Akaroa subsurface flow wetlands - disinfection performance

1.1 Overview

Under normal conditions, including summer holiday peak periods, the Akaroa WWTP will remove most of the larger micro-organism s in the wastewater, such as bacteria and protozoa (eg Giardia), and a significant proportion of viruses (predicted 3-4 log order reduction or 99.9- 99.99%). During significant wet weather events (on average occurring twice per year), bypassing of the membrane will occur. These screened bypassed flows will undergo UV disinfection (predicted 2-3 log order reduction of viruses), before discharge from the WWTP.

Constructed wetlands have been widely used over the past 25 years to treat wastewater from small communities due to their minimum power consumption and low maintenance costs. Studies (eg Green et al, 1997) show that wetland systems can provide substantial disinfection of micro-organisms. Inactivation of faecal bacteria and viruses in subsurface wetlands is achieved by a mix of physical and chemical processes (eg sedimentation, filtration and adsorption) and biological processes (eg predation). Zhang et al (2009) also suggested that natural extracts from hydrophytes might also play a role in disinfection (ie be toxic to micro-organisms).

A limited literature review has been undertaken to assess the disinfection performance of current/y-operating subsurface wetlands. The results of this review provide an indication of the likely performance of a similar system downstream of the Akaroa WWTP – ie before discharge via an "engineered pathway" to the shoreline. A summary of the results from overseas facilities is as follows:

1.2 Virus Reduction

Gersberg RM et al (1989) reported that wetlands are generally hostile to viruses and that reduction within the system is a function of HRT. Reporting the work of Santee et al in California, Gersberg noted a 99% removal of MS-2 bacteriophages in a demonstration scale 800m^2 bulrush bed after 5.5 days retention. These viruses were chosen for investigation as they are similar in size to enterovirus and more resistant to UV light, heat and other disinfection processes than most enteric viruses.

Vidales JA et al (2003) used tracer studies of the enteric bacteriophage PRD1 in a 6 year old gravel wetland. The results were similar to that reported by Gersberg.

Gerba CP et al (2013) concluded that a 95-99% reduction in viruses could be achieved with 5 day retention in a wetland if plants were present. Gerba noted that subsurface systems appear to have greater virus removal potential than surface flow wetlands.

1.3 Bacteria Reduction

The results of a study by Santee in California Reported by Gersberg, 1987) suggest a 99% removal of bacteria after 5.5 days retention.

Kadlec R H et al (1996) reported the results of three separate subsurface wetland investigations in the USA and concluded that faecal coliform reduction varied between 92.1- 99.9% with ~5 day retention. Vegetated wetlands were reported as more efficient than open ponds at removing pathogens.

Kadlec R H et al (2009) also addresses disinfection performance noting that for 1 day HRT, a log reduction of 0.5 is given for a specific sub-surface wetland trial. The log reduction improves to > 0.99 for a 3 day HRT.

Ruhmland S et al (2013) reported the results of studies at 3 subsurface flow wetlands following secondary treatment in Germany. Despite relatively low influent concentrations (ie 10^3 E. col/100mls), between 1.7 and 2.3 log reduction was achieved. The results were not affected by seasons or short-term overloading.

Sartori L et al (2015) studied the performance of a subsurface follows by a surface flow wetland in north-western Italy (constructed to treat wastewater from 150 persons) over a 4 year period (2008-12). The system receives Imhoff tank-treated wastewater. The subsurface wetland was filled with gravel containing the reed species, *Phragmites australis* and had an HRT of 3.7 days. The results of the study demonstrated good removal of bacteria (ie 98% in winter and >99% for E. coli in summer). The main disinfection performance was in the sub surface component.

1.4 Conclusions

For Akaroa wastewater, additional disinfection could be achieved at each point in the process train beyond the WWTP. This would include (for Options 1b and 2 a and b), within the storage pond and subsurface wetland/infiltration basin, as well as prior to final shoreline discharge (ie during seepage through beach gravels or infiltration gallery).

The results of several studies reported above suggest that with an appropriately-designed subsurface wetland (ie well-mixed, vegetated, with HRT of at least 3 days), between 90 - >99% (ie 1- >2 log order) reduction in both viruses and bacteria could be achieved. The results suggest the vegetated sub surface flow wetlands perform better than better than unvegetated or surface flow systems. Performance appears to be unaffected by seasonal conditions.

These international results (which would need to be confirmed in site-specific pilot trials), indicate that infrequent wet weather flows passing through a suitably sized and designed subsurface flow wetland may not require additional mechanical disinfection (ie apart from UV at the WWTP), before discharge through the engineered pathway.

It is also recommended that advice from NIWA (Chris Tanner) regarding pilot trials and design optimisation to maximise disinfection performance be obtained if subsurface wetlands are preferred.

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1.5 References

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