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

Final Report

Part I: Overview Report

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ENVIRONMENTAL LAW & POLICY

WRc

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Milieu Ltd. (Belgium), Rue Blanche 15, 1050 Brussels, tel: +32 2 506 1000; fax: +32 2 514 3603; e-mail: g.goldenman@milieu.be; judith.middleton@milieu.be; web address: www.milieu.be

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

The Sewage Sludge Directive (86/278/EEC) was adopted more than 20 years ago with a view to encourage the application of sewage sludge in agriculture and to regulate its use as to prevent harmful effects on soil, vegetation, animals and humans. In the light of the increased production of sewage sludge across the European Union with the implementation of the Urban Wastewater Treatment Directive, and recognising the need to assess recent scientific research on the reuse of sludge in agricultural soils, the European Commission is currently considering whether the current Directive should be revised.

The European Commission (DG Environment) awarded a contract to Milieu Ltd, together with its partners WRc and Risk & Policy Analysts Ltd (RPA), to prepare a *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 was 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 study thus provides background information for a decision whether or not a revision of the directive is needed and lays the basis for a possible revision.

This final report presents the overall results of the study and it compiles the detailed reports prepared over the course of the project, incorporating the results of two open consultations held in the course of the project.

- This overview report summarises the main project results and forms **Part I** of the final report.
- **Part II** is the **Report on Options and Impacts**, which describes the main options identified for the revision of the directive and presents the cost-benefit analysis of these options: it thus provides the final, detailed analysis of the study and it incorporates the results of the second open consultation.
- **Part III** presents the other project reports:
    - The **Assessment of Existing Knowledge** describes current levels of sewage sludge production, the concentration limits on pollutants in sewage in place in Member States and provides an overview of key EU legislation influencing sewage sludge, of sludge treatment technologies and their prospects and of current scientific literature on risks to human health and the environment.
    - The **Baseline Scenario and Analysis of Risk and Opportunities** estimates sludge production and application levels to 2020 and describes the forces influencing these levels
    - The project **Interim report on the first consultation** compiles the results of the first open, web-based consultation, summarising the comments and additional information provided by public bodies and stakeholders regarding the first two reports.

The two consultations held over the course of the project provided information and comments that were assessed and used where appropriate in the work. The first, from 24 June to 27 July, was an open, web-based consultation on reports 1 and 2. In total, 40 responses were received (including comments received after the deadline): 19 from governmental bodies, and 21 from industry and other stakeholders.[1] (Key information from these responses is compiled in the project's Interim Report – and thus the first two reports should be read together with this one for an overview of information gathered, all of which is used in the cost-benefit analysis.) The second consultation reviewed the draft version of the Report on Options and Impacts and its preliminary cost-benefit analysis. Here, an open web-based consultation was held from 17 December to 13 January, and 39 comments were received (including those sent after the deadline). It was followed by a workshop at the European Commission on 29 January, attended by over 40 Member State officials and industry stakeholders. The comments and new information provided in this second consultation were used to revise the cost-benefit analysis and the Report on Options and Impacts.

Key findings and results of the study are summarised in the following sections.

[1] Of the industry and other responses, 19 were from the private sector and commercial organisations or from associations with commercial interests, 1 from an NGO and 1 from an individual citizen with specialist knowledge. Some were joint responses and some originated from different organisations but reiterated some of the comments.

Review of existing practices and knowledge

The first stage of work involved the collection and assessment of existing information concerning possible risks to health and the environment stemming from the application of sewage sludge on land, as well as the potential economic opportunities.

The Directive was based on the knowledge available at the time, including an evaluation of risks prepared by the COST 68 programme in the early 1980s. Since then, new scientific evidence has been generated relating to the human health and environmental impacts and the soil quality and fertility aspects of recycling sewage sludge to agricultural soil. A number of reports and risk assessments have also been published recently.

Benefits

There is scientific evidence that the application of sewage sludge to agriculture provides a series of agronomic benefits, in particular the recycling of plant nutrients such as nitrogen and phosphorus, and thus sludge is an effective replacement for chemical fertilisers. Indeed, one of the most commonly recognised environmental benefits is the recycling of phosphorus (P) in the food chain. This contributes to the conservation of mineral phosphorus reserves and also reduces external inputs of cadmium (Cd) present in phosphate rocks. Sludge also provides other plant macronutrients, such as potassium and sulphur, and micronutrients such as copper and zinc. The beneficial effects of sludge application on soil organic matter status, structural properties and soil moisture retention are also well documented.

In addition to its use on agricultural land, sewage sludge has been employed successfully for forestry and in land reclamation operations, such as for disused mines or closed landfills.

Some researchers claim benefits in terms of climate change and greenhouse gases emissions from sewage sludge recycled to agriculture, in particular that a portion of the carbon in sludge used in agriculture will be sequestered in the soil. However, this has not been fully scientifically substantiated and it is not believed that any national inventories of greenhouse gas emissions consider sequestered carbon from sludge used in agriculture.

In terms of air pollution, although replacing the use of chemical fertiliser by sewage sludge reduces the nitrous oxide emissions associated with that fertiliser, 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.

Current levels of sludge production

The total quantities (i.e. production) of sludge in the EU27 are currently estimated at 10.13 million tons (dry solids), as shown in the Table 1 on the next page.

Of this total, nearly 40% is estimated to be spread on land for agricultural use. The recycling of sludge to agriculture varies greatly among Member States. In a few EU15 countries – Denmark, France, Ireland, Spain and the UK – more than half of all sludge production is used in agriculture. In three of the EU27 Member States, however, no sludge is recycled to agriculture, and in four others the amounts are less than 5% of total sludge production.

Table 1: Recent sewage sludge production and quantities recycled to agriculture in the EU

Member State	Year	Sludge production (t DS)	Agriculture	
			(t DS)	(%)
Austria (a)	2006	252,800	38,400	16
Belgium				
• Brussels region	2006	2,967	0	0
• Flemish region	2006	101,913	0	0
• Walloon region (b)	2007	31,380	10,927	35
Denmark	2002	140,021	82,029	59
Finland (c)	2005	147,000	4,200	3
France	2007	1,125,000	787,500	70
Germany (d)	2007	2,056,486	592,552	29
Greece	2006	125,977	56.4	<1
Ireland	2003	42,147	26,743	63
Italy	2006	1,070,080	189,554	18
Luxembourg (e)	2005	8,200	3,780	46
Netherlands	2003	550,000	34	<1
Portugal	2006	401,000	225,300	56
Spain	2006	1,064,972	687,037	65
Sweden	2006	210,000	30,000	14
United Kingdom	2006	1,544,919	1,050,526	68
Sub-total EU 15		***8,874862***	***3,728638***	***42***
Bulgaria	2006	29,987	11,856	40
Cyprus	2006	7,586	3,116	41
Czech republic (f)	2007	231,000	59,983	26
Estonia (g)	2005	26,800	3,316	12
Hungary	2006	128,380	32,813	26
Latvia	2006	23,942	8,936	37
Lithuania (h)	2007	76,450	24,716	32
Malta (i))		Nd	Nd	nd
Poland	2006	523,674	88,501	17
Romania	2006	137,145	0	0
Slovakia	2006	54,780	33,630	62
Slovenia	2007	21,139	18	<1
Sub-total EU 12		***1,260,883***	***266,885***	***21***
Total		**10,135,745**	**3,995,523**	**39**

Sources: EC, 2006; EC, personal communication, 2009; Member State responses to the project consultations, 2009

Notes:

a) Austria: in addition in 2006, 177,000 t DM of industrial sludge (mainly from cellulose and paper industry) were produced and 3% of this was recycled to agriculture.
b) Wallonia: in addition in 2007, 48,000 tds of industrial sludge (mainly from paper industry,) were also recycled to agriculture.
c) Finland: the remaining is recycled in landscaping operations including landfill cover.
d) Germany: in 2007, 18% were also recycled in landscaping operations.
e) Luxembourg: in 2005, in addition 32% were reported to be composted – no final outlet provided
f) Czech republic: it is reported that up to 2/3 of sewage sludge is ultimately recycled to agriculture mainly after composting
g) Estonia: estimate based on 20 kg/pe and 90% collection and treatment as no figures were reported for total sludge production.
h) Lithuania: in addition in 2007, 11% were recycled on other land
i) No data for Malta, assumed zero

Although the overall proportion of sludge recycled to agriculture across the EU has increased slightly since 1995, the situation in some Member States has changed dramatically: the Netherlands, for example, has stopped the recycling of sludge to land, while the UK and some other Member States have significantly increased the amounts used on land.

More than 40% of sludge production is spread on land in the EU15, compared to less than 20% in the EU12. Moreover, the EU15 have a much higher level of sludge production, due both to higher populations as well as higher connection rates to urban waste water treatment (UWWT) plants. In the EU15, incineration is at present the main alternative to spreading on land; in the EU12, it is still landfilling. In both groups, however, the variation among individual countries is quite large.

To put these figures – as well as the overall analysis – in perspective, it should be noted that the use of sewage sludge in the EU is relatively small compared to other organic and inorganic fertilisers: sludge contributes less than 5% of the total amount of organic manure used on land (most of which is of farm animal origin), and sludge is applied to less than 5% of agricultural land in the EU.

Contaminants and pathogens

While sewage sludge contains nutrients and organic matter that are beneficial for the soil, it also contains contaminants such as heavy metals, organic compounds and pathogens. There is clear evidence that, since the mid 80s, concentrations of heavy metals in sewage sludge have steadily declined in the EU15 due to regulatory controls on the use and discharge of dangerous substances, voluntary agreements and improved industrial practices. These measures have led to the cessation or reduction of discharges, emissions and losses of these heavy metals to the environment.

The current Sewage Sludge Directive addresses both pathogen reduction and the potential for accumulation of persistent pollutants in soils but sets no limits for organic contaminants. The Directive sets limit values for seven heavy metals (cadmium, copper, nickel, lead, zinc, mercury and chromium), both in soil and in sludge itself. It specifies general land use, harvesting and grazing restrictions to provide protection against health risks from residual pathogens. The Directive requires all sludge to be treated before being applied to agricultural land, but allows the injection of untreated sludge into the soil under specific conditions.. While it calls for the use of treated sludge, the Directive does not specify treatment processes.

Most MS have adopted stricter standards and management practices than those specified in the Directive, either through binding rules or via codes or practice and other voluntary agreements. While the standards for the level of potentially toxic elements (PTEs) in soil in these Member State requirements are similar to the ones specified in the Directive, the majority of MS have introduced more stringent standards for sludge quality including stricter limits for most PTEs. Some have introduced limits for additional parameters such pathogens, organic contaminants and other elements. In general, untreated sludge is no longer applied and in several MS it is prohibited. However, these national (and in some case regional) requirements vary across the EU. In some cases, including the Netherlands, the Flemish region in Belgium and Bavaria in Germany, stringent standards have resulted in an effective ban on use of sludge for agriculture. (Details on Member State requirements can be found in Part III of this report.)

Current risks to human health and the environment

Significant environment or health risks linked to the use of sewage sludge on land in the EU have not been documented in scientific literature since the Directive took effect. It is, however, difficult to establish

whether this is because the provisions of the Directive are sufficient or is due to the fact that more stringent national requirements have been put in place.

The presence of human pathogens in sewage sludge has led to a considerable amount of research to assess the health risks associated with the land applications of sludge. Significant environment or health risks linked to the use of sewage sludge on land in the EU have not been widely demonstrated by observations or risk assessments in scientific literature since the directive has taken effect, although there continue to be authoritative studies that identify and assess concerns. It is difficult to establish if the lack of evidence for adverse effects is because the provisions of the Directive are sufficient or is due to more stringent national requirements in some Member States.

Epidemiological and risk assessment studies on the risks to health from microbial pathogens in sewage sludge for workers and populations in the vicinity of sludge operations have not generally found the risks to be significantly greater than background risks.[2] Overall the health risks from indirect exposure to pathogens have also been found to be low, with no clearly identified public infections from the use of food grown on land where sludge was applied in accordance with the provisions in the Directive. [3]

In terms of other impacts on human health, recent risk assessments indicate that the exposure resulting from organic compounds in sewage sludge applied to land have not found an adverse effect on human health.[4] For risks posed by the wide range of potential organic contaminants, including pharmaceuticals, antibiotics, metabolically active substances, consumer and industrial substances, and for microbial pathogens, stringent precautionary controls are advocated by some authorities to deal with the risks found in some assessments. [5]

Environmental issues related to the recycling of sewage sludge on land include the risk of nutrient leaching, impacts on soil biodiversity and greenhouse gas emissions. Methane and nitrous oxide, both potent greenhouse gases, are both produced after sludge and other bio-wastes and recycled into agricultural land. Procedures and means to minimise their uncontrolled production and emission during treatment and recycling are necessary. In assessments of the global warming potential (GWP) of different treatment, recycling or disposal routes, efficient treatment and recycling to agricultural land can usually be demonstrated to have a lower GWP than other processes. There are some local circumstances, such as the location of the land or the nature of the sludge, in which the overall environmental impacts, either in terms of greenhouse gas emissions alone or in conjunction with other environmental factors, result in assessments that suggest non-agricultural routes may be more beneficial.

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[2] Tanner *et al 2008, Estimated Occupational Risk from Bioaerosols Generated during Land Application of Class B Biosolids*, J Environ Qual.2008; 37: 2311-2321

[3] Gale *et al.* 2003, *Pathogens in biosolids. Microbiological Risk Assessment. UKWIR,* London, UK. ISBN: 1-84057-294-9

[4] Smith SC (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. Available at: http:/www3.imperial.ac.uk/ewre

[5] See for example: Barkowski, D. *Et al* (2005) *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. In addition, the conclusions of a recent risk assessment study (*Méthodologie d'évaluation des risques sanitaires des filières d'épandage des boues urbaines et industrielles*, 2007) carried out by the French institute INERIS together with other government bodies suggested that**:**

- The more stringent limits proposed in the Commission in 2003 (CEC 2003) are acceptable apart from
- Zinc limit value should be decreased from 750 mg t 500 mg/kg DM to reach an acceptable level of risk
- DEHP value of 100 mg/kg DM
- Benzo(a) pyrene separately from other PAHs

In terms of public concerns, odour can be an important issue prompting opposition to the use of sewage sludge on land, either due to the odour itself or to a public perception that substances adverse to health may be present. Despite a number of studies on possible adverse health effects to the public in the vicinity of sludge spreading operations there have been no unambiguously demonstrated adverse consequences to the public as a result of aerosols from properly conducted treatment and recycling operations.

Part III of this final report provides further details on the health and environmental risks and on the literature reviewed. It includes a summary of the information and comments provided by Member State officials and stakeholder representatives on this topic: here it should be noted that there was no clear consensus, with some respondents calling for stricter limits for precautionary reasons and others noting that health and environmental problems have not been identified and calling a continuation of the current requirements or for more relaxed approaches.

A baseline scenario for the future

The study developed a baseline scenario for the period 2010 to 2020: this scenario assumes that no change is made to the Sewage Sludge Directive, and it extrapolates from the current situation and current developments at EU level and in the Member States for its forecasts of future sludge production and sludge use on land. This baseline or reference scenario is an important element of the cost-benefit analysis, which measures the impacts of possible revisions to the Directive against it.

The development of the baseline involves a series of assumptions concerning key forces and trends as well as risks and opportunities that will affect the production of sewage sludge in the EU and its application to land.

In terms of overall sludge production, the following trends were identified for the EU27:

- The population of the EU will grow slowly, from about 499 million in 2010 to just under 514 million in 2020 (according to Eurostat projections)
- While industrial production will grow, process improvements, pollution prevention and improved on-site treatment will reduce sludge coming from industry
- 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 industrial water pre-treatment and pollution prevention, reducing or eliminating discharge of toxic substances (heavy metals, chemicals) and improving sludge quality.

A broad range of EU, national and sub-national legislation could influence the spreading of sludge on land in the coming decade. The analysis gave highest importance to: the Landfill Directive, which will restrict the amount of sludge and other organic waste sent to landfills, and possible future local controls on pathogen content to ensure public acceptability. Many other pieces of legislation will be important, from REACH – whose restrictions on chemicals may reduce contaminants in sludge and increase public confidence – to the new Directive on renewable energy,[6] which could encourage the use of sludge for biogas and other forms of energy recover. Member States efforts to meet the requirements of the Nitrates Directives as well as the Water Framework Directive may restrict the use of sludge on land in local areas.

On the basis of this analysis of EU legislation, together with a review of possible developments in the Member States, the following major trends are expected to influence the spreading of sludge on land:

[6] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

- There will be a general phasing out of sludge being sent to landfill, due to EC restrictions on organic waste going to landfill as well as public disapproval: by 2010 the overall proportion of sludge going to landfill will be lower than currently reported, and it is estimated that by 2020 there will be no significant amounts of sludge going regularly to landfill in the EU27.
- 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. 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 recovery of organic nutrients, including those in sludge.
- The main alternative to spreading sludge on land is likely to be incineration with energy recovery for sludge produced at sites where land suitable for recycling is unavailable. This will be the case in particular where population densities are high and public opposition, e.g. to odour problems, make it more difficult to recycle to land; it will be seen also where animal manures are over-abundant.

Developments related to climate change policy and renewable energy will also influence sludge management:

- Increased attention to climate change and mitigation of greenhouse gas emissions and thus recognised additional benefits of sludge applications to soils.
- There will be increased treatment of sludge with energy recovery through anaerobic digestion, incineration or other thermal treatment, with recycling of the ash. There may be increased production and utilisation of biogas from sewage sludge, as well as some production of alcohols and other fuels directly from sewage sludge using pyrolysis and gasification.
- Increased application of sludge to fuel crops such as miscanthus, hybrid poplars and other non-food energy crops.

On the basis of these trends, it is estimated that sludge production in the EU27 will reach about 11.5 million tons (dry solids) in 2010 and rise to just under 13.0 million tons in 2020 (see Table 2, above). Based on these EU-wide trends as well as analysis of individual Member States, estimates of future sludge production have been made for each Member State (some responses in the first consultation provided further information for these estimates).

Overall, in the baseline scenario the proportion of treated sludge recycled to agriculture across the EU will remain more or less the same, at 42% in 2010 and 44% in 2020 (see the Table below). The share used in incineration will rise slightly, while the share going to landfills will be halved.

Overall, the analysis considers that the use of sludge on land in the EU15 will not change dramatically over the next 5 years. While national, regional and local legislation may impose some restrictions here, the analysis suggests that the use of sludge on agricultural land will increase in the EU12, in particular in some Member States where it is currently little practiced.

Many of the factors that will influence future levels of sludge production and of sludge use on land are uncertain. The analysis identified among the key uncertainties the following factors: the development of treatment technologies for sludge; public perceptions of sludge recycling to land; future demand and supply of mineral fertilisers; and future risk assessments related to sludge (as well as public and political reactions to their results).

Table 2: Estimates of annual sewage sludge production and disposal routes, 2010 and 2020

Member State	2010					2020				
	Total Sludge	Recycled to land	Incineration	Landfill	Other	Total Sludge	Recycled to land	Incineration	Landfill	Other
	tds/a	%	%	%	%	tds/a	%	%	%	%
EU12										
Bulgaria	47,000	50	0	30	20	151,000	60	10	10	20
Cyprus	10,800	50	0	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
EU12 Total	1,411,000	41	8	35	17	2,457,000	37	16	17	31
EU15										
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
UK	1,640,000	70	20	1	10	1,640,000	65	25	1	10
EU15 total	10,153,000	43	29	11	17	10,530,000	44	37	4	15
EU27 total	**11,564,000**	**42**	**27**	**14**	**16**	**13,047,000**	**44**	**32**	**7**	**16**
EU12 (% of EU27 total)	*88*	*5*	*1*	*5*	*1*	*81*	*8*	*3*	*4*	*4*
EU15 (% of EU27 total)	*12*	*38*	*26*	*9*	*15*	*19*	*36*	*30*	*3*	*12*

Source: Based on consultant estimates and information from the consultations; see the annexes to the Report on the Baseline Scenario and Analysis of Risk and Opportunities

Notes: As working estimates, 2010 production rates have been taken to be the same as 2020 production for Member States expected to be in full compliance in 2010. For non-compliant states, rounded 2006 production rates have been used – see Annex 2 of Report 2 for details. The estimate for Belgium includes 110,000 t ds for the Flemish region; 50,500 t ds for the Walloon Region and 5,000 t ds for the Brussels region.

Options for the revision of the Sewage sludge directive

The project team developed a long list of options, based on the review of literature and of regulations in Member States as well as comments received from Member States and stakeholders in the first consultation for this study and the first workshop. This was reviewed with the European Commission. The original list included options which were deemed technically unfeasible or out of the scope of this study (for instance extending the boundary of the Directive to include uses such as reclamation, recreational and energy crops as the Directive is focused on agricultural land only).

As a result of analysis and discussion with the Commission, five options were developed. The options are as follows:

- **Option 1**: do-nothing: keeping the Directive as it is (i.e. the baseline scenario described above);
- **Option 2**: introduce certain more stringent standards, especially for heavy metals, standards for some organics and pathogens, and more stringent requirements on the application, sampling and monitoring of sludge;
- **Option 3**: introduce more stringent standards across all substances and bans on application of sludge to some crops;
- **Option 4**: total ban on the use of sludge on land; and
- **Option 5**: repeal of the Directive.

Table 7 at the end of this report provides a detailed overview of the components of these options.

Analysis of the economic, social and environmental impacts of the proposed options

The analysis of impacts followed the approach recommended in the European Commission's Impact Assessment Guidelines.[7]

The first step was a qualitative screening of the options to identify key impacts. The most important impacts identified in this screening were carried forward for detailed assessment. Table 3 below sets out the results of this qualitative assessment of the Options (the results here and in the following tables include information provided in the consultation on the preliminary version of the impact assessment).

It should be noted that the original screening list was longer: those impacts whose magnitude is considered to be quite limited are not included. This is the case, for example, for impacts on agricultural production. (Here too, these results incorporate the comments on the preliminary version of the analysis.)

A cost-benefit analysis was then prepared for the key impacts. It is important to underline that not all impacts identified in the qualitative analysis as potentially significant could be valued. Table 4 lists the impacts categories where valuations were made in this assessment, and those where valuation was not possible.

It should be noted that Option 1 is the baseline: the costs and benefits of the other options are assessed, in both qualitative and quantitative terms, in comparison with this one.

[7] Available at: http://ec.europa.eu/governance/impact/commission_guidelines/commission_guidelines_en.htm

Table 3: Initial qualitative assessment

Option	Economic Impacts	Environmental Impacts	Social Impacts
Option 1 - Baseline Scenario	0	0	0
Option 2 – "moderate changes"	Costs of alternative disposal (-) Obligation of treatment (-) Changes to regulation: including costs of consultation (-) Policy implementation and control (-) Benefits/costs if meeting other related legislation requirements (i.e. WFD, Waste Directive) (?) Loss of use of sludge as a fertiliser and fertiliser replacement costs (-/?)	Environmental benefits from reduced application (?/+) Environmental benefits/costs from alternative routes of disposal including climate change impacts from incineration, landfilling (-)	Human health benefits from reduced application (?/+) Human health costs from alternative routes of disposal, e.g. air pollution from incineration (-) Odour/amenity impacts (-/?)
Option 3 – more significant changes	As above but greater in magnitude		
Option 4 - Total Ban	Fertiliser replacement costs (--) Alternative routes of disposal for all sludge arisings (--)	Environmental benefits from reduced application (?/+) Environmental benefits/costs from alternative routes of disposal including climate change impacts (--)	Human health benefits from reduced application (?/+) Human health from alternative routes of disposal including climate change impacts (--) Odour/amenity impacts from increased landfilling and incineration (-/?)
Option 5 - Repeal of the Directive	Benefits from reduced policy monitoring and compliance (+)	Environmental benefits/costs from alternative routes of disposal including climate change (?) Potential environmental risks if a MS abandons all sludge regulation (?/--)	Human health from alternative routes of disposal including climate change (?) Potential risks to human health if a MS abandons all sludge regulation (?/--) Odour/amenity impacts from increased landfilling and incineration (-/?)
0: impact expected to be negligible; - : low/moderate negative impacts expected --: significant negative impacts expected +: low/moderate positive impacts ++: significant impacts expected			

Options 2, 3 and 4 will reduce potential environmental and health impacts from spreading sewage sludge to land, but increase impacts from alternative disposal paths. While some of these impacts – e.g. climate change and air pollution impacts from greater incineration – can be and have been assessed in monetary terms, this is not true for all. In particular, Options 2, 3 and 4 can reduce the environmental and health risks and impacts from spreading sludge on land. Here, however, neither the literature reviewed for the project nor the responses to the first consultation provided a basis for quantifying such reductions in risk. However, some Member States have introduced more stringent requirements for precautionary reasons. (See the sections above for an extended discussion of these points.) **It is important to recognise that the potential environmental and health benefits resulting from more stringent sludge standards in Options 2 and 3 (as well as the total ban in Option 4) are not quantified in this CBA.**

Table 4: Overview of impacts considered and approach

Economic impacts	Stakeholder	Description	Quantified?	Qualitative assessment if no quantification and other comments
Costs of alternative disposal	Water and sludge management operators	As sludge recycled will be ended, there will be internal costs from its disposal	Yes	-
Obligation of treatment	Water and sludge management operators	Sludge will need further treatment to deal with new standards	Yes	-
Changes to regulation	Regulators	There will be costs from changing legislation and consultation (not monetised)	No	These are expected to be moderate in comparison with total costs
Policy implementation and control	Regulators	Costs from monitoring in order to check that legislation is being met	No	These are expected to be moderate in comparison with total costs
Benefits/costs if meeting related legislation requirements (e.g. WFD)	Regulators	Option 2 and 3 likely to influence positively meeting the objectives of WFD but may act against Waste Directive (especially Option 4)	No	Depends on the level of changes. A ban may compromise objectives of Waste Directive
Loss of use of sludge as a fertiliser and fertiliser replacement costs	Farmers	As sludge is no longer available, they will have to be replaced by fertiliser (this could be organic and/or mineral)	Yes (included under net internal costs)	-
Environmental impacts				
Environmental benefits from end to application	General public	Impacts on biodiversity, ecosystems, quality of water and groundwater from an end to application	Partly	Only some impacts from air emissions; other impacts, such emissions to water and soil impacts could not be quantified.
Benefits/costs from alternative routes of disposal including climate change	General public	Impacts from increase in use of landfill and incineration for sludge	Partly	Values include externalities from air emissions (including energy recovery) but excludes impacts to the environment and human health through emissions to soil and water
Social Impacts				
Human health benefits from end to application	General public	Owing to national practices and standards, benefits uncertain due to lack of evidence	Partly	As above – Only some impacts from air emissions have been valued
Human health from alternative routes of disposal	General public	Values include human health externalities from emissions (including energy recovery)	Partly	As above – Only some impacts from air emissions have been valued

For Option 5, the impacts are highly uncertain; in particular, the environmental and health impacts could be large. Moreover, a preliminary analysis indicates that Option 5 is not acceptable on the basis of the precautionary principle. Responses received in the second consultation confirmed this assessment. A cost-benefit analysis has not been undertaken for this option, however, due to the uncertainty about the potential impacts on national legislation and practices.

Table 5: Scenario 1 (high cost) – Summary of the net costs of the options for the EU27 (compared to Option 1)

EU TOTAL	Option 2	Option 3	Option 4
Present value	2,144,665,000	4,493,702,000	7,822,364,000
Annualised Cost	219,730,000	460,398,000	801,433,000
PV discounted at 4% for the period from 2010 to 2020			

Table 6: Scenario 2 (low cost) – Summary of the net Costs of the options (compared to Option 1)

EU TOTAL	Option 2	Option 3	Option 4
Present value	8,040,000	460,398,000	7,822,364,000
Annualised Cost	824,000	4,943,000	801,433,000
PV discounted at 4% for the period from 2010 to 2020			

Tables 5 and 6 summarise the costs calculated for the options.

It should be noted that the analysis faced a key problem. A major factor in terms of the economic costs is the proportion of sewage sludge that would not meet the more stringent limits under Options 2 and 3. This has been estimated for each major component of the new limits – e.g. for the proposed limits on heavy metals in sludge, for those on organic compounds and for those in other components.

Most of the information available to make these estimates of costs is by individual component, and there is no way to estimate the cumulative effective of the different components in each option based on the data at hand. Simply totalling the separate shares of sludge failing each component's limits would in part result in a double-counting of the impacts.

The analysis instead focused on the costs of each component in turn. To estimate the total costs of each option, the analysis used two cost scenarios:

1. Scenario 1 (higher cost): the highest cost among the different components is taken as an indicator of the total costs for the Option. For both Option 2 and Option 3, the most expensive component concerns the proposed limits on organic compounds (followed by more stringent limits on PTEs in soil, with costs of similar magnitude);

2. Scenario 2 (lower cost): the lowest costs among the different options' component is taken as an indicator of the total cost for the Option. This reflects a situation where only quality assurance and monitoring requirements are changed.

As it can be seen from the Tables, Option 2 and Option 3 are significantly less expensive than Option 4 for both scenarios. (Moreover, the total ban on spreading sewage sludge on land in Option 4 may act against the principles of the Waste Directive, which give priority to the recycling and reuse of waste.)

The advantage of the component by component analysis used here, is that it allows the Commission services and others to consider the difference in costs among the different components and, as a result, make decisions concerning the individual components of each option. Such decisions could take into account the various responses with regard to the impacts from the different aspects under analysis.

Final notes

The estimates produced here are subject to many uncertainties and as a result should be only interpreted as an approximation of the total estimates for the different components of the options. This is due to uncertainties regarding the amount of sludge affected, disposal options and also the scope of the costs and the uncertainties concerning the unitary values as well as, more importantly, uncertainties concerning the baseline (i.e. percentile distribution of sludge pollutants by MS, level of treatment and background concentrations of heavy metals in soil by MS). The results nonetheless are based on the information gathered, including the responses from the two consultations, and as a result represent the best estimate currently possible based on the information available.

Based on the findings, the Commission may wish to include or exclude specific components from an option or, alternatively, implement only the least costly components. Based on our analysis and the responses received, the most costly components appear to be the limits on organics (in particular the limits on PAHs) and those on heavy metals in soil. The component with the lowest cost implications is that for quality assurance and/or increased monitoring. The limits proposed under Option 2 concerning heavy metals in sludge seem to be quite achievable and indeed many consultation responses called for such changes on the basis that national standards are already more stringent. For this reason, the costs of the more stringent limits on heavy metals in sludge in this option are likely to be limited.

As has been noted, the results do not reflect all costs and benefits. In addition to the unquantifiable reduction in risk from reduced recycling, there may be additional benefits in terms of amenity and public perception from Options 2, 3 and 4. These costs and benefits are highly uncertain, however. One other benefit from these options is that in some geographical areas the more stringent requirements under these options could help to meet other EU objectives, such as those for the Water Framework Directive. Such trade-offs will have to be borne into consideration in any decision on possible revisions to the directive.

Table 7: Overview of the options

	Option 1. Baseline Scenario	Option 2. Moderate changes (some standards more stringent)		Option 3. More significant changes (more stringent standards)		Option 4. Total Ban	Option 5. Repeal of the Directive
Limits on sewage sludge content							
Heavy metals	Retain existing limits (as given in Annex IB and IC)	More stringent standards		More stringent standards		Total ban	N/a
		PTE	mg/kg	PTE	mg/kg		
		Cd	10	Cd	5		
		Cr	1000	Cr	150		
		Cu	1000	Cu	400		
		Hg	10	Hg	5		
		Ni	300	Ni	50		
		Pb	750	Pb	250		
		Zn	2500	Zn	600		
Organics	No change – no limits	1-2 standards for "indicator" organics: PCB and PAH PAH 6mg/kg dry matter PCB 0.8 mg/kg dry matter		Introduce standards for organics for PAH, PCB, LAS, NPE, Dioxins, DEHP PAH8 6 mg/kg dry matter PCB9 0.8 mg/kg dry matter PCDD/F10 100 ng ITEQ/kg dry matter LAS11 5 g/kg dry matter NPE12 450 mg/kg dry matter		Total ban	

[8] Sum of the following polycyclic aromatic hydrocarbons: acenapthene, phenanthrene, fluorene, flouranthene, pyrene, benzo(b+j+k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(1, 2, 3-c, d)pyrene.

[9] Sum of the polychlorinated biphenyls components number 28, 52, 101, 118, 138, 153, 180.

[10] Polychlorinated dibenzodioxins/ dibenzofuranes.

[11] Linear alkylbenzene sulphonates.

[12] It comprises the substances nonylphenol and nonylphenolethoxylates with 1 or 2 ethoxy groups.

	Option 1. Baseline Scenario	Option 2. Moderate changes (some standards more stringent)				Option 3. More significant changes (more stringent standards)				Option 4. Total Ban	Option 5. Repeal of the Directive
Pathogens	No change – no limits	Conventional treatment, i.e. any sludge treatment capable of achieving a reduction in Escherichia coli to less than 5x105 colony forming units per gram (wet weight) of treated sludge.				Advanced standard that sanitises sludge and achieves: a) a 99.99% reduction of Escherichia coli to less than 1·103 colony forming unit per gram (dry weight) of treated sludge; b) a 99.99% reduction in Salmonella Senftenberg W775 for sludge spiked with this micro-organism; c) no Ascaris ova; c) a sample of 1 gram (dry weight) of the treated sludge does not contain more than 3·103 spores of Clostridium perfringens; d) and a sample of 50 grams (wet weight) of the treated sludge does not contain Salmonella spp.				Total ban	
Nutrients	No change – no limits	No standards but provision of information on N:P and C content.				As in Option 2				Total ban	
Other changes concerning quality and aimed at prevention	No change	Require stabilisation (or pseudostabilisation) to reduce methane emissions during storage and from land. A potential indicator is the lack of oxygen demand; use volatile solid (VS) reduction of 38% or specific oxygen uptake rate of less than 1.5mg/h/g total solids				As in Option 2 and Hazard Assessment and Critical Control Points Assessment (HACCP)				Total ban	
More stringent conditions on application of treated sludge to land											
Soil composition											**N/a**
Heavy metals	No change	Heavy metal concentration (mg/kg)				Heavy metal concentration (mg/kg)				Total ban	
		PTE	5≤pH<6	6<pH<7	pH≥7	PTE	5≤pH<6	6<pH<7	pH≥7		
		Cd	0.5	1	1.5	Cd	0.5	1	1.5		
		Cr	50	75	100	Cr	50	75	100		
		Cu	30	50	100	Cu	30	50	100		
		Hg	0.1	0.5	1	Hg	0.1	0.5	1		
		Ni	30	50	70	Ni	30	50	70		
		Pb	70	70	100	Pb	70	70	100		
		Zn	100	150	200	Zn	20	20	200		
Organics	No change	No limits , i.e. no change				No limits, i.e. no change				Total ban	
Pathogens	No change	No limits, i.e. no change				No limits, i.e. no change				Total ban	
Nutrients	No change	Information only				As in option 2				Total ban	

<table>
<tr><th></th><th>Option 1. Baseline Scenario</th><th>Option 2. Moderate changes (some standards more stringent)</th><th>Option 3. More significant changes (more stringent standards)</th><th>Option 4. Total Ban</th><th>Option 5. Repeal of the Directive</th></tr>
<tr><td>Conditions on application</td><td>No change</td><td>Setting periods for harvesting for grassland and/or forage crops– Article 7.a
Make compulsory 10 month period for fruit, vegetable crops
Ban the application of untreated sludge – changes to Article 6 which currently allows MS to authorise under certain conditions the use of untreated sludge if injected or worked into the soil.
Outright ban on the use of untreated sludge injected or worked into the soil – changes to Article 6
Liquid sludge may only be used if injected or immediately worked into soil.</td><td>Ban of application of sludge for fruit, vegetable crops and grassland</td><td>Total ban</td><td></td></tr>
<tr><td>Other changes, i.e. sampling and monitoring, Quality assurance scheme</td><td></td><td>
<table>
<tr><th rowspan="2">Quantity of sludge (tDS/year/ plant)</th><th colspan="5">Minimum number of analyses per year</th></tr>
<tr><th>Agronomic parameters</th><th>Heavy metals</th><th>OCs (except dioxins)</th><th>Dioxins</th><th>Micro-organisms</th></tr>
<tr><td>< 50</td><td>1</td><td>1</td><td>-</td><td>-</td><td>1</td></tr>
<tr><td>50 – 250</td><td>2</td><td>2</td><td>-</td><td>-</td><td>2</td></tr>
<tr><td>250 – 1000</td><td>4</td><td>4</td><td>1</td><td>-</td><td>4</td></tr>
<tr><td>1000 – 2500</td><td>4</td><td>4</td><td>2</td><td>1</td><td>4</td></tr>
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<tr><td>> 5000</td><td>12</td><td>12</td><td>6</td><td>2</td><td>12</td></tr>
</table>
Ease the sampling and reporting requirements in case of QAS for separate discussion. Should be available for both option 2 and 3. Include CEN TC 308 procedures.</td><td>As in Option 2 but Option 3 could have more substances to be tested (organics)</td><td>Total ban</td><td></td></tr>
<tr><td colspan="6">Source: Adapted from CEC (2003): Proposal for a Directive of the European Parliament and of the Council on spreading of sludge on land. Brussels, 30 April 2003.</td></tr>
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