Australian and New Zealand
Biosolids Partnership

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Assessment of Emergent Contaminants in Biosolids
Executive Summary

December 2017
EXECUTIVE SUMMARY

Background

Sewage sludge is a by-product of treating wastewater. Once the sewage sludge is sufficiently treated and complies with the relevant State or National guidelines, it is termed ‘biosolids’ and has a wide range of beneficial uses, including use in agricultural applications.

Over the last 25 years Australia has successfully and safely developed a sustainable beneficial use program. Nearly 90% of the biosolids produced in Australia are now used as a fertiliser in agriculture or for land rehabilitation (Darvodelsky, 2015). Appropriate biosolids guidelines help to protect the receiving environment.

The water industry is continuously monitoring potential emerging risks from new compounds to ensure biosolids use is safe. This review focusses on two compounds which have received significant attention around the world. Commonly called PFOS and PFOA these acronyms are short for perfluorooctane sulphonate and perfluorooctanoic acid.

PFOS and PFOA have been commonly used in a range of common household products and specialty applications, including in the manufacture of non-stick cookware; fabric, furniture and carpet stain protection applications; food packaging; some industrial processes; and in some types of fire-fighting foam. For example, PFOS was the key ingredient in Scotchgard, a fabric protector until it was phased out in 2000 (3m, 2017).

There is no consistent evidence that exposure to PFOS and PFOA causes adverse human health effects (NSW EPA, 2017). However based on the evidence from animal studies and the persistence of these chemicals in the environment potential health effects cannot be ruled out. It is therefore important to understand the level of PFOS/PFOA in biosolids.

National biosolids data

PFOS and PFOA are not presently regulated compounds in biosolids in Australia. As a result there are no recommended safe limits for these compounds in biosolids. None-the-less many utilities in the water industry monitor a wide range of unregulated compounds as a precautionary principal. During 2017, these utilities were asked to share with the ANZBP their
data on PFOS and PFOA to be used as the basis for this review. A number of major utilities provided data from over 100 samples from 13 different sewage treatment plants around Australia.

The overall results of the sampling and analysis program are shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>PFOS</th>
<th>PFOA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Units</strong></td>
<td>mg/kg</td>
<td>mg/kg</td>
</tr>
<tr>
<td><strong>Number of plants</strong></td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td><strong>Number of samples</strong></td>
<td>109</td>
<td>98</td>
</tr>
<tr>
<td><strong>Not detected</strong></td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>0.021</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Standard deviation</strong></td>
<td>0.062</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>Maximum value</strong></td>
<td>0.386</td>
<td>0.050</td>
</tr>
<tr>
<td><strong>Minimum value</strong></td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 1 - Summary of PFOS/PFOA levels measured in Australian biosolids

Of the samples, 17 each did not detect PFOS or PFOA in the biosolids. PFOA was generally found in lower concentrations on most sites. PFOS was found at higher concentrations at two sites with known local PFOS contamination issues.

The results indicate that PFOS and PFOA are generally present in biosolids at detectable levels in Australia.
**Safe levels**

NSW EPA (2017) notes that there is no consistent evidence that exposure to PFOS and PFOA causes adverse health effects in humans. As a result of concerns over potential risks from these compounds the Department has set guidelines for safe levels as set out in the table below. These recommended safe levels form the basis of the analysis in this review.

<table>
<thead>
<tr>
<th>Toxicity Reference Value</th>
<th>PFOS/PFHxS (µg/kg/d)</th>
<th>PFOA (µg/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerable Daily Intake</td>
<td>0.02</td>
<td>0.16</td>
</tr>
<tr>
<td>Drinking Water Quality</td>
<td>0.07</td>
<td>0.56</td>
</tr>
<tr>
<td>Guideline (µg/L)</td>
<td>0.7</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table 2 - Guideline values from Australian Government Department of Health (2017)

**Methodology**

Analysis of the risk posed by PFOS and PFOA in biosolids depends on how a person might be exposed to these compounds, commonly called ‘exposure pathways’. For example, direct ingestion of biosolids is an obvious pathway for people who work closely with biosolids, however this is typically mitigated as workers take precautions to avoid eating them.

In Australia, the National Environment Protection (Assessment of Contaminated Sites) Measure (NEPC, 1999), or NEPM sets out a clear method for assessing emerging contaminants (CRC CARE, 2014). This method was recently updated by the Federal Environmental Health Standing Committee (enHealth) and is used in this review as the basis for determining safe levels of PFOS and PFOA in biosolids.
This review examines two key exposure pathways:

- Direct ingestion of biosolids;
- Direct ingestion of soil in which biosolids have been incorporated.

It is considered in the context of Australian biosolids guidelines and use that these two exposure pathways are likely the highest risk pathways. It should be noted however that insufficient information on factors such as crop and animal uptake rates, currently exists to accurately assess other exposure pathways.

On the basis of

a. these exposure pathways,

b. NSW Department of Health recommended daily safe intake of biosolids and

c. the NEPM/enHealth methodology;

this review calculates safe levels of PFOS and PFOA in biosolids suitable for unrestricted use and for application to agricultural land.

The key steps used to determine safe limits in biosolids are:

1. Use the tolerable daily intake levels of PFOS and PFOA set by NSW Department of Health;

2. Use the NEPM method calculate the health investigation level for PFOS/PFOA in biosolids alone (direct ingestion);

3. Assume typical biosolids application rate, repeat application frequency and incorporation depth for biosolids applied to land;

4. Calculate allowable safe levels of PFOS/PFOA in biosolids applied to agricultural land.

It is notable that the NEPM methodology assumes that any single source of PFOS/PFOA (in this case biosolids) contributes a maximum of 10% of the total intake by any person. This assumption may be considered conservative but recognises that an exposed individual may also consume PFOS/PFOA from other sources such as water, food and cookware (NSW EPA, 2017).
**Results**

The results of the NEPM analysis to calculate recommended values for PFOS and PFOA in biosolids which are suitable and safe for unrestricted uses, such as soil replacement, are shown in the table below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Child</th>
<th>PFOA</th>
<th>Adult</th>
<th>PFOA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toxicity Reference Value</strong></td>
<td>mg/kg/d</td>
<td>0.00002</td>
<td>0.00016</td>
<td>0.00002</td>
<td>0.00016</td>
</tr>
<tr>
<td><strong>Ingestion Rate</strong></td>
<td>mg/d</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>Health Investigation Level</strong></td>
<td>mg/kg</td>
<td>0.3</td>
<td>2.4</td>
<td>2.8</td>
<td>22.4</td>
</tr>
<tr>
<td><strong>Mean value measured in biosolids</strong></td>
<td>mg/kg</td>
<td>0.021</td>
<td>0.003</td>
<td>0.021</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Maximum value measured in biosolids</strong></td>
<td>mg/kg</td>
<td>0.386</td>
<td>0.05</td>
<td>0.386</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 3 - Recommended values for PFOS and PFOA for unrestricted use biosolids

The table shows that the limiting Health Investigation Level value for PFOS is 0.3 mg/kg for child exposure. At this level a child eating 100 mg of biosolids per day would ingest 10% of the maximum daily amount of PFOS recommended by the NSW Department of Health. It is therefore suggested that this level is an appropriate level for a Grade A or C1 biosolids classification: biosolids suitable for unrestricted use.

In terms of the treatment plants sampled as part of this review the average level of PFOS measured in biosolids was around 7% of Health Investigation Level for children. The maximum level of PFOS measured at all plants was lower than the suggested Grade A or C1 level at all but two sites with a known history of PFOS contamination.
Table 3 shows that the limiting Health Investigation Level value for PFOA is 2.4 mg/kg for child exposure. At this level a child eating 100 mg of biosolids per day would ingest 10% of the maximum daily amount of PFOS recommended by the NSW Department of Health.

In terms of the treatment plants sampled as part of this review the average level of PFOA measured in biosolids was around 0.1% of the Health Investigation Level. The maximum level of PFOA measured was lower than the suggested Grade A or C1 level at all sites with the maximum recorded value approximately one fiftieth of the recommended health investigation level. This data suggests there is a low risk from PFOA in biosolids.

The results of the additional calculations to determine safe levels of PFOS and PFOA in biosolids applied to land are based on soil density of 1.4 tonnes per cubic metre, 100 mm depth of incorporation when ploughing biosolids into the soil and an assumed application rate of 20 tonnes of dry biosolids per hectare every five years. These assumptions give a dilution ratio of on part biosolids for 70 parts soil.

The assumptions above and the NEPM analysis were used to calculate recommended values for PFOS and PFOA in biosolids which are suitable and safe for restricted use such as application to agricultural land. The values are shown in the table below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>PFOS</th>
<th>PFOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Investigation Level</td>
<td>mg/kg</td>
<td>0.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Biosolids limit (agricultural application)</td>
<td>mg/kg</td>
<td>4.2</td>
<td>33.6</td>
</tr>
<tr>
<td>Mean value measured in biosolids</td>
<td>mg/kg</td>
<td>0.021</td>
<td>0.003</td>
</tr>
<tr>
<td>Maximum value measured in biosolids</td>
<td>mg/kg</td>
<td>0.386</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 4 - Recommended Values for PFOS and PFOA in biosolids for use on agricultural land

In terms of the treatment plants sampled as part of this review the average level of PFOS measured in biosolids was around 0.5% of the calculated safe biosolids level for agricultural use. The maximum level of PFOS measured was lower than the suggested safe level at all sites by a factor of about 11 including two sites with a known history of PFOS contamination.
In terms of the treatment plants sampled as part of this review the average level of PFOA measured in biosolids was around four orders of magnitude lower than the calculated safe biosolids level for agricultural use. The maximum level of PFOA measured was lower than the suggested safe level at all sites with the maximum recorded value approximately 0.1% of the recommended health investigation level.

It should be noted that the biosolids application assumptions are conservative. In discussion with major biosolids land application operators, typical incorporation depths are 150-400 mm and maximum repeat application rates are 10-15 tonnes per hectare every 3-5 years. This gives best practice dilution rates a factor of 3-4 times higher than presented in this review.

**Conclusions**

The conclusions of this review and analysis are:

- PFOS and PFOA occur in biosolids at detectable levels. PFOS and PFOA were detected in 92 out of 109 samples from 13 different Australian sewage treatment plants;
- PFOS was detected above the NEPM Health Investigation Level at two sites (3 out of 109 samples) with known PFOS contamination issues. Average values of PFOS measured in Australian biosolids were around 7% of the calculated HIL;
- The data shows that PFOS can occur at sites with contamination issues and this highlights the need for further investigation and monitoring of PFOS in Australian biosolids;
- The levels of PFOA detected in this review are significantly lower than Health Investigation Levels suggested by the NSW Department of Health. This data suggests that there is little need to monitor PFOA in biosolids with the maximum recorded value of PFOA being around 2% of calculated Health Investigation Level;
Recommendations

- It is recommended that limits for PFOS in biosolids be adopted as set out in the table below and reviewed regularly on the basis of further data on the levels of PFOS in biosolids.

<table>
<thead>
<tr>
<th>Allowable use</th>
<th>Grading terminology</th>
<th>PFOS limit (mg/kg)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestricted use</td>
<td>A², C1³</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>C², C2³, B⁴</td>
<td>4.2</td>
<td></td>
</tr>
</tbody>
</table>

Table 5 - Recommended PFOS limits in biosolids

1) mg per kg of dry weight of biosolids
2) NSW, QLD, ACT, SA guideline terminology (also TAS for Grade A)
3) National, VIC, WA guideline terminology
4) TAS guideline terminology

- It is recommended that PFOS is routinely measured in biosolids.
- It is recommended that PFOA is not routinely measured in biosolids.
- It is recommended that other exposure pathways for PFOS, PFOA and other PFAS be investigated as and when the necessary information becomes available.
- It is recommended that sites with a known history of PFOS and/or PFOA contamination should monitor these compounds on a case by case basis.
References


