KEY GUIDELINE REQUIREMENTS FOR BIOSOLIDS LAND APPLICATION : THE BASIS AND PRACTICAL IMPLICATIONS

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1.0 INTRODUCTION

Although the predominant approach to sewage sludge management in Victoria has historically involved a progressively increasing stockpile, the Government and the water industry has acknowledged that this is not a sustainable management option. Not only is ongoing stockpiling contrary to obligations under the waste management hierarchy (reuse, recycling before disposal), it is simply a deferment of the costs associated with management since stockpile areas will ultimately need rehabilitation upon plant closure.

There is an ever-increasing amount of information that demonstrates the significant improvements in agricultural productivity that can result from biosolids land application. The constituents of biosolids such as nutrients (nitrogen and phosphorous), micronutrients and trace metals, organic matter and moisture have been shown to result in significant increases in crop yields, particularly in the more weathered soils widely found in Australian agriculture.

Although the reuse of biosolids through land application can have undoubted benefits, inappropriate management of reuse programs has the potential to present health and environmental risks from pathogenic organisms and chemical contamination. Given the benefits of reuse, the challenge in establishing guideline requirements is to ensure that potential risks are appropriately managed, but being mindful that unnecessarily conservative controls will progressively reduce access to the biosolids resource.

The recognition that ongoing stockpiling is not a sustainable management approach, lead to the formation of a water industry-government working group coordinated by the Department of Natural Resources and Environment (NRE) to develop a strategic, triple bottom line based approach for improving management practices. One component of this strategic framework will be a requirement from EPA Victoria that all water businesses undertake risk assessments of current sludge management practices and develop more sustainable sludge management plans. This is expected to result in an increased focus on sludge treatment and handling to enable beneficial reuse in accordance with the regulatory requirements in the draft Victorian biosolids management guidelines. This is clearly an issue of relevance to treatment plant operators and therefore this paper is structured to give operators an understanding of the basis for key aspects of the guideline's requirements.

Victoria is not unique in establishing regulatory oversight of biosolids land application. In Australia, most states have a guideline with the most established being the 1997 NSW EPA publication *Use and Disposal of Biosolids Products*. The National guideline under the National Water Quality Management Strategy has recently entered a public consultation phase. Internationally, there are regulations in the United States (US) (the so-called 503 rule) and a European Commission (EC) directive that apply within the relevant jurisdictions. However, it is important to note that in the US and the EC, a second and sometimes third level of regulatory/guideline requirements are imposed by individual states (US) and Member States (EC). In this paper, some key differences between the Victorian and the international regulatory oversight programs are highlighted.

2.0 MANAGEMENT OF CONTAMINANTS

The framework for managing contaminant risks in the draft Victorian guideline involves a three-contaminant grade system. The highest quality grade (C1) has sufficiently low levels of contaminants that no specific regulatory controls are placed on the product to control contaminant risks ie from a contaminant perspective, the product could be sold bagged in a supermarket.

The philosophy driving the C1 numerical limits is based on protection of a scenario where the biosolids product is land applied to the extent it becomes a topsoil replacement. Therefore, the receiving soil contaminant limits become the C1 biosolids limits, with value adopted representing the most stringent receiving soil limit for protection of the environment, human health (nominally a child ingesting biosolids amended soil) and agricultural produce.

The environmental and human health values are adopted directly from the National Environment Protection Measure (*Assessment of Site Contamination*) contaminated site trigger values. Limits for protection of agricultural produce were derived via scientific advice and literature reviews of plant and livestock uptake rates, targeted for protection of food standards. Copper and arsenic are examples of compounds with limits based respectively on ecosystem protection and human health, while cadmium and the organochlorine pesticides are relatively prominent examples of contaminants with limits based on protection of agricultural produce. Cadmium is particularly relevant since concerns with its plant uptake have resulted in progressive reductions in the limit for cadmium down to 1 mg/kg soil.

Biosolids that have contaminant levels that exceed the C1 limit, but are within a ceiling limit are classified as C2 biosolids. These biosolids are allowed to be used for all end-users (except as a bagged product for unrestricted public sale) however, all application programs are required to have an Environment Improvement Plan (EIP) to demonstrate appropriate management controls are in place. Biosolids that exceed any of the ceiling limits are not considered suitable for land application without a statutory approval via EPA works approval and potentially an application site EPA licence. The ceiling limits are based on a combination of good practice (ie levels that if exceeded, indicate significant difficulties with the management of sewer inputs) and protection of receiving soil limits following a nominal multiple application program.

The EC and the United States management of biosolids contaminants take quite different philosophical and structural approaches. The United States framework is relatively similar to that typically found in Australia, with biosolids management reflecting the concentrations of heavy metals in the biosolids. Similarly to Australia, biosolids achieving the highest contaminant grade (and highest pathogen grade) do not have management requirements. The regulations also specify a ceiling concentration above which biosolids are not permitted to be land applied.

One important difference between the US and the Australian approach is that rather than rely on soil limit concentrations to manage applications, the US includes an annual loading limit for the regulated metals. However, the most fundamental difference between Australian and the US is in regard to the actual limits imposed, with Australia being significantly more stringent than the United States. As an example the C1 limit in Victoria for Cadmium is 1 mg/kg biosolids, while the US 503 imposes a limit of 39 mg/kg.

Likewise, the Victorian C1 limit for copper is 100 mg/kg biosolids, while the US limit is 1500 mg/kg. These differences also exist for the ceiling contaminant limits but are not as marked as for the 'C1' limits eg the Copper ceiling limit in Victoria is 2500 mg/kg, the US is 4300 mg/kg soil. These differences partially reflect the risk assessment methodology the US EPA adopted to derive limits (ie derived based on achieving risk assessment derived soil limits from defined application scenarios) and partially reflect concerns regarding the more highly weathered and acidic soils (hence increased metal impacts) that can be found in Australian agriculture.

The EC directive relevant to sewage sludge establishes only one biosolids concentration limit for each heavy metal, namely a ceiling limit above which land application is not permitted. The ceiling limits are relatively comparable to the draft Victorian guideline. An 'unrestricted' contaminant grade is not described. To ensure land management is managed appropriately, the EC directive specifies annual loading rates to land for the key metals and also soil limits that are partially based on soil pH. The EC directive soil limits are reasonably comparable to the draft Victorian soil limits, with the EC limit expressed as 1-3 mg/kg for Cadmium and 50-140 mg/kg for Copper, as compared to the draft Victorian values of 1 mg/kg and 100 mg/kg respectively.

However, although the Victorian guideline values are currently comparable to the EC, working drafts of a revised directive have proposed significantly reduced soil and ceiling limits for biosolids land application. The working paper proposes ultimate Cd ceiling limits of 2 mg/kg biosolids and Cu limits of 600 mg/kg, levels that, certainly for cadmium, the majority of Victorian sludges would not achieve. However, when looking at the working draft of the EC document, it is important to acknowledge two issues 1) the revised limits are not supported by scientific data or demonstrated risks but reflect policy drivers from selected member states to establish limits based on nominal 'background' metal levels and 2) the proposed limits are in a 'working paper' rather than a formal draft and significant revisions are expected before release. The revision of the directive is also not a priority issue and currently is on hold. It should also be noted that the various member states could impose more stringent requirements than the EC directive.

Where Victoria and the Australian states differ from the US 503 rule and the redrafted EC directive to the greatest extent is with regard to organic contaminants. The draft Victorian guideline (as with NSW) establishes limits for organochlorine pesticides and polychlorinated biphenyls, based on protection of livestock grazing. The current NSW limits for unrestricted grade biosolids for most OC pesticides are based on 0.02 mg/kg biosolids, the Victorian EPA looking to establish a slightly higher limit of 0.05 mg/kg. The slight increase reflecting that the OC pesticides are progressively becoming a reduced issues in biosolids to the extent that contaminants such as cadmium or copper would need to be significantly overloaded to soils before the levels of concern were reached in soils, 0.05 as a biosolids limit continues to provide a margin of safety from unacceptable accumulation in produce and from a practical perspective, 0.02 mg/kg is on (or below) the limit of detection for the majority of Australian analytical laboratories. In comparison to the Australian approach, the EC and US do not regulate organochlorine pesticides in biosolids.

The US explored the risks associated with organic contaminants in the so-called Round One and Round Two assessments. Together, the assessments examined a wide range of organic contaminants and concluded that only one group, compounds with dioxin-like activity, posed risks that required regulatory control.

The US EPA has recently completed a review of the assessment that led to the recommendations for regulating dioxin compounds and continues to suggest a limit value of 300 ppt based on toxic equivalency, but has stated that even this value presents an insignificant risk. Although the working draft of the EC directive proposes a limit for dioxin like compounds of 100 ppt, there are not currently plans to regulate dioxin like compounds in Victoria, due to the relatively low levels (eg 10-20 ppt) that have been shown in the sludges.

Of possibly more direct relevance to Victorian management of biosolids is the EC working papers proposal for concentration limits based on organics such as Linear alkyl benzyl sulfonates and nonyl phenols. The general conclusions in reviews to date have been that although these contaminants can be found in relatively high concentrations, a combination of rapid degradation in soils, low mobility (hence lack of movement to waterways) lack of plant uptake, metabolism in higher organisms and resultant soil levels being below levels that impact on soil ecosystems means that risks of environmental or public health impacts are minimal. It is not expected that limits for these compounds will need to be regulated in Victoria.

In Victoria, the practical impact of the proposed limits is that the majority of biosolids products (without addition of other feed-stocks such as lime or via composting) will have levels of Cu, Zinc and Cadmium that exceed the C1 limit by approximately 3-5 times. Although these levels don't constrain the actual land use associated with the application program, the programs will need to be conducted in accordance with an endorsed EIP.

The EIP will describe a range of features of site management, including: background soil contaminant concentrations, soil contaminant loading rates and other application issues eg management of soil pH. Although an individual EIP can be relatively extensive, the process does not need to be a significant hurdle for establishing a land application program, with the management controls reflecting the nature of the scheme eg infrequent repeat applications versus regular repeat applications. There is also the ability to develop generic or regional EIPs, with further endorsement only required where individual schemes present unusual properties.

A second practical implication of the contaminant limits is on biosolids monitoring requirements. It is expected that STPs will undertake an initial analysis program to characterise the contaminant levels in the sludge. The C1 limits can be used as a mechanism to identify those contaminants that are at sufficiently low concentrations as to require only ongoing spot monitoring to confirm the continuation of low levels. Based on data to date, it is expected that water businesses will need to pay relatively more attention to copper, zinc and cadmium compared to the other contaminants.

3.0 MANAGEMENT OF PATHOGENS

The Draft Victorian guideline describes three classes of biosolids based on pathogen treatment levels. The minimum treatment level (T2) for land application is mesophilic anaerobic or aerobic digestion to achieve E.coli levels of less than $2*10^6$/g. Although the digestion process can result in significant reductions in some pathogens (eg 6 log reduction in poliovirus), the process is less effective for other pathogen groups such as *Campylobacter jejuni*, potentially having minimal impact on numbers. Therefore, this treated sludge is allowed for only a restricted range of uses, such as commercial non-food crops, crops subject to processing, sheep grazing or forestry.

These controls are also coupled with withholding periods for harvesting and other management controls. The T2 limits proposed in the Victorian guideline are consistent with the NSW guidelines and are also relatively similar to the treatment standards under the US 503 rule and in the draft directives. The permitted uses are also similar to the EC requirements, although the EC working draft proposes more restrictive controls on grazing schemes.

At the other end of the spectrum of biosolids treatment, the T1 pathogen treatment processes represent processes that can achieve significant log reductions across a wide variety of pathogenic organisms, reducing levels to below detection limits. Achieving a T1 product requires the use of a prescribed treatment processes eg composting or lime stabilisation coupled with minimum process requirements (typically based on temperature/time profiles) and minimum microbiological criteria of <100 E.coli/g and < 1 Salmonella /50 grams of final product. Technologies other than those prescribed can be used to produce a T1 product, however, verification of the removal of virus and helminths needs to be confirmed through direct testing. A T1 product is considered suitable for unrestricted uses eg bagged sale for public use.

The intermediate pathogen treatment grade T1B is based on treatment technologies that produce a high quality product from a pathogen perspective, however, the process is not believed sufficient to achieve an 'unrestricted grade' classification. Therefore, some restrictions on use are imposed. The draft Victorian requirements for T1 biosolids are consistent with the requirements adopted in NSW's, however, there are some significant differences with the working draft of the EC directive and the US 503 rule. Although the 503 rule prescribes similar treatment processes, the draft Victorian guideline is somewhat more stringent compared to the general microbiological criteria in the US of <1000 Faecal coliforms/4g or <3 Salmonella/4g.

The proposed Victorian validation process for 'new' technologies is more closely aligned with regard to the US approach, which is also based on demonstrated virus and helminth removal. Importantly, the US has an established process for assessing new technologies, which involves verification of 3-log virus removal and 2 log helminth reductions. However, it is somewhat ironic that a key difficulty with demonstrating the necessary log reductions is that the pathogen concentrations in the 'raw' sludge are so low that the necessary reductions can't be seen before the levels are reduced below detection limits.

Specific technologies that have recently been validated as being capable of producing a 'T1' biosolids product include a two stage Autothermal Thermophilic Aerobic Digestion process. The US EPA also provides generic provisions to achieve an unrestricted grade product (from a pathogen perspective) via batch monitoring of virus and helminths to demonstrate compliance with the pathogen objectives. However, this later approach is the least favoured of the various options.

The redrafts of the EC legislation for sewage sludge management have borrowed heavily from the 'safe sludge matrix' recently developed in the UK. This matrix describes treatment processes (termed enhanced treatments) that are similar to those described in the draft Victorian guideline, coupled with microbiological criteria that are also relatively similar to the Victorian approach. However, a key difference between the UK and the US approach, is that UK requires demonstration of a 6 log Salmonella reduction, while the US includes Salmonella limits, but focuses on log reductions of Viruses and helminths.

In practice, the Victorian and NSW approach borrows from both regulatory approaches, through the use of Salmonella criteria but a requirement for showing the helminth and virus reductions for new technologies. As with the US, a challenge in the UK is actually having sufficient levels of Salmonella in 'raw' sludge to show the required log reductions.

4.0 SUMMARY

From a treatment plant operational perspective, controls on contaminants and pathogens are key requirements that need to be considered when establishing a biosolids treatment/management program.

This paper provides an overview of the background behind these requirements and the practical implications of the requirements.

The paper also contrasts the draft Victorian requirements with the provisions that apply more broadly in Australia, the US and the EC. However, although the contaminant and pathogen requirements are important considerations, an important final message is that successful land application program will include a range of additional activities, including community consultation and product marketing, management of sewer contaminant inputs and adoption of stabilisation processes to avoid attraction or vectors and the generation of offensive odours.