Environmental, Economic and Social impacts of the use of Sewage Sludge on Land: Consultation Report on Options and Impacts

Name of organisation consulting: European Commission's DG Environment

Water UK response

Date of submission: 13 January 2010

Contents

1. Introduction

1.1 Water UK welcomes the opportunity to respond to the European Commission's "Environmental, economic and social impacts of the use of sewage sludge on land – Consultation Report on Options and Impacts".

1.2 Water UK represents water and waste water service providers at UK and European level. Our members provide the UK with safe, clean water and contribute to the protection and enhancement of public health and the environment.

1.3 We support the principle outlined in the Waste Thematic Strategic and the long term vision to make Europe a recycling society that decouples economic growth from increased waste generation. We therefore believe that the revised Sludge Directive must facilitate and continue to encourage recycling of treated sewage sludge (biosolids) for use on land.

1.4 In particular we think the EC could be in breach of the Waste Hierarchy provisions of Article 4 (1) of the Waste Framework Directive, if the revised Sludge Directive as a policy instrument encourages disposal instead of practices higher in the waste hierarchy. We believe this is the case because policy makers are required to "apply as a priority order in waste prevention and management legislation and policy: preventions, preparing for re-use, recycling, other recovery (e.g. energy recovery) and disposal". We therefore consider that some of the Options under consideration in this consultation if adopted will be discouraging recycling in favour of disposal (incineration and landfill).

1.5 We support and fully endorse the statement that "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".

1.6 We believe, however, as a general overview and at a fundamental level, the consultation has missed a critical step in the overall review process in terms of developing a reasonable and rational set of technically justified criteria that could provide the basis of a revised directive. For instance, adopting a technical basis to standards and controls on sludge is recommended by WHO, to maximise opportunities for resource recovery from recycling sludge, whilst at the same time ensuring that human health and the environment are protected (Chang et al., 2002). Discussion, consultation and agreement on this is necessary before the environmental, economic and social impacts of a revision can be quantitatively addressed. We discuss some of the specific aspects later in our responses to Options 2 and 3.

1.7 Using the current Sludge Directive as a basis, the UK water industry has developed further plans to increase renewable energy generated from sewage sludge as a primary contribution to the climate change mitigation and the Renewable Energy Directive. We are keen to see that any revision to the Sludge Directive continues to support this policy and enables the residual sludge to be used are fertiliser and soil improver.

2. Subjects not covered by the consultation

2.1 As noted in paragraph 1.6 above we strongly consider that a key step has been missed in the consultation process sets out on sound science basis and justifies the standards proposed. It seems the proposed new and tightened standards have a collation of arbitrary standards against which impact assessments have been made. We think it will be improper for the Directive to be revised on the basis of these arbitrary standards, some of which were set for political and local reasons. We provide detailed comments on the standards for Organic Contaminants, Potentially Toxic Elements (PTEs) and Pathogens for Options 2 and 3 as follows:

2.2 Regarding the limit values for potentially toxic elements (PTEs) and organic contaminants (OCs) specified in Option 2 and 3, these require a robust technical basis. The values have yet to be properly debated and discussed before their impact can be assessed. An initial discussion took place in response to the proposals presented in the 3rd Draft Working Document on Sludge (CEC, 2000). However, this was severely criticised and was ultimately withdrawn because the regime of controls had no technical basis and was simply selected from national regulations. A key problem with this approach is that controls adopted in one country may be applicable locally, but they may not be appropriate in another country where different conditions apply. This strategy therefore undermines a key aim of the revision and to maintain the flexibility provided by the existing Directive. Thus, the overarching regime of controls provided by the revised Directive will differ from those in individual Member States and should take full account of the international scientific research on the environmental effects of sewage sludge recycling to agricultural land – which may not be the case in specific countries, where local, political and perception issues may have a strong influence the decisions regarding national controls on the agricultural use of sludge.

2.3 The options assessed in this report are based on criteria apparently mainly from a draft directive document from 2003 (CEC, 2003), that appears to largely reflect the limit values and controls particularly for chemical contaminants from the original Working Document on Sludge (CEC, 2000), as well as the highly tentative recommendations on pathogens from Carrington (2001). The CEC (2003) values were apparently selected to undertake the impact assessment in the absence of proposals for suitable limits from the first consultation exercise of the review. However, developing the regime of controls for the revised Directive is a non-trivial exercise. Consultees were not asked to provide a view on this, although opinions were expressed, and it would be unreasonable to expect that this would provide the basis for a strategic regime of controls for the revised Directive. This itself requires a full, technical assessment with detailed proposals for consultation. It is unclear what the status of CEC (2003) is as the document has not been 'officially' circulated previously or proposed by the European Commission. However, this consultation report also goes a stage further by proposing a further reduction in PTE limits under Option 3 compared to CEC (2003). A critical question therefore, is what is the rationale and technical basis for the regime of controls evaluated under Options 2 and 3? This should be explained so the basis to the proposed revision of the Directive is clear and transparent. A cursory assessment of the options examined shows that they are generally illogical and arbitrary. Therefore this raises questions over the relevance and validity of the fundamental assumptions to the impact analysis. Specific details and issues relating to these problems are discussed below.

Organic Contaminants

2.4 There has been an increasing level of assessment and evaluation of OCs in sludge and a framework for the risk assessment of OCs in sludge has been developed (Schowanek *et al*., 2004), applying the principles laid down in the *Technical Guidance Document TGD) on Risk Assessment of Chemical Substances following European Regulations and Directives* (EC, 2003). However, the increasing level of investigation and application of risk assessment techniques has consistently shown OCs in sludge amended soil have negligible impact on human health or the environment. This was the view expressed by the WHO Working Group on the Risk to Health of Chemicals in Sewage Sludge Applied to Land (Dean and Suess, 1985) and the COST 68/681 programme (Sauerbeck and Leschber, 1992) and is the opinion repeatedly expressed throughout the international scientific literature (Jacobs *et al*., 1987; Schmitzer *et al*., 1988; Aranda *et al.*, 1989; Kampe and Leschber, 1989; O'Connor *et al*., 1991; Hembrock-Heger, 1992; Offenbacher, 1992; US EPA, 1992ab; Webber *et al*., 1994; Giolando *et al*., 1995; NRC, 1996; Duarte-Davidson and Jones, 1996; O'Connor, 1996; Balk and Ford, 1999ab; McGrath, 2000; Smith, 2000; WEAO, 2001; Petersen *et al*., 2003; Topp *et al*., 2008; Reiss *et al*., 2009; Smith, 2009). The most recent European risk assessment (Eriksen *et al*., 2009) is entirely consistent with international opinion and concluded that the risk associated with the use of sewage sludge as a soil conditioner to be of no significance for the dietary intake of the assessed contaminants, to the soil ecosystem, the aquatic environment or food producing animals. There is a clear consensus in the scientific literature on this important issue demonstrating that limit values for OCs in sludge are unnecessary. Some further relevant examples will be briefly discussed to illustrate this.

2.5 When the European risk assessment methodology for OC in sludge (Schowanek *et al.*, 2004) was applied to the surfactant compound linear alkylbenzene sulphonate (LAS) (Jensen *et al*., 2007; Schowanek *et al*., 2007) the results showed that, even maximum concentrations of this compound found in sludge do not pose a risk to the environment. This analysis therefore superceded the earlier risk assessment by Danish scientists that formed the basis of the national standards on LAS that were adopted in Denmark and that were incorporated into the 3rd Draft Working Document on Sludge (CEC, 2000). Over 30 % of European sludges would fail to meet the CEC (2000) limit of 2600 mg kg^{-1} DS of LAS. (Figure 1). However, the sludge quality standard (SQS) for LAS in sludge derived by Schowanek *et al*. (2004) was 5 g kg^{-1} DS, and this value has been proposed as the limit for LAS in CEC (2003). Only once has an LAS concentration in sludge (3 g kg^{-1} DS) above the SQS value been recorded. Thus, all European sludge can be used on land with no risk to the environment from LAS and setting a European limit for LAS in the revised Directive serves no purpose or environmental benefit what so ever (Figure 1). Furthermore, the fact that LAS is not an identified Water Framework Directive (WFD) Priority Hazardous Substance (PHS) further emphasises its minimal risk to the environment and that regulation in wastewater treatment residuals is unnecessary and would be inconsistent with the broader regulatory regime of the WFD.

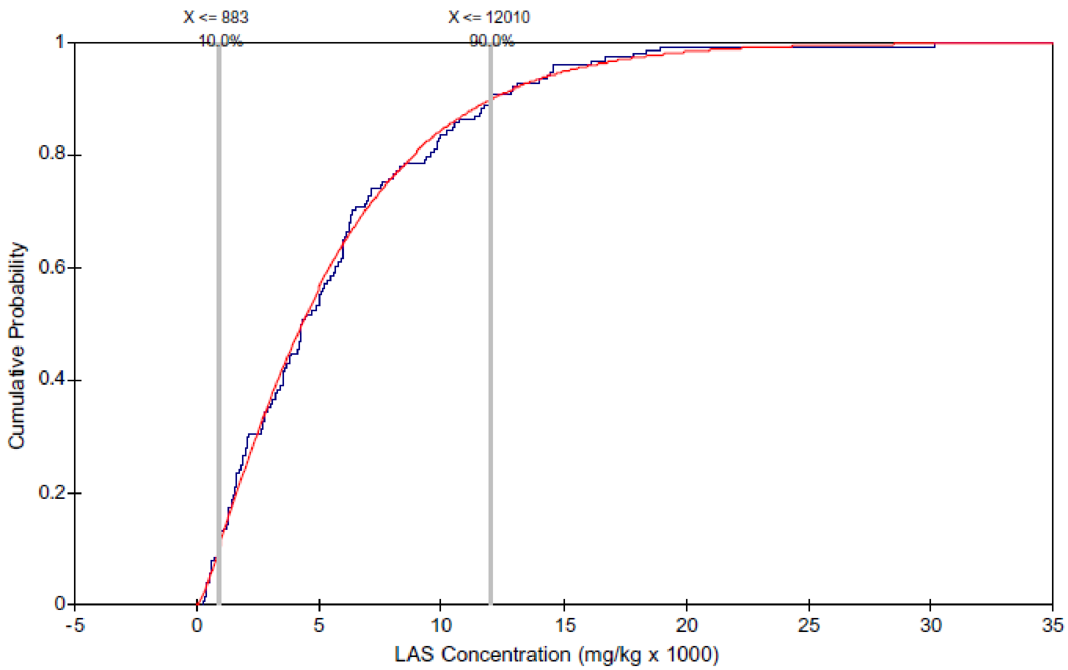

Figure 1. Distribution of LAS concentrations in digested sewage sludge in European Member States (Schowanek *et al*., 2004). The Sludge Quality Standard for LAS is 50000 mg kg^{-1} DS and the maximum LAS concentration recorded in sludge is 30000 mg kg^{-1} DS, therefore all European sludge can be applied to land with no impact on the environment due to LAS. Since all sludges contain less LAS than the SQS there is no requirement to regulate this substance in sludge for agricultural use.

2.6 In contrast to LAS, nonylphenol (NP) is a WFD PHS since it is as an identified endocrine disrupting compound (EDC). Nonyl phenol and nonyl phenol ethoxylates (NPEOs) are also regulated under the Dangerous Substances Directive 2003/53/EC. Consequently there are controls and measures in place to restrict the use and emissions of NP/NPEs to the environment at source and this has markedly reduced the concentrations of these substances in sewage sludge. For example, in 1989, digested sewage sludge samples collected at 2 UK WWTPs contained 250-820 mg kg DS^{-1} NP/NPEO whereas concentrations in a survey of UK sludge in 2009 were ≤30 mg kg^{-1} DS and were typically ≤10 mg kg^{-1} DS. Therefore, the NP/NPE content of contemporary sludges are typically more than 10 times less than the limit value of 450 mg kg^{-1} DS proposed under Option 3. Furthermore, NP/NPEO degradation in soil is rapid (half-life 20 – 60 days for example) and enhanced by the addition of organic substrates such as biosolids and uptake of sludge-bourne NP/NPEOs by plants is very low (Kirchmann and Tengsved, 1991; Roberts *et al*., 2006; Sjöström *et al*., 2008) so the possibility of transfer or risk to the human food chain in practice is limited. Given that NP/NPEOs are effectively controlled at source, the concentrations in sludge are significantly below the proposed limit value, they degrade rapidly in soil and do not transfer to the human food chain, there is no technical argument to support their regulation in sludge for agricultural application. This was confirmed in the recent risk assessment by Eriksen *et al*. (2009), which concluded that NPs, as well as octylphenols and LAS, were of low concern for the agricultural utilisation of sewage sludge. Thus, including a limit value for NP/NPE in sludge has no benefit for human health or the environment. The 3rd Draft Working Document on Sludge (CEC, 2000) included a proposed limit for di(2-ethylhexyl)phthalate (DEHP) of 100 mg kg^{-1} DS, but CEC (2003) did not propose a limit value for this compound. Nevertheless, DEHP is included in the list of chemicals as part of the more stringent regime of standards evaluated although no limit is given in Table 3. However, a maximum concentration of 100 mg kg^{-1} DS is indicated as appropriate in Section 3.3.2 and 4.3.2 of the report describing the 'Environmental impacts' for Option 2 and 3. The English in this part of the report is ambiguous as it states that 'when limits are not set at this level, there could be limited benefits in terms of reduced health risk'. Presumably the authors actually mean that there would be limited benefits if limits were set at this level? However, this analysis and interpretation is completely wrong and a misinterpretation of the scientific evidence relating to the behaviour and environmental consequences of this compound. For a detailed discussion of the implications of DEHP in sludge and amended agricultural soil see Smith (2009). DEHP and other phthalate acid esters are not environmentally persistent and are readily degraded in soils and sewage sludge under both aerobic and anaerobic conditions (Keyser *et al*., 1976; Walker *et al*., 1984; Group, 1986; Staples *et al*., 1997). Experimental data show no uptake of DEHP by crops or impacts of the compound on plant growth or the soil ecosystem (Kirchmann *et al*., 1991; Cartwright *et al.,* 2000; Jensen *et al*., 2001; Petersen *et al.,* 2003). Therefore, DEHP does not transfer to the human foodchain or impact sludge-amended soil (Eriksen *et al*., 2009). DEHP has been subject to review as a possible WFD PHS, however, the European Union risk assessment concluded that there was no tangible risk to the environment or human health (EC, 2008); DEHP has therefore not been designated as a PHS within the WFD. Therefore, it would seem to be entirely inconsistent to regulate DEHP in sludge for agricultural application, particularly when terrestrial risk assessment also concludes that, as with the other identified OCs in sludge, DEHP has no impact on human health or the environment (Eriksen *et al*., 2009). Consequently, there is substantial evidence showing the minimal impact of this compound in sludge-amended soil and demonstrates unequivocally that regulation of DEHP in sludge for agricultural utilisation is unnecessary and categorically would have **no** health or environmental benefits.

2.7 The concentrations of traditional persistent organic pollutants (POPs) in sludge, notably PCDD/Fs, PCBs and PAHs have declined significantly in response to effective source controls imposed through European environmental legislation. For example, the PCDD/F concentration in sludge has declined and is well below the limit value suggested in Option 3 of 100 ng TEQ kg^{-1} DS in contemporary sludges (Figure 2) (also see for example, Martínez *et al*., 2007). Also, research has shown that the consequences of these substances in sludge and amended soil for human health are negligible (eg US EPA, 1992ab; Webber *et al*., 1994; Wild and Jones, 1991; Wild *et al*., 1994; O'Connor, 1996; Duarte-Davidson and Jones, 1996; Jones and Northcott, 2000; IC Consultants, 2001; Stevens *et al.*, 2003; US EPA, 2003). Therefore, the EC JRC recommended that the routine monitoring of PCDD/Fs, PCBs and PAHs in sludge used for agricultural purposes was unnecessary (Erhardt and Prüeβ, 2001).

2.8 PCDD/F and PCB concentrations in UK sludge and measured in international surveys are well below the limits proposed by CEC (2003), consequently there is no case for including maximum permissible concentrations for these substances in a revision of Directive 86/278/EEC. The EU proposals are also that the 'sum of the PAHs' acenaphthene, phenanthrene, fluorene, fluoranthene, pyrene, benzo(b+j+k) fluoranthene, benzo(a)pyrene, benzo(ghi)perylene and indeno(1,2,3-cd)pyrene should not exceed 6 mg kg^{-1} DS in sludge. However, it is not apparent why these particular congeners have been selected from the array of PAHs present in environmental samples. Carefully performed pathways analyses also show that sludge addition to land is a minor source of PAHs and that there are no risks to the foodchain at the loadings typically applied (Duarte-Davidson *et al*., 1995). Nevertheless, a significant proportion of European sludges would fail to comply with the proposed limit of 6 mg kg^{-1} DS as the sum of 9 PAH congeners (Table 1). For example, in a survey of 14 sludge samples from different wastewater treatment plant in the UK (Jones and Northcott, 2000; Stevens *et al*., 2003), all the sludges contained larger PAH concentrations (range:18 – 50 mg kg^{-1} DS ∑of EU 9 PAH congeners) than the proposed PAH limit value, irrespective of the type of catchment and relative proportions of industrial and domestic effluent treated. Thus, *typical sewage sludges from every country and every survey are likely to be in exceedance of the proposed EU standard. It is therefore likely that implementation of this standard would result in the cessation of a very substantial proportion of all sewage sludge applications to agricultural land in the EU with no benefit for human health or the environment*.

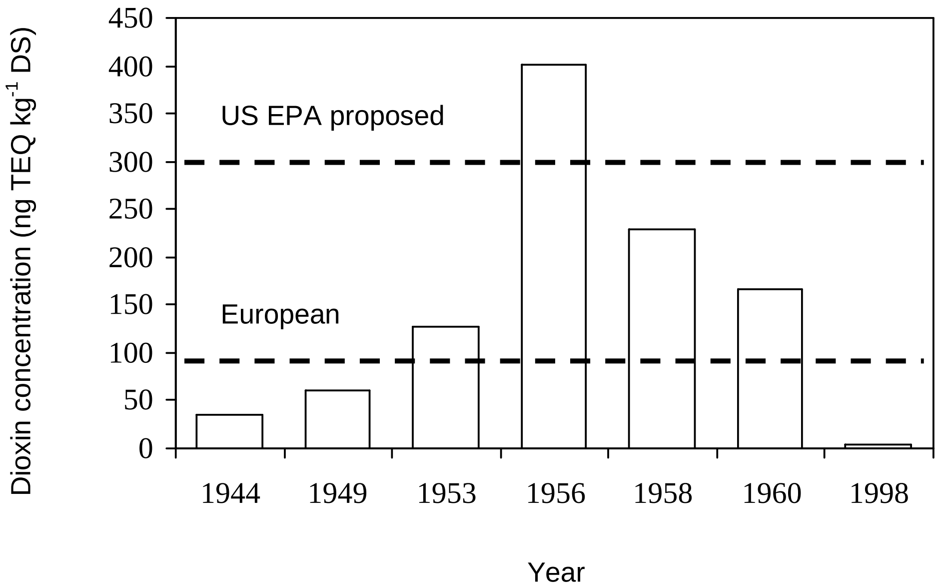

Figure 2. Dioxin content of archived samples of sewage sludge from a major wastewater treatment works in West London, UK (Note: following detailed risk assessment US EPA final decision was not to regulate dioxins in sludge – see USEPA (2003)) (Smith, 2000)

Table 1. Representative mean, maximum and worst case values for the proposed EU standard PAHs in sewage sludges reviewed by Duarte-Davidson *et al*. (1995)*, compared with a UK survey reported in 2000 (Jones and Northcott, 2000**)**

Compound		Representative		UK 2000
	mean*	maximum*	worst case*	
Acenaphthene	1.8	4.2		3 – 6.6
Phenanthrene	7.2	26	44	4.1 - 16
Fluorene	1.9	7.3		3.6 – 8.1
Fluoranthene	2.8	3.9	60	1.4 – 7.4
Pyrene	2.5	3.4	29	2.1 - 35
Benzo(b+j+k)fluoranthene	~2.1#	~2.5#	~23#	~2 - ~11#
Benzo(a)pyrene	0.07	0.14	25	0.69 – 4.0

Benzo(ghi)perylene	1.3	1.1	9	0.47 – 2.3
Indeno(1,2,3-cd)pyrene	1.3	0.05	8	0.39 – 2.7
Range of totals				18-50
Averages totalled	21	49		

Note: excludes data for benzo(j)fluoranthene

2.9 Summary – Organic Contaminants

In overall assessment, the above brief discussion of key scientific evidence demonstrates that there is no technical case or justification for including organic contaminants in a revision of Directive 86/278/EEC. The limits values for most of the proposed contaminants are well above the maximum concentrations measured in contemporary sewage sludge samples and therefore serve no purpose in regulating the quality of sludge for agricultural application or protecting the environment or human health. The proposed limits for DEHP may restrict some European sludges for use in agriculture. However, the limit for PAH would be the most restrictive of sludge recycling in Europe. For example, in the UK, a recent survey of sludge composition completed in 2009 indicated that 50 % of sludge samples would not meet the suggested standard for PAH. This measure would therefore have major consequences for sludge management practices in the UK and severely curtail land application, yet the proposed limit on PAHs has no technical justification or benefit for human health or the environment. Indeed, to reiterate the conclusion of the JRC, the routine monitoring of POPs, including PAHs, is unnecessary for the agricultural use of sewage sludge.

Potentially Toxic Elements

Sludge Limit Values

2.10 The sludge limit values discussed in Option 2 from CEC (2003) originate from CEC (2000). The values for elements; Cu, Ni, Pb and Zn can be traced to the lower maximum permissible limits in sludge stipulated in Directive 86/278/EEC and consequently have an identified basis. CEC (2000) proposed reducing the limit values for Cd and Hg, compared to the lower maximum limits for these elements given in Directive 86/278/EEC and the suggested values were reasonable given the reductions in concentrations of these potentially toxic elements (PTEs) that have occurred in the past 20-30 years. Directive 86/278/EEC did not include limits on Cr, but CEC (2000) proposed a reasonable value for Cr in sludge relative to the concentrations of this element measured in sludge. Therefore, the proposed sludge PTE limits in Option 2 seem reasonable, they reflect the improved chemical quality of sludge and are unlikely to have a significant impact on sludge recycling in the UK specifically or Europe in general.

2.11 In contrast to the Option 2 PTE limits in sludge, which have traceable origins, it is unclear how the more stringent limits for PTEs in sludge in Option 3 have been derived and what is there basis. It is critical that any significant reduction in PTE or other limit values is justified and has a demonstrable environmental or health benefit as this may have a major impact on sludge recycling practices as is the case here. For example, more than 50 % of European sludge currently recycled to agriculture is likely to fail the Option 3 limits for PTEs in sludge, as suggested in the report. However, published experimental evidence (eg De Brouwere and Smolders, 2006) shows that the current European regulatory regime (CEC, 1986) for PTEs in sludge protects soils and crops from the potentially harmful effects of PTEs in sludge. There is no evidence that a stricter regime than Option 2 is necessary to protect the environment from PTEs applied to the soil in sludge and the proposed limits for PTEs in sludge under Option 3 would appear to be arbitrarily selected with no justification or basis. For example, it makes no sense to set a limit value for Cr below that of Zn or Cu, the major potentially phytotoxic elements in sludge, since Cr(lll), which is the form present in sludge- amended soil, is immobile and unavailable for crop uptake (Gary *et al*., 1977; McGrath and Cegarra, 1992). Indeed, phytotoxicity due to Cr, as well as due to Cu and Ni, has not been reported in realistic sludge application conditions in the field (Cartton-Smith and Davis, 1983; Carlton-Smith and Stark, 1987; Chang *et al*., 1987; Chang *et al*., 1992; Carrington *et al*., 1998; US EPA, 1992ab, Smith *et al*., 1993).

2.12 Given that PTE concentrations have declined markedly in sludge and Cr, Ni, Hg and Pb have no negative effects on human health and the environment at the concentrations of these elements found in sludge, it is technically justified to drop these elements from the regulatory regime if they fall below the Option 2 sludge limit values. Therefore the two options relating to limit values for PTEs in sludge that are recommended for consideration in a revised Directive are the proposed Option 2 limits and a reduced list of limits for only the critical elements: Zn, Cu and Cd.

Soil Limit Values

2.13 Option 2 and 3 limit values for PTEs in soil are identical except for substantially more stringent limits for Zn in soil at pH 6-7 and pH 5-6 in Option 3 compared to Option 2. Directive 86/278/EEC set a range of maximum permissible limit values for PTEs in soil enabling Member States to select an appropriate regime of soil standards to take account of local circumstances particularly, for example, the natural geogenic properties and background PTE contents of soil within an individual country. This flexible approach to regulating sludge is regarded as one of the major strengths of the current Directive. However, the regimes proposed in Option 1 and Option 2 substantially move away from the flexible and pragmatic measures adopted in the original Directive and therefore have serious and major limitations. In the first place the values do not appear to have any consistent origin. Taking the limit values proposed for soil of pH 6-7 as a benchmark, the limits for Cd, Cu and Zn are the same as the lower maximum permissible concentrations in Directive 86/278/EEC. The limits for Ni and Pb on the other hand are larger than the lower values stipulated in the Directive, whereas the proposed limit for Hg at pH 6-7 is less than the Directive value. The rationale to the revised limits for PTEs in sludge-amended soil therefore requires a full explanation.

2.14 More importantly, however, a number of fundamental scientific problems exist with the proposed numerical values. In particular, the proposed PTE limits in soil should incorporate principles of basic soil chemistry that fundamentally influence the behaviour and bioavailability of PTEs in soil. For example, Cu, Pb, Hg and Cr are tightly bound and immobile in soil and their availability is not influenced by the soil pH value. Therefore, there is no technical reason to have pH related limit values for these elements in sludge-amended soil. The elements that are pH responsive, on the other hand, where there is a possible case for pH related limits, include Zn, Ni and Cd. For a detailed discussion on the effects of soil properties and pH on metal behaviour see Smith (1996) and Smith (1994ab).

2.15 The current Directive permits individual Member States to develop national controls on PTEs appropriate to local circumstances. In the UK, for example, controlled environment and field research (for example: Davis and Carlton-Smith, 1984; Carlton-Smith, 1987) was completed to underpin national statutory limits for PTEs within the framework of controls stipulated by the Directive. This international research experience was also published and shared amongst European Member States through the COST 68/681 programme which ran from 1972 until 1990 (Hall *et al*., 1992). The flexible requirements of the Directive relating to PTEs recognise that conditions differ between Member States. For instance, the mineralogy of UK soils is very different and they contain larger background concentrations of PTEs compared to many other regions in Europe. Thus a combination of local soil characteristics and quantitative research demonstrated that the upper maximum limits for PTEs in sludge-amended soil permitted by Directive 86/278/EEC were appropriate for UK conditions. More than any of the other areas requiring regulation concerning the agricultural use of sludge (eg pathogens and organic contaminants) recognising the need for flexibility in the PTE limit values is an essential and fundamental concept that was successfully implemented through the current Directive. However, the proposed changes to the metals limits described in Option 2 and 3 apparently ignore this critical feature.

2.16 Option 3 introduces further problems due to the reduction in Zn concentration to 20 mg kg^{-1} for soil of pH<7. This is a drastic change in the criteria for Zn compared to the current Directive and the Option 2 limits and relative to the limit proposed in Option 3 for soil of pH ≥7 (200 mg Zn kg^{-1}). Indeed this would not be permitted by Directive 86/278/EEC which allows Member States to set higher limit values for Zn, Cu and Ni for soils of pH>7, but they must not exceed the limits at pH 6-7 by more than 50 % (Note that Directive 86/278/EEC does not permit higher values for Cd, Pb or Hg in alkaline soils). Consequently, the proposed PTE criteria in Option 2 and particularly Option 3 represent a major departure from Directive 86/278/EEC, basic principles of soil chemistry and scientifically endorsed limits. Furthermore, it is unclear what technical rationale has been applied to support a reduction in the soil Zn limit to 20 mg kg^{-1} in Option 3. This needs clear explanation as it would have major consequences for sludge recycling in many European countries simply because the background Zn concentration in many soil types is >20 mg Zn kg^{-1}. In the UK, for instance, the normal range of Zn concentrations in soil is 24 - 260 mg Zn kg^{-1} (Smith, 1996); therefore only soils of pH>7 would be accessible for sludge application if this measure were introduced. Consequently the limit values for Zn in Option 3 for soil of pH<7 appear to be totally arbitrary with no technical basis.

2.17 Current maximum soil PTE limits permitted by Directive 86/278/EEC are presented in Table 2. Recent research has indicated that revision of the limit values for Cd and Pb may be justified primarily to comply with recent EU food quality standards. For example, recent field research (Chaudri *et al*., 2007) suggests a lower limit for Cd is necessary to avoid exceeding the EU food standard for this element in wheat grain. Animal feeding trials suggest lowering the limit for Pb as a precautionary measure to prevent the food limit in kidney offal meat in sheep being exceeded under worse case grazing conditions (Carrington et al., 1998; Stark et at., 1998). However, the Pb content in sludge has declined to such an extent it is very unlikely that accumulation in soil would represent an issue for food quality or the foodchain. It is emphasised that current EU upper limit values for these elements pose no risk to the human diet due to the intake of these elements through the foodchain from sludge-amended soil (MAFF/DoE. 1993a). The upper EU soil limit for Zn has also been identified as a potential risk to sensitive soil microbial processes (MAFF/DoE, 1993b). However, an overview of the scientific evidence indicates that a reduction in microbial activity due to Zn has been detected only where exceptionally contaminated and, therefore, potentially toxic sewage sludge compared to contemporary standards has been applied, that would not be permitted by Directive 86/278/EEC, or where metal bioavailability has been increased artificially by the addition of metals salts to soil. Furthermore, there are no negative effects of Zn apparent at the current upper limit value in fine textured soil types. The overall conclusion from a recent extensive programme of multi-site field investigations (UKWIR, 2007) was that the evidence for negative effects of Zn on soil microorganisms was equivocal (Defra, 2007) and that no change to the maximum permissible limit value for this element was necessary.

2.18 Therefore, it is proposed that the existing EU upper numerical limits for Cu, Ni and Hg and the UK limit for Cr (European limits for Cr were not agreed in Directive 86/278/EEC, but the effects of Cr in sludge-amended soil have been well researched in the UK - see Smith *et al*., 1993), and the revised values for Cd and Pb, also listed in Table 2, should be adopted as upper limits in a revision of Directive 86/278/EEC. There is no evidence that the upper soil limit for Zn is hazardous to the soil ecosystem at the concentrations of this element found in contemporary sewage sludge applied to soil. Nevertheless, given the controversy it would be prudent to keep the soil limit for Zn under review. These recommendations are technically justified and protect the environment and human health from the potentially long-term adverse effects of PTEs applied to soil in sludge. The regulatory regime could be further simplified, however, by removing Ni, Cr, Hg as well as Pb as the concentrations of these elements in sludge have declined to such an extent that they no longer pose a risk to human health or the environment from the agricultural use of sludge (Table 2). For example, similar recommendations are being considered by the South Australia Environment Protection Authority (SA EPA, 2009) implementing results from a multi-site experimental programme on PTEs in sludge-amended soil under Australian conditions (Warne, 2009), which are arguably more sensitive to PTEs compared to European soil types.

Table 2. European maximum permissible limit values for PTEs in sewage sludge-treated agricultural soil and proposed technically based upper limits recommended for consideration in a revision of Directive 86/278/EEC (for soil pH 6-7)

Element	Directive 86/278/EEC maximum soil limit (mg kg^{-1} dry soil)	Recommended maximum soil limits values for revised Directive (mg kg^{-1} dry soil)
Cadmium[a]	3	1.7
Chromium	--	400[b]
Copper	140	140
Mercury	1.5	1.5[b]
Nickel[a]	75	75[b]
Lead	300	200[b]
Zinc[a]	300	300[c]

[a] The bioavailaibility of these elements is influenced by the soil pH value and limit values may be increased or decreased in soils of pH >7 and <6, respectively.

[b] The concentrations of these elements have declined in sludge to such an extent that they no longer pose a threat to human health or the environment at the concentrations present in sludge applied to agricultural land and they can therefore be removed from the regulatory regime.

[c] Extensive, multi-site field investigations show that potentially negative effects of Zn on sensitive soil microbiai processes at the maximum soil limit value for this element are equivocal and have only been demonstrated with exceptionally contaminated, toxic sludges or in systems where bioavailability of metals is artificially raised through addition of metal salts. There is no evidence of a detrimental effect of Zn in fine textured soil types or for contemporary sludge types containing typical Zn concentrations found in operational practice. Therefore, no revision to the upper soil limit value for Zn is recommended at this time, and the limit should be kept under review.

Summary - PTEs

2.19 Upper maximum soil limits for PTEs are well defined and are based on 30 years of field and laboratory research (Table 2). However, the

concentrations of Ni, Cr, Hg and Pb in sludge have declined to such an extent that they no longer pose a risk to human health or the environment from the agricultural recycling of sludge - the regulatory regime on PTEs in a revised Directive could therefore be further simplified by removing these elements from the statutory list of regulated elements. The maximum limits proposed in Option 2 and 3 are lower than scientifically derived values and would significantly constrain sludge recycling to farmland in Europe. The rationale and basis to the proposed soil PTE criteria are uncertain and should be examined and reviewed before a valid impact assessment can be completed. Directive 86/278/EEC provided Member States with the flexibility necessary to set national standards for PTEs in soil appropriate to the local conditions, to take account for instance of variations in background soil PTE contents. However, this key feature has been lost from the proposals on PTEs examined in the impact assessment. Overall the PTE criteria assessed in Option 2 and 3 are more stringent than is scientifically justified and they do not recognise the need for flexibility in setting soil standards in different Member States to take account of local circumstances. The increased stringency and reduced flexibility will have a negative impact on recycling sewage sludge in agriculture but this will not result in any beneficial effects for human health or the environment.

Pathogens

2.20 Sludge Treatment Parameters

The pathogen criteria for Option 2 and 3 set out an 'either or' set of conditions for conventional or advanced treated grades of sludge, respectively, in the option assessment. In practice, however, controls implementing specific pathogen reduction criteria include both levels of microbiological status, for example, the US EPA 503 Regulation and UK Safe Sludge Matrix (US EPA, 1993; ADAS, 2001). Therefore, to provide flexibility and facilitate sludge management routes and different end-uses a revised Directive should include criteria for both conventional and advanced (or enhanced) treated sludge. Therefore, the option assessment should include a sensitivity analysis assuming different proportions of sludge will be treated to conventional and enhanced status within the same regulatory regime. For example, in practice, 20 % of sludge may be treated by advanced (enhanced) processes and 80 % by conventional treatment.

2.21 The pathogen reduction criteria detailed in Option 3 are taken from Carrington (2001). However, the microbiological criteria recommended by Carrington (2001) for conventionally treated sludge have not been adopted in Option 2. Conventional treatment status is achieved by a 2 $\log_{10}$ reduction in the indicator bacteria, *Escherichia coli*, as this demonstrates that the treatment process has provided an effective barrier to pathogen transmission by applying a stress to the enteric microbial community increasing their vulnerability to environmental stress and decay once applied to soil in the field (Carrington, 2001). However, the Option 2 criterion for conventional treatment is a maximum limit on the number of *E. coli* of 5×10^5 g^{-1} (wet weight). This is a less exacting requirement than the log reduction specification because, on a dry weight basis the limit value is equivalent to 2 x 10^6 *E. coli* g^{-1} dry solids (DS) in a typical dewatered cake at 25 % DS, which is in the range of the background concentrations of *E. coli* in raw untreated sewage sludge (Sidhu and Toze, 2009). Field research shows that pathogen decay is increased in soil amended with sludge treated to the conventional treatment conditions specified in the UK Safe Sludge Matrix compared to untreated sludge (Cass, 2009). However, there is no correlation between the survival of *E. coli* in soil and the numbers initially present in the applied sludge (Cass, 2009). Consequently, specifying a reduction in *E. coli* numbers is more relevant to and robust for controlling the microbiological status and quality of sludge treated to conventional standard compared to a maximum limit on *E. coli* numbers. Therefore, the pathogen reduction criteria for conventional treatment should specify a 2 $\log_{10}$ removal of *E. coli* and the requirement on maximum numbers is less relevant and should be removed.

2.22 Option 3 pathogen reduction requirements also require clarification to separate the quality assurance measures from those intended for validating new processes (CEC, 2003). Carrington (2001) advised that, for routine quality assurance purposes, sludge treated to advanced status should contain $<10^3$ *E. coli* g^{-1} DS, as this level of reduction in *E. coli* numbers in sludge is associated with the elimination of enteric bacterial diseases and viruses. Consequently, there is no need to also specify log reduction criteria as suggested in Option 3. Carrington (2001) also tentatively recommended a limit on the numbers of *Clostridium perfringens* spores, but provided no quantitative evidence to justify the selection of this organism. Indeed, the selection of *C. perfringens* as an indicator to regulate the microbiological quality of sludge would be a controversial step since internationally no other regulatory authorities recognise or have adopted this organism in microbiological standards for sludge. Furthermore, the value of using as *C. perfringens* surrogate indicators for oo(cysts) of protozoan parasites, and enteric viruses is disputed as their inactivation is poorly correlated with the decay of pathogenic organisms (Sidhu and Toze, 2009) and recent research shows them to be unsuitable as indicators of enteric pathogens in sludge (Rouch *et al*., 2008). Therefore the research and evidence base is simply not available or robust enough to support inclusion of *C. perfringens* in a statutory regulation for sludge.

2.23 To validate new advanced treatment processes, Carrington (2001) suggested a reduction of 4 $\log_{10}$ of added *Salmonella* and inactivation of *Ascaris* ova was appropriate. However, Option 3 apparently does not make a distinction between the quality assurance parameters and those intended for process validation and it should be emphasised that these measures are unnecessary for routine process monitoring and quality assurance. Furthermore, Option 3 specifies *Salmonella senftenberg*, but recent research (Lang and Smith, 2008) shows that *E. coli* is essentially equivalent in terms of thermotolerance and is more persistent than *Salmonella* species in general. Thus, *E. coli* is a robust indicator and suitable surrogate organism for *S. senftenberg* and, therefore, validation tests with *S. senftenberg* serve no practical purpose and can be removed to simplify validation testing.

2.24 There is also a question over the relevance of including *Ascaris* in the microbiological criteria for sludge as, in many European countries, infections by this organism in the human population are extremely rare. This measure would therefore only be relevant in regions where infections by enteric parasites are prevalent and eggs and oocysts are detectable in sludge.

Land Use Restrictions

2.25 The objective of treating sludge to advanced status is to eliminate the pathogenic content thereby increasing the flexibility in possible end uses compared to conventional treatment, where land use restrictions are required to allow the natural decay of residual pathogens in the soil environment. The two-tier approach to sludge treatment was first introduced by the US EPA in Final Part 503 Rule (US EPA, 1993) which classified sludge into two different microbiological types according to the extent of pathogen removal achieved by the sludge treatment process. This approach recognised that sludge treated to a high microbiological standard (Class A, synonymous with advanced or enhanced treatment status) to eliminate microbial pathogens provided a single effective barrier against pathogen transmission and could be used without end-use restrictions. On the other hand, sludge that is treated by processes that significantly reduce, but do not eliminate pathogens (Class B, synonymous with conventional treatment status) can only be used in particular ways following the multi-barrier approach to prevent transmission of enteric disease from the agricultural use of sludge. The waiting period requirements for conventionally treated sludge under Option 2 appear reasonable. However, banning the use of advanced treated sludge on fruit, vegetables and grassland under Option 3 reduces flexibility and opportunities for recycling sludge and is inconsistent with the objective and reason for treating sludge to this high microbiological standard. HACCP measures ensure the microbiological quality of sludge, therefore it is unnecessary to ban advanced treated sludge types for use on these crops as this achieves no benefit to human health.

Summary - Pathogens

2.26 A major criticism of the impact assessment is that the microbial parameters examined in Option 2 and Option 3 only apply to either conventional or advanced treatment status, respectively. However, pragmatic regulatory controls (eg US EPA, 1993; ADAS, 2001) include specifications for both levels of treatment at the same time with the option to treat sludge to either standard as required by local circumstances. Therefore, a more realistic impact assessment would address different relative proportions of sludge treated to conventional or advanced status. Furthermore the microbiological parameters specified in Option 2 and 3 could be more effective and simplified and they require further clarification to remove inconsistencies. The application restrictions on advanced treated sludge under Option 3 are also inconsistent with the objective of treating sludge to this high microbiological standard, which is designed to increase flexibility in the

outlets and end uses for sludge, including application to fruit, vegetables and grassland.

3. Response to specific questions in the consultation document

We respond to the specific questions in the consultation document as follows.

Q 1: *Do you have any comments on the Options as proposed, in particular in terms of their expected impacts?*

Further to the detailed assessment and points noted in Section 2 above we consider that there is little reason for the introduction of metals limits in sludge/biosolids given that soil concentration limits are set. It is logical to focus on metal limits in soil as this has the potential to influence metals limits in crops/environment rather than the sludge content per se. It should be noted that the existing directive provides flexibility for Member States to control metal level by a combination of maximum sludge application rate and the metal levels in the soil.

We reiterate the points made in Section 2 above that any introduction of organic limits should be based upon sound science with a proven negative impact on environmental or human health. The current proposals for the Options fail to provide adequate justification.

The tightening of soil metal limits would remove some agricultural land from the currently available landbank. We reproduce paragraph 2.16 here to highlight the point of the impact:
"Option 3 introduces further problems due to the reduction in Zn concentration to 20 mg kg^{-1} for soil of pH<7. This is a drastic change in the criteria for Zn compared to the current Directive and the Option 2 limits and relative to the limit proposed in Option 3 for soil of pH ≥7 (200 mg Zn kg^{-1}). Indeed this would not be permitted by Directive 86/278/EEC which allows Member States to set higher limit values for Zn, Cu and Ni for soils of pH>7, but they must not exceed the limits at pH 6-7 by more than 50 % (Note that Directive 86/278/EEC does not permit higher values for Cd, Pb or Hg in alkaline soils). Consequently, the proposed PTE criteria in Option 2 and particularly Option 3 represent a major departure from Directive 86/278/EEC, basic principles of soil chemistry and scientifically endorsed limits. Furthermore, it is unclear what technical rationale has been applied to support a reduction in the soil Zn limit to 20 mg kg^{-1} in Option 3. This needs clear explanation as it would have major consequences for sludge recycling in many European countries simply because the background Zn concentration in many soil types is >20 mg Zn kg^{-1}. In the UK, for instance, the normal range of Zn concentrations in soil is 24 - 260 mg Zn kg^{-1} (Smith, 1996); therefore only soils of pH>7 would be

accessible for sludge application if this measure were introduced. Consequently the limit values for Zn in Option 3 for soil of pH<7 appear to be totally arbitrary with no technical basis".

In respect of pathogens level controls in sludge, current evidence indicates that an E. coli limit is unnecessary as this organism has a low survival ability in agricultural soils and therefore does not pose a risk relating to contamination and transfer to the food chain via combinable crops.

If adopted, the analysis reporting should not be confined to CFU as most laboratories now use MPN as the preferred methodology when estimating E. coli levels.

Changes in sampling frequency are likely to significantly increase costs with no obvious benefit for environmental/human safety. Decades of sludge analysis has shown that there is little variation in sludge quality and the current sampling requirements capture this adequately. We do not support the adoption of CEN TC 308 as these should be left for MS to decide in accordance with the subsidiarity principle.

We do agree with the definition of stabilisation (or pseudostabilisation) in respect of methane emissions, oxygen demand and use of volatile solid. We would like to see proper scientific justification and supporting evidence.

The impact assessment has not allowed for the impact of IPPC Directive for additional capital and operational expenditure when existing sludge treatment facilities for agricultural land are considered as disposal activities under Options 4 and 5. This is likely to be significant, for example we estimated that the ongoing negotiations on the Industrial Emissions Directive (at the first reading) would cost the UK water industry about £480 millions/year.

Q 2 – *Would your MS be affected by any of the above components?*

Option 2 is likely that the suggested limit for PAH at 6 mg/kg dry matter will preclude a significant amount of biosolids from application to soils.

Q 3 - *Do you agree with our estimates of recycled sludge failing the limits on heavy metals and the impacts on disposal and treatment?*

The utilisation of landfill will diminish in the future as either the costs significantly increase (gate fees and escalating landfill tax) or availability becomes an issue, as an example it is suggested that the Southeast of England has only 3 years of landfill life left. It is likely that current incineration capacity will need to be increased to accommodate such volumes of sludge.

Q 4 - *Do you agree with our estimates of recycled sludge failing the limits on organic contaminants and the impacts on disposal and treatment?*

Please refer to our detailed comments on Organic Contaminants in Section 2 above. We believe the case for setting OCs has not been made and justified on the basis of sound science. It is likely that the % recycled sludge failing new limits on OC's for the UK of 40% is an underestimate, data from 2007 (Smith and Riddell-Black) suggests the majority of sludge has PAH's greater than the 6 mg/kg limit.

Q 5 – *What percentage of sludge will be affected by the new limits on pathogens and will receive further treatment? Would this treatment consist of adding lime?*

The estimate of 40% of sludge affected is likely to be a little high as significant investment in advanced digestion is occurring across the UK. The reliance upon lime addition as a main treatment process or a 'back-up' process for achieving pathogen compliance is predicted to significantly reduce over the coming 5 years as companies responsible for sludge treatment are aiming to maximise the energy value associated with sludge and moving towards anaerobic digestions as the predominant treatment process.

We think the costs of liming seem rather low. For example we estimate that 22Euro per tds would only cover the material costs, and would not cover impact of labour, power and maintenance. Our estimate (based on Ofwat July Return data) would be closer to £150/tds for lime treatment OPEX.

Q 6 – *Do you have and can you provide costs data on HACCP? Please provide estimates of the number of staff or time required per installation if feasible.*

It is estimated that HACCP monitoring is in the region of £5000 - £8,000 per treatment site/year.

Q 7 – *What do you expect the % of total agricultural land to be failing to comply on the new limits of heavy metals in soil? Would production be maintained through the application of fertiliser?*

We believe that the data provided by WRc for the UK to be a reasonable estimate of the land not available for biosolids recycling. It is probable that production would be maintained through the application of commercial fertilisers.

Q 8 – *What % of total agricultural land do you expect will be affected by the ban on injecting untreated sludge and/or liquid sludge into the soil? Will there be costs arising from these new conditions?*

It is expected that such a ban will have a negligible effect on the % of total agricultural land in the UK.

Q 9 – *What are the costs implications of these new monitoring requirements? Please explain (e.g. number of additional FTE, administrative costs, etc.)*

It is likely that the sampling requirements will increased staffing levels, with sampling and administration adding a probable 2 FTE posts (per Company) resulting in up to 30 additional posts in the UK. The analysis is likely to be contracted out to a service provider and as such will not impact on FTE's to the Water Companies but increase current opex costs by a suggested 10 fold.

Q 10 – *Do you agree with our assessment? If not, please expand. Feel free to add comments on the benefits and costs from Option 2 as well as any data that could influence the assessment.*

In general the assessment is reasonable. However we consider the benefit of this option to implementation of the Water Framework Directive (WFD) is overstated and unlikely. For example use of biosolids on land is not even considered a risk to meeting the WFD objectives in the recently published River Basin Management Plans in the UK. There are definitely no measures identified in the RBMPs relating to the Sludge Directive.

Q 11 – *Would your MS be affected by any of the above components?*

Option 3 will preclude a significant amount of biosolids from application to soils due to the proposed standards for copper, nickel, PAH, PCDD/F5, LAS6 and NPE7.

Q 12 - *Do you agree with our estimates of sludge failing the limits on heavy metals and the likely percentages receiving further treatment or going for incineration/landfill?*

The utilisation of landfill will diminish in the future as either the costs significantly increase (gate fees and escalating landfill tax) or availability becomes an issue, as an example it is suggested that the Southeast of England has only 3 years of landfill life left. It is extremely likely that current incineration capacity will need to be increased to accommodate such volumes of sludge.

Q 13 - *Do you agree with our estimates of recycled sludge failing the limits on organic contaminants and the impacts on disposal and treatment?*

It is likely that the % recycled sludge failing new limits on OC's for the UK of 50% is an underestimate, data from 2007 (Smith and Riddell-Black) suggests the majority of sludge has PAH's greater than the 6 mg/kg limit. See detailed comments in Section 2 above.

Q 14 – *What percentage of sludge will be affected by the new limits on pathogens and will receive further treatment? What is the preferred treatment? Please specify the costs of this treatment if possible.*

The introduction of Option 3 will lead to a figure as high as 70% of sludge that would not be compliant with the proposed standard and therefore require additional treatment. The additional treatment is likely to be advanced digestion, probably thermophilic anaerobic stabilisation and possibly some thermal drying.

Q 15 – *What are the costs of HACCP? Please provide estimates of the number of staff or time required per installation if feasible.*

It is estimated that HACCP monitoring is in the region of £5,000-8000 per treatment site/year

Q 16 – *What do you expect the % of total agricultural land to be failing to comply on the new limits of heavy metals in soil set by Option 3? Would production be maintained through the application of fertiliser?*

We believe that the WRc estimate of land not available for biosolids applications due to PTE's in the soil, in particular chromium, mercury and zinc levels would be the critical elements. . It is probable that production would be maintained through the application of commercial fertilisers.

Q 17 – *What % of total agricultural land do you expect will be affected by the ban? What are the costs implications?*

If biosolids are applied to fruit or vegetable crops it is only a minimal amount and therefore the ban is unlikely to have any significant financial impact.

In respect of Section 4.2.7, we are very concerned about proposed ban on use of grassland and salad crops. In some areas in the UK around 20% of biosolids application is through these routes. Some 78% available landbank in these some areas is grassland (unlike other largely arable areas in the UK). A ban would have a severe affect in this area.

Q 18 – *What are the costs implications of these new monitoring requirements? Please explain (e.g. number of additional FTE, administrative costs, etc.)*

It is likely that the sampling requirements will increased staffing levels, with sampling and administration adding a probable 2 FTE posts (per Company resulting in up to 30 additional posts in the UK). The analysis is likely to be contracted out to a service provider and as such will not impact on FTE's to the Water Companies but increase current opex costs by up to 10 times.

Q 19 – *Do you agree with our assessment? If not, please expand. Feel free to add comments on the benefits and costs from Option 3*

We feel that the assessment is reasonable.

Q 20 - *Do you have any comments on the Options as proposed, in particular in terms of their expected impacts?*

Option 1 remains viable given that biosolids recycling to agriculture under the current regulatory framework has a proven record as a low risk environmental activity that does pose a risk to public health. The introduction of HACCP regulations would be a logical step however and this should perhaps be evaluated before the existing Regulations are amended or the tighter options introduced. An alternative would be to introduce HACCP Regulations separately.

Options 2 updating of the current Regulations would be useful if it led to an increase in consumer/retail confidence.

Option 3 will significantly increase costs to the MS without any proven material benefit.

Option 4 should not be considered as a viable proposition based on risk analyses and given the overall benefits of sludge recycling.

Option 5 should not be considered as a viable proposition as Regulations prevent poor practice and assists in engendering confidence.

Q 21: *Do you agree with our cost data and assumption presented in this report and the overall estimates presented in Table 51? Please expand, providing us with your data and estimates if possible.*

The costs against the total ban are an underestimate. For example based upon the most recent data within the industry, a capital cost of £2500/tds is estimated for the construction of incineration plant.

Applying this data to the construction of incineration plant with a capacity of 1,050,000 tds (currently applied to the landbank) gives an immediate total capital costs of the order of £2.6bn.

Comments on Annex 3: GHG Emissions

We note that GHG emissions don't mention the offset from CHP power generation and avoided fertiliser application (and manufacture). We suggest this is corrected.

The emissions from sludge routes seem to be based on a lot of assumptions that are not adequately developed or justified. We think this area needs more work.

Option 2 and 3 include a stabilisation requirement to reduce methane emissions. The parameters appear to have been taken directly from US EPA 503 Rule (US EPA, 1993) and have been interpreted out of context. The VS reduction or SOUR parameters are designed for vector attraction reduction, and are not intended for methane emission control. Stabilisation criteria such as this will not deal with the main sources of methane emissions from sludge, which arise from secondary storage of stabilised product in open tanks following mesophilic anaerobic digestion. Thus sludge may meet the stabilisation requirement, but could still be a source of methane emission. The recommended approach to cut methane emissions is to collect and flare the gas by covering secondary digestion tanks (Barber, 2009).

Carbon Footprint and Environmental Impacts

The impact assessment claims to have included CO_2 emissions. This is a critical aspect of the assessment. However, the detail on CO_2 emissions is embedded in the analysis and it is difficult to assess the significance of this or any of the other components within the impact assessment for the different options. Agricultural recycling coupled with anaerobic digestion has amongst the lowest carbon footprints compared to other sludge management options (provided biogas emissions from secondary digestion are collected and flared). It is unclear how this has been addressed in the impact assessment. Incineration on the other hand has the poorest carbon footprint because fossil fuels and electrical power are consumed in the process to operate the plant and maintain sludge combustion. The impact assessment should more clearly indicate the specific impacts on the carbon footprint of restricting or preventing agricultural recycling of sludge. The current situation in terms of sludge management in different countries is used as the baseline for the impact assessment calculations. Thus, under Option 4 for instance, which examines the impact of a total ban on agricultural recycling, there are no costs attributed to sludge management for The Netherlands, presumably because agricultural use is not practiced and incineration with ash disposal in landfill is the main outlet for sludge. The impact assessment should not ignore the potentially significant environmental costs for instance in terms of CO_2 emissions of the current practices, to give a global picture of the environmental and economic costs of the alternative management routes compared to agricultural use.
Recovery and recycling of phosphorus (P) will become an increasing priority in the next 10 - 20 years as global reserves of this finite resource are depleted. Sewage sludge is a rich source of P and recycling this resource to land to complete nutrient cycles has been identified as an important priority area of focus for Government policy (Green Alliance, 2007). This important issue will become increasingly important and a central feature for sustainable development in the near future, but does not appear to have been addressed in the impact assessment. This issue alone will become justification for recycling sewage sludge to agricultural land and should therefore be addressed in the environmental, social and economic elements of the impact

assessment. It is critical that 'near horizon' issues are considered to ensure that the revised Directive will be relevant under future circumstances and conditions.

Comments on Annex 4: Monetisation of Environmental Impacts

We comment as follows:

Table 1 suggests that landfills have the ability to leach to soil and/or water, as 'modern' landfills are lined and controlled.

Table 2, we are surprised to see the 'value' of CH_4 the same as CO_2 as it is 20x more harmful.

Table 3, should the table match Table 2 and include Emissions from transport? Also similar comments to operation of a 'modern' landfill

Table 5, should the table match Table 2 and include Emissions from transport?

Table 6 , we are surprised to see no 'value' against CH_4 as the industry (through the workbook) suggests significant levels of CH_4 associated with biosolids application to land.

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