Land Application of Biosolids – Managing Nitrogen

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Irrigation of Biosolids

Biosolids are a byproduct of biological wastewater treatment plants, consisting predominantly of bacteria and other micro-organisms that accumulate in the wastewater treatment plant as a result of breakdown of contaminants in the wastewater.

To maintain the treatment efficiency of the plant it is necessary to periodically remove the biosolids from the plant, with various methods being used for disposal, from landfilling to pasture irrigation.

For lagoon based wastewater treatment plants, irrigation to land offers benefits over other alternative disposal methods as it provides for reuse of the biosolids as a "fertilizer" while minimising dewatering and disposal costs.

Regional authorities frequently limit the rate of irrigation based on the total nitrogen loading rate, as is the practice with effluent irrigation. However, to limit biosolids application on this basis is restrictive as the bulk of the nitrogen is not immediately available for release.

Nitrogen Management

Nitrogen in effluent or biosolids can exist as either organic nitrogen, ammoniacal nitrogen or nitrate nitrogen. Organic nitrogen is not available for plant uptake and must first be mineralised by micro-organisms to ammoniacal nitrogen and then nitrified to nitrate nitrogen before it can be utilised for plant uptake (refer to Figure 1).

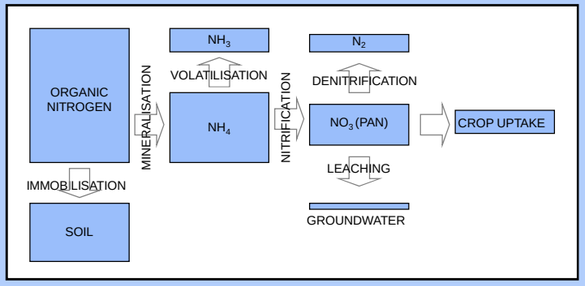

FIGURE 1: Fate of Nitrogen when Applied to Land

Nitrogen application to land is generally limited by the plant uptake capacity. The typical limit for grazed pasture is 200kg.N/ha/yr (MfE 2003).

However, this limit is based on nitrogen that is readily available for plant uptake (e.g. fertilizer and treated effluent). Nitrogen in biosolids has a high proportion of organic nitrogen, as detailed in Figure 2.

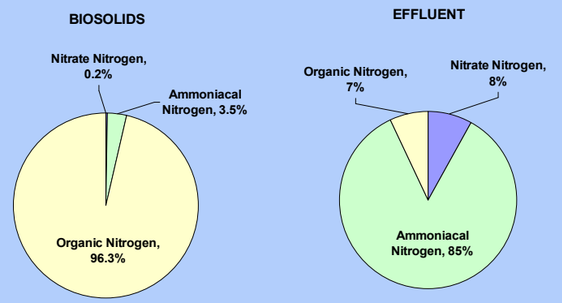

FIGURE 2: Typical Nitrogen Proportions in Biosolids and Treated Effluent

Because the organic nitrogen must first go through mineralisation, the released load of plant available nitrogen is reduced to only a fraction of the initial total nitrogen loading rate. Henry *et al* 1999 suggests that for aerobic biosolids the total mineralisation potential is limited to 30-50% of the initial organic nitrogen load.

While the nitrogen release rate is dependent on the following factors (Wang *et al* 2003):

- the source of the biosolids;
- the carbon to nitrogen (C:N) ratio;
- the soil type;
- the pH; and,
- the temperature.

Henry *et al* suggests the following mineralisation rates:

Years Following Application to land	Mineralisation Rate (% of remaining organic N)
1	5 - 12
2	2 - 6
3	1 - 2

Table 1. Estimated nitrogen mineralisation rates from biosolids for years following application.

Field Experience

Pattle Delamore Partners Limited was involved in a project to irrigate aerobic biosolids from a meatworks wastewater treatment plant to sheep and beef pasture.

Due to land area limitations, a heavier loading rate was required than would otherwise have been allowed by the regional authority based on their regional plan's nitrogen loading limits of 150 kg.N/ha/year.

Due to the impending urgency of the desludging activity, literature based mineralisation rates were utilised for establishing nitrogen release rates to plant available nitrogen.

A nitrogen balance model was developed to establish the allowable organic nitrogen loading rate, based on plant available nitrogen calculations (Henry *et al* 1999) taking into account nitrogen from previous biosolids application events.

FIGURE 3: Accumulated Biosolids in the Wastewater Treatment Lagoon

Because previous fertiliser and biosolids loading rates had varied between paddocks, the allowable biosolids loading rate was varied to maintain a uniform plant available nitrogen loading rate, allowing a total nitrogen loading rate of up to **735 kg.N/ha** as a one off irrigation event to maintain the PAN release rate below **150 kg.N/ha/year.**

The regional council was initially hesitant to accept this loading rate as at first appearances the requested nitrogen loading rate was far higher than the conventional nitrogen limit in their regional plan. Following significant consultation with the council, the requested loading rate was accepted but with strict operational conditions to prevent nuisance and runoff.

FIGURE 4: Pasture Irrigation Method

This approach was utilised for two other applications, involving two different regional councils. On both occasions the application rates were accepted, with one being operated under the existing effluent irrigation consent.

Future Investigations

For all three of these irrigation activities the resultant nitrogen release rates were not monitored, however, there was scope for installing lysimeters to assess for any release of plant available nitrogen below the root zone.

While this will not quantify the exact conversion rate or organic nitrogen to PAN, it will help identify any affects on the receiving environment and potentially strengthen the basis for future biosolids applications.

References

Ministry for the Environment, 2003. Guidelines for the Safe Application of Biosolids to Land in New Zealand, *P 41*

Henry, C., Sullivan, D., Rynk, R., Dorsey, K., Cogger, C. 1999. Managing Nitrogen from Biosolids. *Washington State Department of Ecology* and *Northwest Biosolids Management Association.*

Wang, H., Kimberley, M.O., Schlegelmilch, M. 2003. Biosolids-Derived Nitrogen Mineralization and Transformation in Forest Soils. *J. Environ Qual., 32: 1851-1856.*