Pathogen Monitoring in Land Treatment Systems

Biosolids application to land should attain the highest benefit from re-cycling of nutrients onto land whilst limiting environmental impacts on soil, water, air, crops, and safe guarding public health. Monitoring of the site is recommended to ensure that the application is optimal. In addition monitoring provides data for effective record keeping and historical knowledge that allows feedback enabling operators and managers to respond to problems soon after they develop, when they are most easily dealt with.

The range of pathogens that may be found in waste streams include bacteria, viruses, parasites (helminths/protozoa) and fungi. As pathogens can be difficult to monitor due to detection methods that may be expensive, not available or unreliable, especially for low numbers, monitoring of the indicator organism E. coli is recommended. A subset of pathogens may also be monitored depending on disease incidence. Frequency of monitoring is dependent on many variables including the pathogen loading of the wastes applied to the site, frequency of application and proximity to sensitive areas (Tables 1 and 2). Pathogen application of wastes to land should not significantly increase pathogen numbers above those already present in the environment.

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Table 1: Recommended suite of monitoring activities and sampling strategies.

Media monitored	Parameter or feature	Recommended frequency	Reasons for including/notes	Sampling strategy	Analytical method
Case-by-case basis taking into account treatment level and how product will be applied. Fortnightly to quarterly for effluent.	*E. coli*		Required in early system design to determine loadings of pathogens. Helps evaluate treatment plant performance, manage application and allows pro-active response to any potential application site failures	>1 sample per week for routine sampling of Grade A biosolids. Depends on the variability of the effluent.	Most Probable Number (MPN) technique Plaque assay for viruses, or presence absence PCR. Membrane filtration for bacteria in effluent (APHA, 2005).
Soil	E. coli	Monthly to quarterly for effluent, frequency will depend on: application method and frequency. For biosolids, before lifting of restricted access period.	To ensure no cumulative increase in pathogens at the site which would significantly affect use or mobilise off site.	No specific guidance: Topsoil samples of at least 30 to 40 cores taken across the sample area at 0-15cm. (DEC, 2012) or minimum of 10 samples/ha to a depth of 200mm (NZWWA, 2003)	Most Probable Number (MPN) technique (APHA, 2005).
Surface and groundwater	Consideration of type of waste. Biosolids: E. coli Effluent: E. coli, protozoa, Salmonella, and/or Campylobacter	Monthly to quarterly for effluent or case-by-case basis taking into account season, rainfall, soil saturation etc.	LTS performance evaluation and consent conditions. To ensure no movement of pathogens into near-by watercourse and aquifers and to minimise risks to any nearby aquaculture.	Grab samples for surface water. Groundwater sampled after purging well to obtain constant electrical conductivity	ColilertTM for E. coli or EPA method 1103.1, 1985 Membrane Filter Method for E. coli (APHA, 2005).
Air	E. coli, thermotolerant clostridia	No monitoring recommended unless the site is situated close to an urban area, then need for sampling should be based on potential for health impact.	No monitoring recommended unless the site is situated close to an urban area	Sampling times of 10 min - 1.5 hrs, at least one sampling site 300 m upwind and one 100 m downwind of the site (three replicates upwind, five downwind) (ASTM, 2001).	Impingers; (ASTM, 2001); impactors (Brandi et al., 2000)

Table 2: Factors to consider in pathogen monitoring.

Product	Comment
Type of product	Characteristics of the waste such as: biosolid or effluent; % solids; nutrient e.g. nitrogen; BOD content; dissolved constituents e.g. cations; potentially toxic elements e.g. heavy metals, will impact on pathogen loading and pathogen survival in the receiving environment.
Treatment/stabilisation of product	Primary: e.g. solids removal – screening and grit removal, sedimentation/clarification, flotation, pathogens associated with solid matter settle out (e.g. ova of animal parasites). Secondary: e.g. aerobic, anaerobic digestion, reductions in pathogen numbers on a time of exposure-dependant basis. Tertiary: e.g. wetlands, maturation ponds, disinfection – reductions on a time of treatment – dependant basis.
Application	
Intensity of waste application	Quantities applied and rates of application – survival of pathogens can be prolonged by heavy dressing/high application rates.
Type of application	Irrigation system: may form aerosols which could contain pathogens. Surface spreading: greater exposure to sub-optimal environmental factors such as UV and desiccation. High rates e.g. border dyke may cause rapid movement through soils. Injection near subsurface/ploughing-in: protection from UV but has the advantage of increasing exposure to competing soil organisms.
Receiving environment	
Weather conditions	Microbial movement in soils is dependant on the water saturation state, which is in turn influenced by rainfall intensity and duration. Microorganisms move rapidly under saturated conditions. There is increased pathogen survival in moist/wet conditions. Temperature: effects on pathogen die-off rates, survival generally longer in cooler climates, survival is prolonged in warm climates where re-growth may also occur. Sunlight: effects on pathogen die-off rate, increased die-off with high UV. Wind: may increase soil moisture losses (and therefore increase desiccation) and also effects on aerosol dispersal.
Soil type	Physical properties impact on rate of movement through soil (e.g. clays favour adsorption of microbes to soil particles). pH also impacts on survival, with decreased survival at low/high pH. (Also see over page)
Surface and ground-water	Proximity of surface watercourses and depth of aquifer: consideration of downstream use of watercourses (e.g. recreational water used for bathing or aquaculture); and level of treatment (e.g. is it drawn on directly as a source of drinking water).

Soils that have received wastes

Soil is a complicated medium and a habitat for many organisms. Many of the soil dwelling organisms can grow in the same media used to culture specific pathogens which can interfere with analytical results. For this reason it is not cost-effective to routinely analyse soil for protozoa, helminths, viruses and most bacteria.

However, the analysis of soil samples for the presence of E. coli is neither arduous nor expensive, and may provide useful information on pathogen die-off in the receiving soils. Decisions on frequency of monitoring should be made on a case-by-case basis depending on type of waste applied, application method and frequency of application. For example, at a Grade B biosolids application site monitoring could be carried out at the end of a restraint period (e.g. public access constraint after application of biosolids to forestland) in order to ensure that there has been no cumulative increase in microorganisms due to biosolids application.

Control samples (i.e. from an adjacent site that has not had any biosolids applied to it) should be taken before application and at the end of the restraint period to determine 'background' E. coli numbers as these may fluctuate naturally (with season), high background levels could also indicate input from feral animals, or from birds.

If numbers of E. coli are found to be 100 fold higher than background counts, decisions about further restricted access or land-use should be made on a case-by-case basis after consultation with the appropriate regulator.

Sources

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