6% (450tds) other outlets (AEV 2004 and Kneip *et al* 2007). In 2005, 46% (3,780 tds) were recycled to agriculture ; 32% (3,510 tds) were composted (28% in Luxembourg and 15% in Germany) and 11% (900 tds) were incinerated in Germany (AEV 2005).

Sludge quantities produced in 2007 were reported to amount to 9,300 tds (Eureau survey 2008) and to be mainly recycled to agriculture (95%). The remaining sludge was sent to incineration.

Year	**Sludge production (t DS per annum)**	**Agriculture**	
		(t DS per annum)	**%**
1999	7000	5600	80
2003	7770	3300	43

For our baseline, by 2010, we have assumed that there will be no change in the collection rate but that compliance with the UWWT Directive will have been reached for all the sewage and sludge quantities will have risen by 7% to their maximum of 10,000 tds. The majority (90-95%) will still be recycled to agriculture including about 35-40% after composting, 5-10% will be thermally treated and 5% disposed of to other outlets (potentially recycled to land other than agriculture). In 2020, the proportion of sludge recycled to agriculture will have decreased but will still be significant at around 80% (mainly after composting). The proportion of sludge which is thermally treated, either by incineration or co-incineration in cement plants will increase to at least 20% after a study found it to be the best environmentally option (CRTE).

Malta

No information is available, but it is believed that until 2004 there was only a very small amount of sludge produced as there was limited wastewater treatment (17% of generated load). At the end of 2005, there were 6 agglomerations ≥ 2000 pe with a generated load of 584,000 pe. Under the UWWT Directive, by 31 March 2007 all untreated wastewater (25 M m^3 per year) should have been collected and treated to the relevant standards. Since 2006, 3 new wastewater treatment plants have been built or are under construction with the construction for the final one having started in January 2009.

For our baseline, by 2010, we have assumed that all urban wastewater will be collected and treated to the relevant standards and sludge production will have risen to 10,000 tds (25 kg * 400,000 pe). By 2010, agriculture will not be an important outlet and all sludge will be sent to landfills. By 2020, a small proportion may be recycled to agriculture (up to 10%) while the rest is still landfilled.

Netherlands

The following description is based on information provided by Kreunen for the latest version Global Atlas (LeBlanc *et al*, 2008).

The Netherlands has already achieved high compliance with the UWWT Directive. At the end of 2005, there were 340 agglomerations ≥ 2000 pe with a generated load of 16,162,030 pe, 100% was collected and 98.1% was treated by more stringent treatment. Quantities of sewage sludge are not expected to increase over the next 15 years. There are 26 Water Boards providing wastewater services in the Netherlands.

Recycling of sewage sludge in agriculture has been banned in the Netherlands since 1996 as a result of increasingly stringent standards for the application of sludge to land in the late 1980's.

The use of sewage sludge on land is regulated under 'Besluit kwaliteit en gebruik overige organische meststoffen (BOOM) van 30 Januari 1998' [Decree on the quality and use of other organic fertilisers (BOOM) of 30 January 1998].The regulations specify strict limit values for PTEs in soils and restrictions on use. For example, it is forbidden to use sewage sludge on grassland whilst it is being grazed. This ban also applies to land on which forage crops are cultivated, sludge cannot be applied less than three weeks before harvesting. For land which is used for fruit and vegetable plantations, with the exception of fruit trees, the ban applies during the growing period. Finally, it is forbidden to use wastewater sludge on land intended for the cultivation of fruit and vegetables which are in direct contact with the soil and are consumed raw, less than 10 months before harvesting, and during harvesting.

Sludge quantities as reported to the Commission (CEC 2006) are presented below:

Year	**Total sludge production (tds/y)**	**Agriculture**	
		(tds)	**%**
2001	536,000	27	0
2002	571,000	38	0
2003	550,000	34	0
2004	60,579	15,919	29
2005	65,680	16,243	25
2006	71,252	24,716	32

A private company - GMB Sludge Processing Company has two composting plants which process about 15% of the total (dewatered) sewage sludge produced by municipal wastewater treatment plants in the Netherlands, which amounts to approximately 1.5 million tons per year (with a total plant capacity of 1,370,000 PE). Since 2004, this granular product has been used as a biofuel in power stations, both in Germany and the Netherlands. The granules are used by the power stations either as an additive or as a stand-alone biofuel. Of the remainder, approximately 58% is incinerated and 27% thermally dried. The product resulting from these techniques (composting, incineration and thermal drying) still requires further (final) processing.

There is no support in the Netherlands for the application of sewage sludge into or onto the soil, or in agriculture. In addition, the animal manure surplus means that the farming sector is more likely to demand the exclusion of sewage sludge. For our baseline scenario, we have assumed no changes over the next 15 years.

Norway

The following description is based on information provided by Blytt for the latest version Global Atlas (LeBlanc et al, 2008). *This report has been updated following comments received from one commercial stakeholders during the on-line consultation of August 2009.*

Norway has a long coastline and is dominated by forests and mountains. Arable land covers only 3% and is mostly located near bigger cities and at the bottom of valleys. Norway has 4.5 million inhabitants. During the 1970's and 1980's, there was an increase in the number of wastewater treatment plants, especially in the parts of the country with discharges to inland waters and narrow fjords. There are currently about 1,400 treatment plants, most of which are very small.

The sludge from smaller plants is usually transported to larger treatment plants. In total, 62 treatment plants have registered their treated sludge to be regarded as a fertilizer product. Sludge is primarily treated with lime (42%), anaerobically digested (20%) treated by advanced anaerobic digestion (20%) or dried (4%).

The total quantities of sludge produced in 2006 and the main disposal outlets are presented as tds in the table below:

Year	Total production	Total utilization	Agricultural	Green areas	Mixed soil products	Top layer on landfill	Land filled	Other
2006	86,030	86,484	56,055	10,198	13,178	2,934	2,957	1,162

More than 90 % of Norwegian sludge is used as a soil improvement product on land. One-third goes to parks, sports fields, roadsides, and the top cover of landfills, and two-thirds goes to arable land within the agricultural sector. There is no incineration of sewage sludge and nearly no landfilling.

In order to achieve this high rate of land application, stringent standards have been set for the content of heavy metals and pathogens, and control of odour nuisance has been given a high priority. Norwegian regulations concerning sludge are stricter than those for most of the countries in Europe.

Since the late 1990s', political support to recycle organic waste has increased, along with requirements to remove organic waste from landfills, in order to reduce emissions of methane and leachates. Applying sludge on arable land is considered by the Norwegian authorities to be the socio-economically acceptable and cost-effective way to utilise sludge. This implies that farmers are willing to accept the use of sludge. The sewage sludge market is very sensitive to negative reports as farmers acceptance is influenced by many factors including opinions of retailers and consumers. Authorities and wastewater treatment plants work continuously on communicating these benefits, and the low levels of risk.

In the mid-1970's, a reform in the agricultural sector changed the agricultural land use in the populated regions around Oslo and Trondheim from dairy farms with grassland to the production of cereals (barley, wheat, rye and oats) and oil seeds. Single-crop farming depletes organic material in the soil. As there is very little animal manure available, there is a need for organic fertiliser like sewage sludge. Changes in the farm structure and land use are contributing factors to use of sludge on agricultural land. Sludge is not used in forests in Norway.

Several municipalities started to collect separate kitchen waste for making compost. The ministries found it necessary to harmonize the parallel regulations for different types of recycled organic waste. In 2003 a new joint regulation *"Regulation on Fertilizers Materials of Organic Origin",* prepared by the Ministry of Agriculture and Food in co-operation with the Ministry of Environment and Ministry of Health was published. This covered all organic materials spread on land that were derived from materials such as farm waste, food processing waste, organic household wastes, garden waste and sludge. It was also believed that to promote and standardise waste such as sludge, higher treatment and quality control standards had to be implemented.

The 2003 regulation sets the following major requirements for organically derived fertilizers in general, with a few special requirements for sludge:

- All producers have to implement a quality assurance system.
- Quality criteria of the products include standards for heavy metal content, pathogens, weeds and impurities, in addition to a more general requirement of product stability (linked to odour emissions). There is a requirement for taking reasonable actions to limit and prevent contamination with organic micro-pollutants that may cause harm to health or the environment.
- Requirements on product registration and labelling before placement on the market.
- Special crop restrictions for sludge, including a prohibition on growing vegetables, potatoes, fruit and berries for three years, and on spreading sludge on grassland.
- Requirements for storage facilities before use. Sludge cannot be spread on frozen soil so must not be applied later than November and not before 15 February. Sludge has to be mixed into the soil (ploughed) within 18 hours of application.
- Beside the limit values for heavy metals, the hygienic requirements are: no *Salmonella sp*. in 50 grams, no viable helminth ova. and less than 2,500 fecal coliforms per gram dry solids.

All farmers must are required to make a plan for all fertilizers including sludge to be spread on his fields, and to notify the municipality at least three weeks before sludge is locally stored or spread. The wastewater treatment plant or the sludge transport company often assists the farmer with this notification. A farmer cannot apply sludge more frequently than every 10 years on the same field, but that will depend on to the sludge quantity and amount used.

There is no change expected to the rate of sludge recycling to agriculture. However, there may be some restrictions in regions which have high P levels in soil to comply with the WFD requirements.

Markets for sludge within the landscaping sector are increasing. New markets for green energy may enhance cultivation for energy crops. This may increase sludge application on these types of arable land. There are ongoing experiments and pilot trials making synthetic diesel from sludge and organic waste. It is becoming more common to co-digest sludge and food waste in order to increase the production of biogas (methane). This will lead to a sludge quality with a lower metal, but higher nutrient content.

Poland

The following description is based on information provided from a presentation by Twardowska in 2006 and a paper by Przewrocki et al 2004.

At the end of 2005, there were 886 agglomerations ≥ 2000 pe with a generated load of 41,598,316 pe. In 2001, 51.5% of the population were connected to a sewage treatment plant. No recent update to this information has been supplied to the Commission.

Sludge production has steadily increased from 340,040 tds in 1998, 397,216 tds in 2001, 476,000 tds in 2004, 495,675 tds in 2005 and 523,674 tds in 2006 (CEC 2006 and 2009). Compared with the 2001 figure, a doubling of sludge quantities is expected by 2015 along with an amelioration of the quality of the sludge due to the reduction of industrial pollutants discharged into sewers. Almost all sludge produced is stabilised by anaerobic digestion or by a natural drying method,

The recycling of sewage sludge to agriculture increased from 8% in 1998 to 14% in 2000, then reduced to 12% in 2001 and up again to 17% in 2006 (44,819 tds in 2004, 42,558 tds in 2005 and 44,284 tds in 2006). Between 2000 and 2001 the amount of composted sludge increased from 25,528 tds to 27,591 tds (7%), while recycling to agriculture dropped slightly from 50,628 tds (14%) to 49,302 tds (12%). Industrial use (not specified) of sewage sludge increased from 19,815 tds (5%) in 1998 to 28,274 tds (7%) in 2000 and then fell to 24,220 tds in 2001 (6%). Quantities of sewage sludge sent to landfill have dropped from 191,600 tds in 1998 (56%) to 151, 618 t ds in 2000 and rose again to 198,630 tds in 2001 (50%). Quantities incinerated dropped between 1998 and 2001 from 14,389 tds (4%) to 6,937 tds (<2%).

According to a 2008 Eureau survey, sludge production in 2005 amounted to 790,900 tds; 147,000 tds (18%) was sent to landfill; 80,600 tds (10%) recycled to agriculture; 4,500 tds was incinerated and 558,700 was sent to other outlets (not specified).

The estimates for sludge management routes prepared by the Ministry of the Environment are presented below:

- The proportion of municipal sewage sludge disposed of to landfill will rise to 45% in 2010 but will decrease to 39% in 2015.
- The proportion of sewage sludge incinerated should rise from 1.6% in 2001 to 5% in 2010 and 8% in 2015. This will depend on new investments in incineration plants.
- Composting is the preferred method of sewage sludge treatment. It is estimated that 20% of sewage sludge could be composted; however, this requires the construction of sufficient composting plants.
- Another route will be recycling to agriculture. The introduction of more effective and stringent regulations will limit the increased use of sewage sludge in agriculture. In 2015, it is predicted that about 26% of sewage sludge will be recycled via this route. Sewage sludge use as fertilizers will reach 46%, including composted sludge.

Portugal

The following description is based on information provided by Duarte for the latest version Global Atlas (LeBlanc et al, 2008). *This has been revised following comments received from the Environment Agency and a commercial stakeholder during the first on-line consultation in August 2009.*

Regulations on the recycling of sewage sludge to agriculture have recently been amended by Decree-Law No 118/2006 of 21 June 2006, repealing Decree-Law No 446/91 of 22 November 1991, Portaria [Order in Council] No 176/2006 of 3 October 1996 and Portaria No 177/96 of 3 October 1996.

The principal changes to be found in Decree-Law No 118/2006 of 21 June 2006 are the adoption of more stringent rules as regards analyses, definitions, information to be provided, specific bans on the use of sludge in some situations (e.g. in organic farming) and the extension to all soils of the licensing system for the use of sludge. There are also additional provisions such as a compulsory application of sludge within two days of delivery.

Another recent regulation, Decree-Law No 173/2008, approves recycling to agriculture as the Best Available Techniques (BAT). According to the official sources, these two regulations should contribute to an increase in quantities recycled to agriculture, while the industry commented that the new regulatory regime makes it complicated and difficult to obtain the necessary authorization for sewage sludge recycling and as a result, there are some serious problems in the recycling process in Portugal.

There is a strategic plan (2007-2016) for diverting biodegrable waste from landfill through anaerobic digestion, composting, Mechanical Biological Treatment (MBT) and incineration with energy recovery. Two thermal treatment centres are planned to be operational by 2013 for combined sewage sludge and refuse derived fuel (RDF).

In Portugal, there are wide regional differences in sludge production and management as the number of inhabitants, development of wastewater treatment varies greatly along with soil and climatic conditions.

Since the implementation of the UWWT Directive, there have been major upgrades of existing wastewater treatment plants and construction of new ones, leading to an increase in sludge production. At the end of 2005, there were 404 agglomerations ≥ 2000 pe with a generated load of 11,255,420 pe; 95.2% was collected; 71% was treated by secondary treatment and 24% by more stringent treatment.

65% of the population was served by a treatment plant, most having secondary treatment (43%); 24% also providing tertiary treatment. The Southern regions (Algarve Alentejo and Lisboa e Vale do Tejo) had about 76% of the population served by a treatment plant and the Northern regions (Centro and Norte) about 58%. The objective as set up in the strategic plan for water supply and wastewater (2007-2013) is to connect 90% of total population to public sewer networks and treatment plants.

Industrial discharges to these treatment plants account for 50% of the load in the Southern, and up to 70% of the load in the Northern regions where industry is more important. The total generated load was estimated to be about 10,650,000 pe.

The available information on sludge production was reported to be scarce and dispersed. Based on field studies carried out in two different Portuguese regions: Algarve (2005) and Center Alentejo (2006), the amount of sludge produced has been estimated and is reported in the table below:

Region	**pe**	**Daily sludge production ratio (g DM/pe.day)**	**Sludge production (tds/year)**
Norte	3,500,300	80	102,209
Centro	2,404,800	50	43,888
Lisboa e Vale do Tejo	3,441,600	50	62,809
Alentejo	802,500	70	20,504
Algarve	499,500	40	7,293
TOTAL	**10,648,700**	**60**	**236,703**

The range assumed for the sludge production (40 – 80 g DM/pe.day) depends on the sludge treatment process, the upper limit is for non-digested sludge with lime addition and the lower limit is for digested sludge without lime addition.

It is estimated (AdP, 2009, personal communication) that the rate of sludge production is currently about 22 to 23 kg/pe/year. As compliance with the UWWT Directive is not yet complete, it is possible that the rate will rise, in the next decade. However, it is expected that the future volume of industrial discharges will decrease. It has been estimated that by 2015, Portugal will produce around 750.000 tds of sludge. Based on the hypothesis of 25 kg DS per capita and 90% connection – the total urban sludge production in Portugal should amount to about 150,000 tds.

Quantities reported to the Commission (CEC 2006 and 2009) are presented below:

Year	**Sludge production**	**Quantities recycled to land**	
	tds	**Tds**	**%**
1995	145,855	44,000	30
1996	177,100	53,130	30
1997	214,200	64,260	30
1998	121,138	41,413	34
1999	374,147	66,547	18
2000	238,680	37,176	16
2001	209,014	69,853	33
2002	408,710	189,758	46

Year	Sludge production	Quantities recycled to land	
	tds	Tds	%
2003	ND	ND	-
2004	63,758 [a)]	216,784 [c)]	-
2005	401,017 [b)]	225,301 [d)]	56
2006	ND	ND	-

Notes:

a) this amount does not seem correct but it is as reported by the official authorities to the Commission: 6,966 tds of urban sludge and 56,792 tds of industrial sludge
b) including 26,096 tds of urban sludge (6.5% of total) and 374,921 tds of industrial sludge
c) including 31 tds of urban sludge and 216,753 tds of industrial sludge
d) including 30 tds of urban sludge and 225,331 of industrial sludge

Until recent years, the most common disposal outlet for sewage sludge was landfill. However, this disposal option is becoming more restricted as regulations limit disposal of organic matter and the cost of landfilling is increasing.

It is reported that public opinion is against incineration and protest actions have taken place every time plans for waste incineration plants have been presented. There are also reported public concerns about the recycling of sewage sludge to agriculture. However, it is believed that the agricultural use of sludge could play a major role in the future in Portugal, especially in the Central and Southern regions of the country where soils are deficient in organic matter.

Increasing numbers of operators have started to transport and apply sludge on agricultural and forestry land. The main agricultural crop receiving sludge in Portugal is maize, followed by vineyards and orchards. Some sporadic applications occur in forage areas and in forestry after forest fires.

At the same time, other industries and activities such as agro-industries have products, such as municipal solid waste (MSW), manure and slurry from intensive livestock production also rely on agricultural land for the disposal of their waste and are thus competing with sewage sludge for the available land. This is especially the case in the Northern and Central regions which are more highly populated, thus the regions treatment plants produce more sludge and also more intensive livestock production occurs and thus production of manure and slurry competes for available agricultural land.

In 2010, Portugal will have thermal drying systems that could produce approximately 10.000 tonnes of dry pellets a year. The implementation of solar drying will allow the use of sludge in the cement industry which could receive up to 30.000 tonnes/year of dried sludge.

In 2013 Portugal will have two incineration plants operational, which will treat, together with RDF, almost 350,000 tds/year of sludge, corresponding to approximately 50% of the total estimated future sludge production.

The main outlet for the other 50% will be recycling on agricultural land, and eventually co-incineration in cement factories.

For our baseline scenario, we have assumed that by 2010, compliance with UWWT Directive will not be achieved but that sludge production would have risen slightly to about 420,000 tds and that recycling to agriculture will be about 50%. The remaining sludge will be thermally treated (30%) and landfilled (20%) depending on treatment capacity. Full compliance with the UWWT Directive will have been achieved by 2020 and sludge production will reach 750,000 tds; 50% will be incinerated and 45% will be recycled to agriculture and 5% sent to other outlets such as cement factories.

Romania

The report is based on information submitted to the Commission for the latest sludge survey and from a paper from Crac (2005). *This report has been revised following comments received from the Ministry of Environment during the first on- line consultation in August 2009*.

Romania joined the EU in January 2007 and has been granted an extended period, up to 2019, to comply with the UWWT Directive. At the end of 2005, there were 2605 agglomerations ≥ 2000 pe including 22 large agglomerations (>150,000 pe) generating a total load of 26,418,555 pe (including 9.5 M pe for large agglomerations which will have treatment plants with tertiary treatment). It is reported that at that time 47.3% of generated load was collected; 28% was treated by secondary treatment and 1.3% by more stringent treatment.

Directive 86/278/EEC was transposed in Romanian legislation by Ministerial Order no. 49/2004. Sludge quantities are reported below. Sludge production seems to have decreased between 2004 and 2006 (CEC, 2009 personal communication).

Year	**Total production (tds/y)**
2001	171,086
2004	164,969
2005	134,322
2006	137,146

There is currently no recycling of sludge to agriculture, the majority of sludge is sent to landfills. In 2005-2006, 97% of sewage sludge was stored and 3% was disposed of through other methods (not specified) (MoE, 2009, personal communication). It is reported that recycling to agriculture has been considered as an option for future management together with co-incineration in cement plants (Crac, 2005).

For our baseline scenario, the following points were taken into account: decline of population; existence of 22 big cities generating large quantities of sludge; moderate development of agriculture between 2010 and 2020; and the expansion of vulnerable areas up to 55% of agricultural land. We have assumed that by 2010 the situation will have not changed compared with 2006 and that full compliance will be achieved by 2020.

By 2020, sludge quantities will have risen dramatically to 520,000 tds (25 kg/ds/inh *21 M inhabitants). By 2020, it is expected (MoE, 2009, personal communication) that about 20% of sludge will be recycled to agriculture; 30% will be stored, 10% incinerated and the remaining 40% will be disposed of by other methods (30% for energy recovery and 10% recycled to other land (mines reclamation projects or forestry).

Slovakia

The following description is based on information provided by Sumná for the latest version Global Atlas (LeBlanc *et al*, 2008).

At the end of 2005, there were 356 agglomerations ≥ 2000 pe with a generated load of 5,054,900 pe; 75.5% was collected and 12.1% relied on individual treatment systems; 65% received secondary treatment and 18% underwent more stringent treatment. Following the implementation of the UWWT Directive, it is estimated that sludge production will increase by 20-40%. During the period 2004-2006, about 55,000 tds of sludge was generated per annum.

Sewage sludge production (tds per annum) and disposal outlets in the years 2004 – 2006 (CEC 2009) are presented in table below.

Year	Total	Incineration	Agriculture (1)	Landfill (2)	Forestry	Other
2004	53,114	0	41,116	10,581	0	1,417
2005	56,360	0	34,784	17,236	0	4,340
2006	54,780	0	33,630	15,375	0	5,775

Notes:
1) While sludge was directly applied to agricultural land in 2004 and 2005, by 2006 large quantities were diverted for the production of compost.
2) Landfill also includes quantities of sludge that were temporarily stored.

About 90% of monitored sewage sludge production in Slovakia meets the limit values for PTEs as a result of pollution reduction programmes for industrial discharges to public sewers that have been implemented.

Recycling of sewage sludge to agriculture is the preferred option, not only because it was the cheapest option but because it was recognised as being the best environmental option for sustainable development. Direct application of sludge onto agricultural land is regulated according to the Act on Sewage Sludge Application into Agricultural Land. This determines the conditions for sewage sludge application onto agricultural and forest land without affecting soil properties, plants, water, or the health of humans and animals. The Act authorises, under specific conditions, applications to arable land and permanent grassland and forestry (only soil in forest nurseries, in plantations with Christmas trees, fast-growing wood plants, energetic and intensive growths). It does not deal with the application to non-agricultural land or use of sludge in land reclamation.

Application of compost, soil, fertilizers or growing media is regulated by the Act on Fertilizers. In this case, the sludge 'product' is subject to certification and assessment that technical documentation is in line with related technical standards and legal regulations.

There is currently no incineration capacity suitable for sludge incineration. However, the national waste management plan for 2005-2010 plans to increase the capacity and to promote energy recovery from waste. The capacity for waste co-incineration in two cement plants exists in the Slovak Republic (others do not comply with the conditions of the Act on Air Protection), but currently it is reserved for the handling of industrial waste and co-incineration of animal waste. However with the decreasing production of animal waste, sludge could be considered as an alternative in the future in these facilities.

Disposal of sludge to landfill is the least favoured option for sludge management by the Slovak Government. However, due to lack of incineration capacity, it is the only alternative option for sludge disposal. It is expected that the proportion of organic waste disposed at landfills will be limited in line with the requirements of the EC Landfill Directive.

The aim of the Waste Management Programme of the Slovak Republic is to decrease the amount of landfilled waste to 13% of the total amount of waste being generated by 2010.The measures planned to achieve this are, decreasing the amount of sewage sludge disposed of to landfill, and increasing the cost of landfill disposal for all materials.

For our baseline, we have estimated sludge quantities to amount to 135,000 tds by 2020. The proportion of sludge recycling to agriculture as compost will be 50% or more, landfilling will decrease to 5% or less depending on thermal treatment capacity which could treat up to 40% of sewage sludge.

Slovenia

The following description is based on information provided by CEC, 2006; Grilc and Zupancic for the latest version Global Atlas (LeBlanc *et al*, 2008), a presentation given by Mayr and Zugman in 2005 and by Medved in 2006 and a paper from Vukadin and Podakar (from Environmental Agency) in 2007. *This report has been revised following comments received from the Ministry of Environment during the first on- line consultation in August 2009*.

Slovenia was a part of former Yugoslavia until 1991 and in May 2004 it became a member of the EU. Wastewater treatment capacity has increased steadily since 2000 when Slovenia entered the process of accession to the EU.

By the end of 2005, there were 156 agglomerations ≥ 2000 pe with a generated load of 1,531,749 pe; 73.2% was collected; 50% at least treated by secondary treatment and 19% by more stringent treatment. In 2007, there were 223 municipal wastewater treatment plants in operation with a total capacity of 2 Mpe; 10 % with a treatment capacity larger than 10,000 pe and 5 plants with a capacity larger than 100,000 pe. In 2007, about 60 % of the population was connected to a centralised treatment plant while 40% relied on cesspools. About 41% (i.e. 72.2 M m^3) of total generated load was treated by secondary treatment and 19% (i.e. 31.2 Mm^3) by more stringent treatment. The current level of connection to sewers and treatment is still low but full compliance with the UWWT Directive should be achieved by 2017.

The recycling of sewage sludge to land is regulated by the Decree 62/08. The available arable land in Slovenia is limited to 36% as 60% of the country is covered with forests and woods. Application of sewage sludge in forestry is prohibited. There is a ban on landfilling of untreated waste (including sewage sludge) due to stricter waste acceptance criteria being in force from 15 July 2009.

Current sludge production ratio in Slovenia is about 10 kg DS per capita (Mo E, 2009). Sewage sludge quantities reported by Crilc and Zupancic (2008) indicate an increase from 15,000 tds in 2002 to 47,000 tds in 2006. The official quantities reported by the Slovenian Environmental Agency (SEA 2007, CEC, 2009, MoE, 2009, personal communication) are much lower and were estimated to amount to only 7,000 tds in 2002 and about 19,500 tds in 2006 (see tables below). These figures differ slightly from figures submitted to the EC for the period 2001-2006.

Figures from the Environmental Agency of the Republic of Slovenia (MoE 2009, personal communication) are reported below:

Year	**Sludge production**	**Quantities recycled to agriculture**		**Landfill**		**Composting**		**Incineration**		**Other**	
	(tds)	**(tds)**	**%**	**(tds)**	**%**	**(tds)**	**%**	**(tds)**	**%**	**(tds)**	**%**
2000	8,800	300	3	7,500	85	1,000	11	-	-	-	
2001	8,200	500	6	6,800	83	900	11	-	-	-	
2002	7,000	1,100	16	5,000	71	900	13	-	-	-	
2003	8,800	500	6	7,000	80	0	0	-	-	1,400	16
2004	12,900	100	>	9,000	70	0	0	-	-	3,700	29
2005	16,900	100	>	9,500	56	100	>	-	-	7,200	43
2006	20,100	0	0	9,200	46	0	0	5,200*	26	5,600	28
2007	21,139	18	>	8,871	42	3,526	17	5,099	24	5,600	26

* there is no incineration plant in Slovenia – sludge is exported for incineration

Figures reported by the Commission (CEC 2006 and CEC 2009, personal communication) are presented below:

Year	Sludge production (tds)	Quantities recycled to agriculture (tds)
2001	8,200	500 (6%)
2002	7,000	1,100 (16%)
2003	9,400	800 (9%)
2004	9,687	125 (<1%)
2005	13,580	71 (<1%)
2006	19,435	27 (<1%)

Both sets of figures show that quantities of sewage sludge have increased steadily, more than doubling since 2003. The rate of increase will level off in the next few years as the construction of the largest plants is completed.

Filter presses and belt filters are mainly used at small plants, whereas continuous centrifuges are used at large plants. Anaerobic digestion of sludge is relatively rare (10 plants only), mainly at larger plants, where biogas production contributes to the reduction of treatment costs. Some plants use combined input; that is, fresh sewage sludge and separately collected biodegradable municipal waste, food waste, and other similar materials.

Crilc and Zupancic (2008) reported that, in 2006, some wastewater companies disposed of around 14% of their sludge on-site (internally). The main 'internal' outlets for dried sewage sludge was land application and recycling after composting on the premises of treatment plants or of their operators (mainly non-arable land). In addition, small amounts of sludge were temporary stored, before the most appropriate (or cheap) method could be found. The largest proportion of sludge (47%) was exported abroad in granulated dry form for incineration. The reason for this is the absence of proper incineration facilities in the country and increasingly stringent landfill requirements. The existing industrial thermal processes have not yet obtained permits to co-incinerate dried sludge as an alternative fuel. Co-incineration in cement kilns is however not considered to be particularly attractive in Slovenia due to its relatively low calorific value (about 11-12 MJ/kg at 90% DM.). The export of sludge for incineration abroad should however, only be a temporary solution as new thermal treatment facilities for wastes and sludge are currently under construction. Landfill disposal of dried sludge was reported to amount to 30% in 2006.

Figures from the Environment Agency of the Republic of Slovenia (MoE 2009, personal communication), show that agricultural recycling has became almost inexistent due to the high content of PTEs in sludge, especially zinc, copper, chromium and lead. However, it is expected that this outlet could be a viable future option with the expected improvement of sludge quality. It has been estimated that 27% out of 440 ha of arable land could be suitable for sludge application. However, locally, the Nitrates Directive requirements could significantly restrict its application.

Composting of sewage sludge seems to be favoured by the official authorities, and quantities have increased again from 0% in previous years to 17% in 2007. It is usually composted in combination with biodegradable municipal waste and other structural materials (bark, corn stalks). Compost is used in non-agricultural applications such as for recultivation of landfill sites, land reclamation of degraded areas, public parks maintenance and other similar locations.

Landfill disposal of dried sludge has been the most traditional disposal method and, was still the preferred route for sludge disposal in 2007 (42%), with about 25% exported for incineration as there is no thermal treatment plant in Slovenia.

From 2008, sludge disposal to landfill will decrease due to stricter waste acceptance criteria for landfills, such as the requirement for a total organic carbon content of less 18% DM and a calorific value less than 6 MJ/kg. In particular, the required TOC/DOC limit values are difficult to reach by conventional digestion/composting stabilization processes.

Figures from Grilc and Zupancic (2008) are presented below:

Disposal Methods	Internally		Externally	
	Quantities (tonnes DS/y)	%	Quantities (tonnes DS/y)	%
Temporary storage	321	<1	589	1
Recycling/Composting	2,831	6	4,030	8.5
Land use	3,288	7	0	0
Landfill disposal			13,967	30
Export (to incineration)			21,916	47
Other disposal types			123	2
Total	**6,440**		**40,625**	**47,065**

For our baseline, the situation in 2010 will remain the same as in 2007, with quantities of sludge expected to increase by 2020 to 50,000 tds. Between 2010 and 2020, the proportion of sludge being recycled to land will increase as sludge quality improves but will stay relatively low at around 15%. Disposal to landfill will also decrease to 5-10 % whilst thermal treatment will remain the preferred option.

Spain

At the end of 2005, there were 2381 agglomerations ≥2000 pe with a generated load of 71,739,629 pe. With the implementation of UWWT Directive, sewage sludge production will continue to increase. Sludge quantities reported to the Commission (CEC 2006 and CEC 2009, personal communication) are presented below:

Year	Sludge production (tds)	Quantities recycled to agriculture (tds)
1997	685,669	314,329 (46%)
1998	716,145	353,986 (49%)
1999	784,882	413,738 (53%)
2000	853,482	454251 (53%)
2001	892,238	606118 (68%)
2002	987,221	658453 (67%)
2003	1,012,157	669554 (66%)
2004	1,005316	662,009 (66%)
2005	986,086	628,553 (64%)
2006	1,064,972	687,037 (64%)

Spain has problem of soil erosion and desertification, and so the recycling of sewage sludge to agricultural land is the preferred option, as indicated in the National Sewage Sludge Plan of WWTP 2001-2006: "As long sewage sludge complies with legal requirements, including those which might be established in the future (...) it is considered that the most sustainable option is the recycling of nutrients and organic matter by agricultural land application" (art. 1.3.).

This plan estimated that by the end of 2005 the production of treatment plant sludge in Aunsalucia would reach 1,250,000 tons of wet material per year, while in Galicia, it would reach 90,000 tonnes dry matter/year. It was assumed that 40% would go to agricultural use and soil conservation, (excluding composting), 25% for composting, 20% to incineration with energy recovery, and 15% to landfill.

Recycling of sewage sludge to agriculture is regulated under the Royal Decree 1310/1990 of 29 October 1990 and its application Order of 26 October 1993. In addition, two other national regulations impact on sewage sludge recycling; Royal Decree 824/2005, of 8 July, on fertilizer products, which governs the use of sewage sludge and other bio-solids in the elaboration of organic fertilizers and their commercialization, and the Royal Decree 261/1996, on the protection of the waters produced from the nitrates from agricultural sources.

Sweden

The following description is based on information provided by Hultman et al (1999).

Sweden has a population of about 9.2 million people. The proportion of people living in urban, rural or in sparsely populated areas is about 85%, 5% and 15%, respectively. At the end of 2005, there were 339 agglomerations ≥ 2000 pe with a generated load of 7,889,073 pe; 100% of load was collected and 100% load was subject to more stringent treatment. There are approximately 2,000 municipal wastewater treatment plants and 95% of the population live in towns and agglomerations with more than 200 inhabitants and are served by plants with tertiary treatment. Full compliance with the UWWT Directive is already achieved.

Sweden has strengthened its regulations concerning limiting values of metal concentrations in sludge. In addition there are also limit values for organic substances (nonyl-phenol, toluene, total PAH and total PCB).

There are legal restrictions on disposal to landfill and, since 2005, organic wastes including sludge from wastewater treatment plants have effectively been banned from landfill disposal. In addition, since 1 January 2000, a landfill tax has to be paid when sludge is disposed of to landfill.

Centrifuges are the most commonly used dewatering equipment followed by belt presses. Other conditioning methods are used such as the KREPRO process which uses sludge conditioning by use of acids and heat. There is a growing interest to use natural and biological dewatering methods, for example, by use of reed beds.

All large treatment plants use anaerobic digestion, while the other methods are used at small and medium-sized plants. There are also some examples of thermal drying.

Co-treatment of sewage sludge with solid wastes has been investigated at different scales, for example:

- Sludge incineration together with municipal solid wastes
- Anaerobic digestion of sludge together with other organic materials
- Large-scale composting of sludge together with other organic materials.

Sludge production has been relatively stable for the last 10 years at around 210,000 tds per annum (CEC 2006 and 2009) while quantities recycled to agriculture have fluctuated due to debate over the safety of the outlet but it seems to have reached a stable level at around 10 -15 %.

At the end of the 1980s, sludge disposal outlets in Sweden were agriculture (35%), landfill (50%), land reclamation (15%) and others (5%). Ten years later (1998) agricultural use had declined to 25% and disposal to landfill had increased to 46%. In 2006, the agricultural and landfill outlets had further reduced to 15%, and 4%, respectively while other outlets (land reclamation, green spaces, co combustion, etc) were reported to have reached 81% (Eureau, 2008).

Estimated sludge production and recycling to agriculture (CEC 2006):

Year	Sludge production (tds)	Quantities recycled to agriculture (tds)
1995	230,000	67,800 (29%)
2000	220,000	35,000 (16%)
2003	220,000	19,000 (9%)
2004	210,000	20,000 (9%)
2005	210,000	25,000 (12%)
2006	210,000	30,000 (14%)

The main reason for the decrease in sludge recycling to agriculture was that, in 1990, the Federation of Swedish Farmers (LRF) recommended that its members should not use sludge. A national consultation group was formed between LRF, the Swedish Water and Waste Water Works Association (VAV) and the Swedish Environmental Protection Agency (SEPA) which reached agreements concerning agricultural use. However, at the beginning of 2000, LRF argued that agricultural spreading should be suspended because of the presence of brominated flame retardants in sludge and their possible negative effects on soils and organisms.

In the early 2000's, VAV ordered a product certification system from the Swedish Testing and Research Institute (SP). The food industry requires that sludge be quality assured through a certification system. However this offers no guarantee that the sludge will be accepted for use in agriculture. A quality assurance system (ReVAQ) has been designed together by the concerned parties, water companies, farmers, nature conservation and the food industry but the future of agricultural use of sludge is still uncertain. Future use of sludges in agriculture may, however, decrease due to concerns of the food industries and the public.

Landfilling had increased due to recommendations to avoid sludge in agriculture, but has now decreased to below 5% by 2005 due the legal restrictions on organic wastes going to land, the introduction of a landfill tax and the difficulties in finding new land areas or getting permits for the disposal.

Incineration is a well established method for solid waste treatment but not for sewage sludge. Co-incineration with solid wastes may be an alternative to mono-incineration although it seems that most existing incineration plants for solid wastes do not have excess capacity to also burn sludge. Therefore, attention has been directed towards co-incineration with biofuels (wood, peat etc), coal power plants or plants producing building materials at high temperatures (cement, brick etc). The use of incineration of sludge in Sweden will be influenced by the potential introduction of a tax on incineration and the potential requirement that phosphorus must be recovered either before or after incineration.

Other land uses of sewage sludge represent 10-15% of sludge production in Sweden. Sludge based products and soil conditioners can be used on reclaimed land, parks, golf courses, green areas etc (there are about 400,000 hectares of green areas in Sweden). Sludge can also be used as landfill cover material. Sludge used in forestry has received some attention from forest companies. Sludge can be spread dried, in pellet form, on mineral soil to compensate for nitrogen losses due to soil acidification and intensive forestry.

Increased interest has been devoted to extraction of products from sludge. Two commercial systems are mainly under consideration in Sweden, namely the KREPRO and Cambi processes. The Cambi and KREPRO processes aim to see the dissolved substances as resources, either through improved methane production in the digester (Cambi) or by reuse of precipitation chemicals, production of a fertilizer (ferric phosphate), and separate removal of heavy metals in a small stream (KREPRO).

For the baseline study, sludge quantities are expected to increase slightly mainly due to population growth. By 2010, sludge quantities will remain at 210,000 - 220,000 tds increasing to 250,000 tds by 2020. Over the next 10 years, the proportion of sludge recycled to agriculture will stay at 15% - 20% while recycling to other land uses is expected to be around 70-75%, disposal to landfill will reduce to 1% and 5%-10% will go for co-combustion.

United Kingdom

The following description is based on information provided by Matthews for the latest version Global Atlas (LeBlanc et al, 2008). *This report has been revised following comments received from the Ministry of Environment and commercial stakeholders during the first on- line consultation in August 2009.*

At the end of 2005, there were 1638 agglomerations ≥ 2000 pe with a generated load of 64,218,933 pe. About 96% of the UK population is connected to sewers leading to sewage treatment works (DEFRA, 2002). Most of the remainder are served by small private treatment works, cesspits or septic tanks.

Sludge quantities in the UK have increased steadily over the last 11 years (see table below) from 1.1 M tds in 1995 to 1.5 M tds in 2006 (CEC, 2006 and 2009, personal communication). This includes about 1.3 M tds in England and Wales; 140,000 tds in Scotland and 35, 000 tds in Northern Ireland.

In Scotland it is estimated that there will be a 17% increase in the amount of sewage sludge produced over the next 20 years as improvements to sewage treatment are implemented as required under the EC Directive. In Northern Ireland, by 2010, total sludge production is estimated to be equivalent to 52,000 tds.

Before 1998, about a quarter of UK sewage sludge was either dumped at sea or discharged to surface waters but this practice was banned in 1998 under the UWWT Directive. The most common option in the UK for sludge disposal is now recycling to agricultural land, at around 70% in 2006 (CEC 2006 and 2009). This is followed by incineration with subsequent disposal of ash to landfill. Landfill, which was always the less preferable option, is now used less due to increasing restrictions following the 1999 Landfill Directive, lack of site availability and costs. Liquid sludge can no longer be disposed of into landfill sites. There are however regional differences between England and Wales, Scotland and Northern Ireland.

In Scotland, in 2005, 51,000 tds (36%) was incinerated and 29% was recycled to agriculture; 23% was recycled to other land and 11% was landfilled.

In Northern Ireland, up until the end of December 1998, about half of the sludge was spread on agricultural land and most of the remainder (approx 15,000 tds) was disposed of at sea to a licensed area outside Belfast Lough. A small proportion, some 2,000 tds, was taken to landfill. In 2004, incineration was the preferred option treating about 22,000 tds (65%) whilst the remainder was disposed of to other outlets (not specified).

Sludge recycling to land is encouraged in the UK as a contribution to the environment by recycling valuable nutrients and organic matter. It is recognised by the Government as the BPEO in most circumstances. Requirements are defined in the 1989 Sludge Regulations (Use in Agriculture) as amended (implementing the EC Sewage Sludge Directive) and the associated non-statutory Code of Practice, and have been made more stringent by the voluntary agreement – the Safe Sludge Matrix - between the British Retail Consortium, Water UK (which represents the UK Water Utilities), and ADAS (the Agricultural Development and Advisory Service), with the support of the Environment Agency. The UK Government announced its intention to revise the regulations to provide further safeguards against the transfer of pathogens from sewage sludge to the food chain and could make current voluntary requirements statutory. Regulations have not yet been amended partly because the voluntary agreement is being respected.

Year	**CEC 2006, 2009**	**DEFRA 2009**			
	Sludge production ($x10^3$ tds)	**UK sludge**	**England and Wales ($x10^3$ tds)**	**Scotland ($x10^3$ tds)**	**Northern Ireland ($x10^3$ tds)**
1995	1,120	1,124	993	93	34
1998	1,045	1,058	936	97	25
2001	1,187		1,137	-	-
2002	1,303	1,390	1,249	113	28
2003	1,360	1,422	1,280	113	29
2004	1,445	1,368	1,221	113	34
2005	1,511	1,509	1,369	140	ND
2006	1,545	ND	ND	ND	ND

ND – no data

Outlets for sewage sludge in the UK (CEC, 2006 and 2009 ad DEFRA, 2009)

Year	**Quantities recycled to agriculture**		**Incineration**		**Landfill**		**Sea**		**Power generation**		**Land reclamation**		**Other**	
	($x10^3$ tds)	**%**	**($x10^3$ tds)**	**%**	**($x10^3$ tds)**		**($x10^3$ tds)**	**%**	**($x10^3$ tds)**	**%**	**($x10^3$ tds)**	**%**	**($x10^3$ tds)**	**%**
1995	550	49	82	7	115		254	22	-		-		125	11
1998	504	48	185	17	115		150	14	-		-		105	9
2002	761	58	232	17	65		0		52	4	84	6	196	14
2003	824	61	227	16	38		0		50	4	106	7	177	12
2004	878	62	265	19	15		0		0	0	150	11	60	4
2005	1,056	70	NI		NI		0						NI	
2006	1,050	68	NI		NI		0						NI	

Untreated sludge is no longer applied in agriculture. The extent of dewatering and stabilisation varies from site to site. A variety of treatment methods are used depending on the local treatment facilities. There is no set treatment requirement and many factors are taken into account to meet the required treated sludge quality.

A common method of treating sludge at present is anaerobic digestion to standards that meet the terms of the Matrix. After a period of doubt in the 1990's about the future of anaerobic digestion, the process now has a secure place in sludge strategies, and the design and operation of plants has developed significantly. The process has been extended to higher levels of efficacy and effectiveness to meet the terms of the Matrix by the use of additional stages. These can also have the advantage of improving product quality (that is, releasing ammonia, improving consistency, and reducing smell), producing gas and reducing volume. When digestion is used, the value of the energy created from the methane in the sludge gas is becoming increasingly important. Most sludges are dewatered using centrifuges or belt presses. There continues to be an interest in other thermal processes, such as pyrolysis and gasification, but these are not currently available.

The application rate onto agricultural land depends on the crops, which can be a cereal, but on a local basis could be maize, rape, or sugar beet, (uses for growing potatoes and other root vegetable have become much less frequent in recent years). A typical application rate would be 6-8 dry tonnes/ha/year.

In the past, small quantities of sludge have been supplied to the domestic and horticultural market. The practice has not been widely encouraged for the domestic market due to the difficulties of effecting realistic controls over application and the disproportionate costs. One opportunity to supply a product would be as compost, which incorporated sludge with other materials. Investigation of this continues but, so far, products including a straw-based compost have not proved to be an attractive or cost effective product. If such products are supplied, there is a move towards the much tighter standards produced by the British Standards Institution, such as PAS 100, for composts, and details can be found on the Sustainable Organic Resources Partnership web site – www.sorp.org).

Only a small amount of sludge is used in forestry and this will probably not increase in the future. Untreated sludge is no longer used for any part of the forestry cycle.

Sludge has also been applied on energy crops such as willow and poplar or miscanthus in short rotation plantations. The harvested wood can be used for a number of purposes, including use as a fuel source. The use of untreated sludge is permitted for these crops.

It is unlikely that the use of sludge on conservation and on recreational land would ever constitute more than a small fraction of the disposal of sludge. This market might be bigger than that at present if sludges were composted or dried and pelletised. The soil criteria for agricultural land apply, and it is likely that only fully treated sludge would be used, particularly on recreational land.

There is some use of sludge for land reclamation (i.e. capping landfill sites and creation of woodland on brownfield sites) However, these tend to be opportunistic and will probably never constitute a significant outlet for sludge.

For our baseline scenario, the two main options will continue to be recycling to agricultural land and thermal treatment. The issues of energy consumption/production and carbon footprint will become important in assessing the sustainability of operations.

The UK is in the process of reviewing sludge use legislation. The UK Government has proposed the incorporation of the Safe Sludge Matrix into Regulations and could incorporate further changes to reflect any developments of knowledge and attitudes. If implemented, the Regulations would make many of the restrictions explicitly mandatory, rather than placed in a Code context. However as yet there are no firm indications as to when the law will be changed. Nevertheless the Companies are incorporating the principles in their operations. There is a clear awareness of the issues of risk management and accredited quality assurance programmes and many schemes have been registered under ISO 14000 or 9000.

Some of the changes to the Regulations would be:

- Use of untreated sludge would be banned
- Treatment will be in accordance with definitions of conventional treatment and
- enhanced treatment
    - Conventional treatment is 99% (2 log) reduction of *E. Coli* and an MAC of 100,000 per gram DS
    - Enhanced treatment is 99.9999% (6 log) reduction of *E. Coli* and an MAC of 1000 per gram DS and an absence of *Salmonellae* sp
- Ban the use of conventional sludge on grassland unless it is incorporated
- Restrict access for harvesting or grazing for conventional sludge to 12-month intervals for field vegetables and 30 months for vegetables eaten raw
- Max limit for lead lowered to 200 mg/kgDS
- Max limit for zinc in soils pH 5.5-7.0 would be 200 mg/kgDS and for pH values above 7 with a calcium carbonate content more than 5% would be 300 mg/kgDS.

For our baseline, sludge production is not expected to increase over the next 10 years from the 2006 level of 1.6 million tds. Recycling to agricultural land will also stay at a similar high level at around 65-70% over the next 10 years; incineration may increase to 20-25%; land reclamation will increase to 15-20% and landfill will remain low at about 1%.

Table 20 **Estimates of annual sewage sludge production and percentages to disposal routes, 1995 – 2005 (Using data in this report)**

	1995					2000					2005				
Country	total sludge	agriculture	incineration	landfill	other	total sludge	agriculture	incineration	landfill	other	total sludge	agriculture	incineration	landfill	other
	tds/a	%	%	%	%	tds/a	%	%	%	%	tds/a	%	%	%	%
Bulgaria	20,000			100		20,000			100		33,700	40	0	60	
Cyprus	4,000			100		4,000			100		6,542	52		48	
Czech Republic	146,000	24		50	26	210,000	45		30	25	220,700	10	10	10	60
Estonia b)	15,000					15,000					26,800	10			
Hungary	30,000					30,000					125,143	34	1	25	40
Latvia	20,000					20,000	37		38	33	28,877	23	0	40	37
Lithuania	48,000			90	10	48,000	10		90	10	65,680	25	0	6	69
Malta	0					0									
Poland	340,040	8	4	56	32	397,216	12	2	50	36	495,675	8	1	18	70
Romania						171,086	0		100		134,322	0		97	3
Slovakia											56,360	62	0	30	8
Slovenia						8800	3	0	85	12	16,900	<1	0	56	43
Austria a)	390,000	12	5	11	72	401,867	10	10	11	60	238,100	17	43	5	35
Belgium	87,636	32	34	32	2	98,936	13	76	14		125,756	17	67	4	12
Denmark	166,584	67	25		8	155,621	60	43	2		140,021	59	40		
Finland	141,000	33			66	160,000	12			88	147,000	3			97
France	750,000	66	15	20		855,000	65	15	20		1,021,472	62	21	13	4
Germany	2,248,647	42	28		30	2,297,460	37	34	3	20	2,059,351	31	38	2	29
Greece	51,624	0		95	5	66,335	0		95	5	116,806	0		95	5
Ireland	34,484	10	0	43	42	33,559	45	0	54	1	59,827	76	0	17	7
Italy	609,256	26	5	30	40	850,504	26	5	30	40	1,074,644	20	7	31	42
Luxembourg	7,000	80			15	7,000	80			15	8,200	40	18	0	42
Netherlands	550,000	0	100			550,000	0	100			550,000	0	100		
Portugal	145,855	30	0	70		238,680	16	0	84		401,017	56	0	44	
Spain	685,669	46		54		853,482	53		47		986,086	64		46	
Sweden	230,000	29		50	20	220,000	16		44	40	210,000	12	2	4	82
United Kingdom	1,120,000	49	7	10	33	1,066,176	55	21	5	16	1,510,869	70	19	1	10
EU12 % of total EU	8	1	0	4	2	11	2	0	6	2	12	2	0	4	5
EU15 % of total EU	92	36	19	15	22	89	33	22	16	16	88	37	22	13	18
EU27 % of total EU	100	37	19	19	24	100	35	22	22	19	100	39	22	17	23

Notes:

a) In Austria, quantities reported to the Commission for 1995 and 2000 included sludge from municipal treatment plants (60%) and industrial treatment plants (40%) (mainly from cellulose and paper industry)
b) No data provided for Estonia – quantities produced have been estimated

Table 21 **Estimates of annual sewage sludge production, and percentages to disposal routes, 2010 - 2020 (from data in this report)**

Country	2010 total sludge	2010 agriculture	2010 incineration	2010 landfill	2010 other	2020 total sludge	2020 agriculture	2020 incineration	2020 Landfill	2020 other
	tds/a	%	%	%	%	tds/a	%	%	%	%
Bulgaria	47,000	50		30	20	151,000	60	10	10	20
Cyprus	10,800	50		40	10	17,620	50	10	30	10
Czech Republic	260,000	55	25	10	25	260,000	75	20	5	5
Estonia	33,000	15			85	33,000	15			85
Hungary	175,000	75	5	10	5	200,000	60	30	5	5
Latvia	30,000	30		40	30	50,000	30	10	20	30
Lithuania	80,000	30	0	5	65	80,000	55	15	5	25
Malta	10,000			100		10,000	10		90	
Poland	520,000	40	5	45	10	950,000	25	10	20	45
Romania	165,000	0	5	95		520,000	20	10	30	40
Slovakia	55,000	50	5	5	10	135,000	50	40	5	5
Slovenia	25,000	5	25	40	30	50,000	15	70	10	5
Austria	273,000	15	40	>1	45	280,000	5	85	>1	10
Belgium	170,000	10	90			170,000	10	90		
Denmark	140,000	50	45			140,000	50	45		
Finland	155,000	5			95	155,000	5	5		90
France	1,300,000	65	15	5	15	1,400,000	75	15	5	5
Germany	2,000,000	30	50	0	20	2,000,000	25	50	0	25
Greece	260,000	5		95		260,000	5	40	55	
Ireland	135,000	75		15	10	135,000	70	10	5	10
Italy	1,500,000	25	20	25	30	1,500,000	35	30	5	30
Luxembourg	10,000	90	5		5	10,000	80	20		
Netherland	560,000	0	100			560,000	0	100		
Portugal	420,000	50	30	20		750,000	50	40	5	5
Spain	1,280,000	65	10	20		1,280,000	70	25	5	
Sweden	250,000	15	5	1	75	250,000	15	5	1	75
United Kingdom	1,640,000	70	20	1	10	1,640,000	65	25	1	10
EU12 % of total EU	12	5	1	4	2	19	7	3	3	6
EU15 % of total EU	88	37	26	9	15	81	36	30	3	12
EU27 % of total EU	100	42	27	14	17	100	43	33	6	18

15 Annex 3 – Respondent comments summarised

The summary table has been prepared as a link between this report and the individual respondents comments. These summaries of each respondents comments must only be used as a guide to the original comment. The original comments must be regarded as the authoritative source.

Name	Type	Country	Respondent comments summary
Officials			
Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (Austrian Ministry of Environment)	MS	Austria	Forecast figures for Austria realistic Extend scope of directive to cover all land uses Review limit value to current state of the art Limit values for OCs are necessary Quality assurance system is necessary Allow more stringent local limits Not enough covering of alternative for poor quality sludge (P recovery) Favour mono-incineration in order to enable P recovery Check more recent data submitted to COM. Justification of stricter national limit missing Wider group of stakeholder to consult REACH impact on quality of sludge not expected Check info on MBT outlet Check number of states banning recycling and criteria for landfilling
Danish Ministry of Environment-Environmental Protection Agency	MS-A	Denmark	Check connection rate figure 90%, 10% with individual treatment or septic tanks Strict limit in place including for 4 OCs New studies to be included on triclosan (summary in English) and musks (not yet published) Include Kyoto protocol effect Figures for disposal outlets submitted for 2002 - only estimates for more recent years – no figures for future production but some comments such as a reduction of tax on incineration of waste (incl sewage sludge) and potential future increase of sludge going to incineration instead of being recycled. Recycling to land is promoted in DK as P properties of sludge important in DK and help to reduce CO2 emissions by acting as carbon sinks in relation to Kyoto protocol commitment Strict limit values is reported to have lead to an improving of quality fo SS Some public concerns about leaking of unknown harmful substances to groundwater
Romanian Ministry of Environment	MS	Romania	Need to update information: 22 cities for WWTW & correction to collection rate of 54% (by end of 2005) and number /load of big STWs. Only limited agriculture expected, some difficulties with nutrient status including Danube and NVZ. Proposes change to our predict usage in 2020 – 20% ag, 10%

Name	Type	Country	Respondent comments summary
			incin, 30% storage and 40% other – but also refers to EU money to do AD on 30% destined to storage. Need to clarify if storage means landfill
Slovenian Ministry of Environment and spatial planning/Department for prevention of environmental pollution	MS	Slovenia	Update tables on sludge production and management (need checking as total outlets >100%), but 2020 prediction agreed. No figure for industrial sludge. About 60% popn connected, but expect to meet WWTP reqs including nutrient removal by 2015 most country. Ban on landfilling after July 2009. No incineration capacity so 25% sludge exported for incineration. Expect to reduce these quantities but poor quality sludge (high level of PTEs) and more stringent local decrees on PTEs eliminate sludge from agriculture. Consider possibility of other future recycling as quality improve and non-agricultural uses – renovation, but not forests (ban) (64% of country) as only 36% arable land. Should have consistent formal risk management methods through EU. Sludge has greater benefits than nutrient content only – soil conditioning, and climate change benefits
UK Department of Environment, Food and Rural Affairs/water quality	MS	UK	Confidence in reports. Provisional comments at this stage. Not UK government view. UK Environment Agency input needed. Recycling option vital for many MS. Flexibility to be retained for domestic guidelines. Any changes to standards for pathogens, untreated sludge and metal limits to be harmonised across MS. Difficult and inappropriate to standardise risk management procedures across all MS. More emphasis on C release re future management of sludge (incineration).
Portuguese Environment Agency	MS-A	Portugal	Partial comments (awaiting additional comments) Short email: Recently published regulations which introduced a faster licensing procedure and recognise agriculture recycling as BAT should encourage and increase recycling to land. In addition strategic plan for solid waste (2007-2011) aims at diverting biodegradable waste from landfill through anaerobic digestion, composting, MBT and incineration. Plan to reach 90% of sewer connection by 2013
Ministry of the Environment of the Republic of Latvia/Environmental Protection Department	MS	Latvia	Very brief response. Agree with summary report and situation as described except for limit values for PTEs in sewage sludge as reported in Table 6 (rep 1). Baseline scenario overall realistic Few corrections for country report. Date of accession 2004 and not 2007; Incineration is not one of the main priority in the near future and unsure about future forecast for 2020- however no other figures proposed.
Lithuanian Ministry of Environment	MS	Lithuania	Brief responses only on the country report. No responses to questions. Few figures to correct about number of UWWT plants and number of composting and digestion plants. Disposal include landfill **AND** mainly storage. Update figures on sludge production and outlets (2007). No changes to future estimates and outlets.
Hungarian Ministry of Environment	MS	Hungary	Complimentary about reports (very detailed and thorough studies). Not all 28 questions have been answered (need more time) but

Name	Type	Country	Respondent comments summary
			willing to collaborate further to this process. Importance of protection of soil and groundwater. Agreed with actual sludge production and usage figures given although the reported sludge production rate is 25.8 kg/pe/y compared with 13 kg/cap/y (need checking). Update future outlets: proportion for recycling (77% excessive but 58% realistic). Estimates provided. Additional land available. Composting and anaerobic digestion is increasing. Landfilling is decreasing. Data on nutrient sludge quality is provided. The Hungarian regulations for sludge recycling to land are given. A formal common risk management approach throughout the EU may not be feasible or preferred because of different agro-ecological situations between the MS. Important to have a ban in forestry (as already the case in Hungary). Ban in organic farming. Statutory longer waiting periods (i.e. 1 year for vegetable crops and fruits).
French authorities (secretaire general des affaires européennes- sgae)	MS	France	Update tables 1,2,3,4 and 6, 7 and 8 in summary report 1- have submitted even more recent data for 2006, 2007 and 2008 (only partial). Anaerobic and aerobic digestion are less widespread than implied in the report Latest development – computerised reporting, national risk funds, review assessing implementation of new tracability measures for the last 10 years Additional references to be potentially included. Quantities produced increasing and Recycling to agriculture is on the increase
German Ministry of Environment	MS	Germany	Excellent survey, overall agreement, description for Germany still actual. Some small improved data. Cu and Zn not necessary to have limit, Cu used by farmers. Most German Fed states keen on sludge recycling – Bav & Baden special cases – has proposed additional sentences to this effect. Sludge should be WASTE. Replace figures in table 3 (rep 1) with data provided on disposal routes for 2007 Data in other tables 5 and 6: still valid. Table 8: update last row - others Expect no changes in sludge quantities in future at about 2.06 Mio t ds per y incl. 20% industrial sludge (55 g/pe*d/y fr 82 Mio p.). Agree with 25% for future recycling to agriculture. Expect to increase demand for sludge esp. with improved quality and QA. Sludge regulations the most important factors. No comment on OCs other than studies sent to BZ (need to be included). Note in estimate that 90% sludge undergoes AD.
Bavarian Ministry of Environment and Health	MS-R	Germany	Comments not included in tables: Economic figures too old – figures for 2006 available in 2006 study (see ref). Also do not take into account recent development such as solar drying and decentralised disposal and incineration plants. Investigations on OC in Bavaria showed that a large number of

Name	Type	Country	Respondent comments summary
			OCs are found Insufficient information on nanoparticles and pharmaceuticals. Underestimation of dioxin and dioxins-like compounds such as PCBs; synergetic effects of these compounds Precautionary approach not included. Check reference list and hyperlinks REACH and WFD positive impacts are not confirmed: i.e. risk due to perfluorinated surfactants, dioxins and PCBs Antibiotic resistance genes not adequately considered The advantages of using of solar energy or other non-usable waste heat to dry sludge (negative CO2 balance and net energy gain) not covered in report see LCA study by IFEU in 2001. Strong public opposition in Bavaria to recycling
North Rhine Westphalia - Ministry of Environment and Conservation, Agriculture and Consumer Protection	MS-R	Germany	Submitted 2 reports on organic contaminants (not thoroughly reviewed – not yet included) Risks to soil organisms and animal and human food supplies should be considered not only human health Stricter limits and new limits for organics should be included
Baden-Württemberg Ministry of Environment	MS-R	Germany	Recycling to agriculture in BW has decreased from 20% in 2001 down to 2% in 2008 for precautionary environmental and health protection. Incineration increased from 31 to 87%. Main points for issue are OCs – sewage sludge is the only route of entry to soils (no background level). Soil protection has to follow precautionary principle! Study is not thorough enough! Some suggestions: Need a chapter defining criteria for assessment of contaminants in soils! Additional review of literature on OCs (see studies listed on CIRCA) Need a chapter on leaching of contaminants to groundwater, soils organisms, etc. REACH will not be sufficient to control OCs Cost data need updating Solar drying is missing Incineration and co-incineration: recycling! Recommended to integrate an evaluation of European regional strategies
Belgium			
Brussels Region – IBGE-BIM (Brussels Institute for Environment)	MS-R	Belgium	Update sludge production figures and disposal routes for 2006 instead of 2002. no existing study on future trends so no comments – study currently being done. Update legislation table (LV for soil and application rates) No comment on risk and opportunities report
Walloon Region Ministry of Agriculture, natural resources and	MS-R	Belgium	Need a glossary/list of abbreviations to define 'sewage sludge'(incl. industrial sludge?) and clarify 'disposal i.e. storage and treatment'; too UK orientated. Additional references to be potentially included especially to

Name	Type	Country	Respondent comments summary
Environment –Soil and waste department – soil protection direction (DGANRE-DSD-DPS)			update country annex (not always relevant: i.e. one on waterworks sludge!) Existing local practice additional controls on OCs; Update figures for sludge production with latest figure available for 2007 (but could use 2006 for comparison with other MS). Sludge production: industrial sludge not included – this could explain low sludge/pe; No figures available for total production of municipal +industrial sludge only quantities recycled to land available. Future trends based on 25 kg/cap as well as linear increase between 2005 and 2020 unrealistic for Wallonia.- two estimates provided - update future sludge production Data provided on implementation of UWWT plants Update data provided on sludge quality for 2006. Update figures on disposal routes for 2007. Landfilling prohibited since 2007. Expect increase in agricultural use; No limits values for OC but OCs are monitored against defined thresholds for sludge recycled to land. Main issues with PAH and prohibition to recycled sludge if landfill leachates have been treated in STW. No limits for pathogens but monitored Better definition of analytical methods. Expect competition with other organic wastes. Prohibits sludge to vegetables (by industry agreement). Improving sludge quality. Additional regulations to consider/amend: a) Soil Framework Directive/measures taken for soil organic improvement and nitrate pollution may compete b) Animal by-product regulation 1774/2002? (could apply to industrial sludge going for composting) c) Renewable energy directive – impact uncertain d) Waste directive: can also be negative Information on costs provided
Flemish Region-OVAM (Flemish waste agency)	MS-R	BE	Does not support to recycling to land (stricter limit values and ban for untreated sludge and uneconomical for treated sludge since 2006), no landfilling but rather biogas or other energetic valorisation: 88% is incinerated (2006)! Review new ref. progress report 2005-2006 Update figures of sludge production and production rate for 2006 (101913tds i.e. 16.7 kg/inh) Future sludge production is overestimated as 100% connection in rural areas unrealistic: update figure 110,500 tds form 2010 and 2020. Increased capacity for digestion and incineration across Europe encourage by green energy financial support
Ministry of Environment/Waste Management department	MS	CZ	No fundamental comments. Some corrections: Table 1 – update sludge quantities with 2007 figures Correct date of accession 2004
Ministry of Agriculture, Natural	MS	CY	Brief responses for first 3 questions All sources mentioned

Name	Type	Country	Respondent comments summary
Resources and Environment/			Check limit for Cr in soil Update future sludge production (official figures provided) No comments on future risks
Commercial organisations			
Water UK	NF	UK	Very extensive response and detailed comments on both reports including specific questions and additional references (38 pages!). Complimentary comments (good basis for review and baseline reflect most current knowledge). A few improvements suggested: 0. Whilst a re-examination of the directive is appropriate, the commission need to send a clear message of support towards recycling to land (BPEO) and that the current directive has demonstrably protected human health and the environment 1.References missing (see list provided) (tbc) 2.Conflicting population projections! 3. Forecasted sludge quantities underestimated as Landfill Directive and WFD (and in particular EQS directive) will lead to increased sludge production (proposed a change baseline timing from 2010 to 2015 to fit with first cycle of WFD). 4.Update figures in tables 3,4 and 5 through consultation 5. no scientific evidence justifying the need for LV on OCs, simplify controls on PTEs and limit to 2 or 3 main limiting elements (Zn, Cu) and pathogens controls to include different levels of quality according to treatment and end use. Untreated sludge banned. Waiting period to eliminate pathogens for treated sludge unnecessary 6. Corrections to legal sections (see responses for details) . Correct nitrates directive discussion page 13 7. update tables 5 and 6 (check) 8. Cost data provided- check figures (dispute statement on limed cake being the cheapest) and need to update 2002 figures 9. Other comments which could be considered to update reports (see response for details: especially on agronomic values and risks from OC including antibiotics and risks from pathogens 10..Update Table 4 sludge production and rate and check disposal outlets figures for 2007: inc 17%, ldf: 1%, other thermal 0% 11. further restrictions: advanced treated sludge: no restrictions and conventional treated sludge: 10 weeks waiting period; expand uses to include restoration and forestry. But unnecessary to move towards enhanced treatment for general agricultural application! 12. risk management: need to be flexible ! 13. increasing co-digestion and co-composting 14. list of treatment should also include pre-treatment such as prepasteurisation 15. revision of directive should permit and recognise the development of sludge materials that meet end-of-waste criteria, also land recycling of materials arising from co-digestion processes with sludge 16. odour nuisance is the single most important factor that raises public hostility

Name	Type	Country	Respondent comments summary
			17. green house gases: major concerns over the data sources as no references mentioned. 18. what about the impacts of biowaste directive?
EFAR (European Federation of Recycling in Agriculture)	EF	France	Complimentary comments (good synthesis of the current knowledge) 1. too much focus on land recycling and not enough on other outlets 2. imbalance between benefits (1 pg) and risks (10 pgs) 3. should also include industrial sludge 9at least food and paper also in baseline scenario) 4. other land application not afforded a more positive judgment 5. to sum total quantities recycled to land: should add composting to the agriculture: 5,162 M tds (50%) 6. European waste catalogue should be mentioned in legislation 7. CH policy should not be mentioned as not EU member- need to discuss relevance of limit values on total HM conc in solid as only limited fraction available Need to include other fertiliser (manure, compost , mineral). pH also varies on same plant during the year (!). Any new limit of PTE ins soil should look at cost and benefits taking into account existing data on HM conc in EU soils- could provide data 8. need to update costs data (2002!) 9. need to mention for FR a health review committee in place since 1997 and the fact that there has been no reported cases of animal disease following sludge application 10. check comments for Austria 11. nitrates directive - check 12. need to present main assumptions to establish green house gas emissions 13. additional ref on public perception 14. see suggestions for additional reporting information and additional monitoring 15. check table 13 unit for pH 16. costs: global costs no need to split them up 17. need clarify impact for landfill, incineration and waste directives 18. sludge incineration is **NOT** a source of renewable energy – see Austria study 19. justify future additional crops restrictions and other outlets 20. need to dispose of data on sludge quality per country AND per size of WWTP or at least taking into account DS production 21. competition with inorganic fertiliser – adapted to EU context 22. check cost data in euros and not dollars!
InSinkErator (manufacturer of food waste disposers)	IS	USA/UK	Support the addition of food waste to sewage sludge via sewer system Support a common regulatory regimes for sludge and biowaste and the resulting digestate Long justification about the merit and advantages of this technique.

Name	Type	Country	Respondent comments summary
Aguas de Portugal	IS	Portugal	Some of the data for Portugal is missing or out of date; some new figs. are given. More emphasis needed on high tech processes which urban areas will have to move to, and also energy recovery. Q 1-28 are answered in order.
DAKOFA (Danish Waste Management)	NF	Denmark	Additional references: tbc See comments on C- sequestration and P shortage: drivers Update future outlets: 25% inc may be too high- however reduction of tax on incineration could have a positive effect Apparent reduction in sludge quantities due to different methods for reporting (content of DS) Public opinion is the most uncertain factor)end of waste criteria may be one solution to increase acceptance High quality and sufficient management systems
FP2E (Professional Federation of Water Companies)	NF	France	Additional references – see comments Forecast for France unrealistic LCA support (i.e. JRC work) Support voluntary quality assurance schemes and constant approach for sludge and other biowaste Clarify definition of sludge and outlets Lack of discussions on analysis methods Update figures for FR sludge production and disposal with 2007 official figures Some data on treatment Concerns about a widespread use of prohibition clause from food industry Odour! End of waste status for compost – important issue in FR as 15% of recycled sludge are composted. Impact of future IPPC (i.e. waste treatment BREF!) See interesting figure on ratio sludge production/proportion of necessary arable land Price of mineral fertiliser has a positive impact Support co-treatment but current existing barriers exist
EUREAU (European federation of national associations of drinking water suppliers and waste water services)	EF	EU	Complimentary comments: comprehensive review of existing knowledge; good basis for review. Some suggestions: 1. strengthened reporting requirements under the directive to have annual update 2. collect more recent data for tables 1,2,and 3 via consultation process 3. additional notes for legislation sections (see comments for details) 4. need to take into account biogas production and its contribution to renewable energy in economics section 4 5. justify statement about pyrolysis costs versus incineration and also in section 10 6. disagree with changes proposed to Zn soil limits- need to justify further changes proposed to Zn, Cd in solid and Pb in

Name	Type	Country	Respondent comments summary
			sludge 7. need to considered RED proposals and declared source for table 10 8. include policy owners and merchant and supply chain contractors as principal stakeholder 9. treated production rate with caution 10. EQS directive, WFD, UWWT and Landfill Directive will lead to increasing sludge production 11. Although ongoing revision of IPPC Directive could lead to increased treatment and process control costs for sludge recycling as recovery activity 12. For MS that have a higher target to increase renewable energy generation - Renewable energy directive will lead to increased biogas generation from sewage sludge and the resultant digestate used as fertiliser subject to county policy preferences 13. nitrates directive may reduce landbank if further designation are made. WFD may lead to reduced localised sludge application rarest due to high soil P from artificial P. 14. evolvable could open up organic farming land bank 15. support for treated sludge used in forestry (see ref in SE and FI examples) 16. support a voluntary and flexible risk management 17. increasing prices of inorganic fertiliser seems to have a positive effects on demand for quantities of sludge recycled to land 18. co-treatment is important issue
Incopa (European coagulants producers)	EF	EU	Report 1 - Too UK focus Report 2 – very good report More exhaustive list of abbreviations Add missing references, substantiating some figures Check legislation (Lahti Energies case) Additional technologies (i.e. oxidation processes) Availability of nutrients: check/ref. Future trends: stabilised volumes of municipal sewage sludge more co-anaerobic digestion . reduced proportion of industrial sources input Increased sterilisation/pasteurisation/pathogen kills P issues Check info for SE and Kemicond
Ecosol (European producers of Linear Alkylbenzene)	EF	EU	Brief comment mainly focusing on LAS Check spelling for full name in reports 1 and 2
FederUtility (representative of local public utility companies)	EF	Italy	Brief comments – not all questions answered Legislation in Emilia Romagna limit drastically recycling to agriculture as well as legislation in Veneto regions – check but I think this is already mentioned Expect increased difficulties for recycling to agriculture and large increase in cost of the other outlets (3-5 times in the last 5 years)

Name	Type	Country	Respondent comments summary
			Nitrates directive will have a negative impact. Do not have information for the whole of Italy (only 7 water companies!!!!)
EWA (European Water Association)	EF	EU	Preliminary response to be read in parallel with individual members responses (i.e. CIWEM, ASTEE and DWA) Based on EWA Pembroke workshop of April 2008 (paper provided on QLA) and EWA response to Biowaste green paper in Feb 2009. Need to extend the scope of this analyst to over all biowaste under a biowaste directive Should be a full review of COST 68/681 programme Need to include other routes such as landscaping and forestry. Need to distinguish mono and co - incineration Need more discussions on climate change (incl soil conditioning properties reducing moisture loss) Importance of soil conditioning and P fertiliser properties as Phosphare reserves diminish could simplify controls of PTEs as conc have declined and propose statutory monitoring for Zn and Cu and possibly Cd and monitoring of other elements for quality assurance purposes such as Ni, Pb, Cr and Hg development of pathogen controls (ban of untreated sludge and 2 levels of treatment for different end uses review QAS for Germany and Sweden update Commission reports on OC published in 2001 sewage sludge product should be granted an eco-label
FIWA (Finnish Water and Waste Water Works Association)	NF	Finland	All references covered and baseline projections realistic. Agreed with figures on sludge production and outlets. Currently mainly landscaping - large amount used as landfill cover. As many ldfs will be closed and new incineration plants will be built – this outlet will decrease. No figures for future but comments supporting report summary: i.e. – mainly landscaping, maybe use in forestry (as 70% land is covered by forests (20.3 M ha) – this is currently being studied but not yet used) or increasing proportion in agriculture and incineration may become more popular. One problem scenario is that treated sludge is defined as product and falls under REACH: could be too expensive! Control at source! Co-treatment- should be encouraged - need a clear legislation covering such issues Some additional information on Finnish situation: majority of sludge is composted (need to correct 73% of waste water treatment plants reported that sludge is treated in open pile or windrow composts and 21% reported that sludge is composted in composting plants, screened and mixed with other materials (sand and pear) and marketed as a growing medium or solid improver for landscaping- this outlet needs to be better recognised. New decree in 2004 on upgrade sewer connection and sewage treatment for rural areas by 2014 including improve individual treatment and 90% of sludge transported to municipal treatment plants so increase sludge production.

Name	Type	Country	Respondent comments summary
			63% connected population will have N removal treatment and 100% P removal. P is usually limiting factor when sludge applied to agriculture: 40% of P in sludge is considered to be available. In some cases N is the limiting factor. In some cases Cd is the limiting factor (as limit value :1.5 g Cd/ha/y over 4 years or 6 g Cd/ha total). Famers association is against sludge use in agriculture. Large amount of manure in some areas. Current proportion recycled to agriculture 3% compared with 10-17% a few years ago.
Copa-Cogeca (European Farmers and Agri-cooperatives)	EF	EU	Good and comprehensive overview of current situation Not revising the directive is not a sensible option Need to extend the scope of directive to cover all land uses Quality assurance schemes are vital to guarantee a process of checking quality Should have harmonised list of compounds also for other pollutants and pathogens Need to extend discussion on competition with other biowaste
Part of COPA-COGECA response: Austrian Chamber of Agriculture	NF	AT	Extend the scope to cover other land uses Possibility to keep more stringent national limit values Need to discuss a mandatory quality assurance system
BDE (Federation of German Waste Management Industries)	NF	Germany	Way to improve public confidence through mandatory quality assurances and quality management systems – urgently needed to be part of a revised EC directive No significant changes expected in Germany until 2020 No impact from IPPC! Fertiliser regulation was revised in 2008 with new restrictions imposed since 2009 and further requirements by 2017. This could lead to a shift towards thermal treatment. Revised sludge regulation in DE will probably distinguish between 3 types of soils limiting the use of sewage sludge Main PTEs: Pb and Cd. Future potential reduction in some PTEs but Cu and Zn may increase Conc of N and P have increased since 1995 and will continue to increase. Importance of P fertiliser value could cover 20-30% of total P need in agriculture.
DWA (German Association of Water)	NF	Germany	Rep 1 – good basis for the review Need to include landscaping and to sub-divise incineration into mono- and co- Update data for DE on sludge outlets for 2007
EuLA (European Lime Association)	EF	EU	Brief comments on risks due to pathogens Need to list possible treatment processes for the reduction of pathogens in order to obtain public acceptance Need to include in annex 1 and section 2.4.2 established processes as well as new processes
Alan Srl	IS	Italy	Partial and vague comments (only for Lombardy) and not always substantiated with figures – not included. Unrealistic baseline scenario Figures for Lomardy only: 120,000-130,000 tds/y recycled to land

Name	Type	Country	Respondent comments summary
			including 80-85% of municipal sewage sludge. Private companies have agreement with farmers Storage capacity must be 1/3 of total amount spread in a year and treatment capacity for 100% Main treatment is lime. One plant use ammonia and others mix with green waste but don’t produce compost (?!) Production of compost in NOT main process to recycle sludge Some STW produce dried sludge (expecting more comments)
VEAS (Vestfjorden Avløpsselskap – Oslo water company)	IS	Norway	Correct summary report on Norway No change expected Suggest a change to allow sludge derived products to receive eco-label P is an issue and price for fertiliser has a positive effect on demand for sludge No justification for OCs No co-treatment foreseen
Other			
CEN (European Committee for Standardization)	Other	EU	No comments on questions Additional references (tbc) and Update of table 14 – list of CEN sludge analysis
CIWEM (Chartered Institution of Water and Environmental Management)	NGO	UK	Support recycling to land as a safe and effective fertiliser and soil conditioner Refer to EWA workshop Support a consistent framework of controls for all residuals applied to any land No documentary evidence of any adverse effects on public health when treatment and use have conformed to existing legislation and known small risks Take climate change impacts! Risks should be borne by producers and not landowner so farmer should be indemnify for an extended period against the possibility of adverse effects until the risk could be considered nul Extend scope of study to cover all biowaste under a biowaste directive and all soil requirement (lack of soil framework!) No barrier to eco-label for suitably treated sludge Sewage sludge = sewage biowaste=wastewater biosolids Clostridia- not a sensible indicator Aerosol measurement – see reference Greenhouse gases (check table 10) (to be reviewed by experts) Pyrolysis- not a strong future prospect Assumption in report 2 – quite reasonable Future increased sludge production at around 28 kg/pe/yr with tertiary treatment or chemical nutrient removal Recovery of fertilisers from dewatering liquids becoming more practicable ! Proposed amendments:

Name	Type	Country	Respondent comments summary
			1. Odour – should be a legal requirement 2. revise pathogen reduction requirements similar to Safe Sludge matrix and require treatment based on HACCP. No OC limit values! Separate regulatory regimes for biowaste inhibiting co-treatment Future trends: increased recycling with increasing anaerobic digestion Nitrates directive may lead to co-composting with green waste P fertiliser value : important issue and price of fertilisers has an positive impact on demand for sludge