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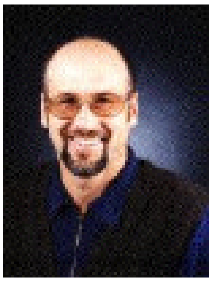
Status of Wastewater Treatment Wetlands in New Zealand



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URL NIWA: http://www.niwa.cri.nz
Sheet with 3 additional photos (ca. 90 kB)

Introduction

Constructed wetlands have been adopted enthusiastically by many New Zealand communities as a cost-effective means of secondary and tertiary wastewater treatment. Some small systems have now been in existence for nearly 30 years, while wetland treatment systems for larger towns and small cities are a more recent trend. A nation-wide review of constructed wetland sites undertaken by NIWA (National Institute of Water and Atmospheric Research) has shown a steady increase in constructed wetland use through the 1990's, with 80 constructed wetland treatment systems now in operation in New Zealand (population 3.8 million).

Photo 1: Surface-flow wetlands providing advanced secondary treatment at Kaiwaka after 2-stage waste stabilisation ponds. see also: Additional photos (ca. 90 kB)

Sixty-five constructed wetlands were identified treating domestic sewage only, while 5 treated domestic sewage combined with other waste types, 4 treated meat processing wastewaters, and 5 treated a variety of other types of wastewater (e.g. poultry, dog pound). Constructed wetlands treating storm water or farm dairy wastes were specifically excluded from this survey.

A distinct regional trend in the distribution of constructed wetlands was obvious (see Fig. 1). Numbers generally increase as you move northwards through the country, with nearly 40% of all constructed wetlands situated in Northland. This prevalence in Northland is likely to be associated with factors such as its warmer climate, prevalence of small, relatively poor communities, and early recognition and success with wetland treatment. Maori (local indigenous people) in many areas of Northland have accepted wetlands as a natural treatment option that more closely conforms to their cultural values relating to human waste treatment.

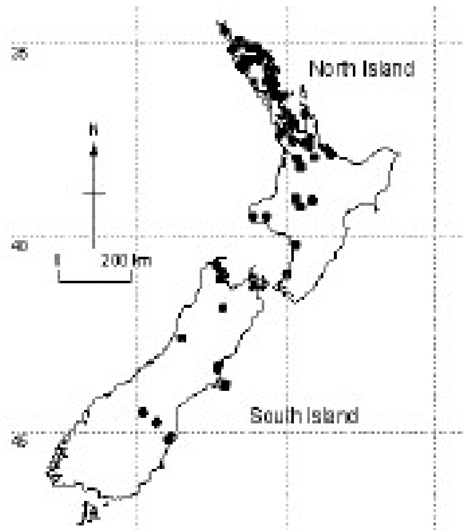


Fig. 1: Constructed wetland locations in New Zealand by 1999.

Categories of constructed wetlands

Constructed wetlands can be most simply subdivided into two main categories: surface-flow or subsurface-flow design. In surface-flow wetlands, the wastewater flows through a shallow "pond" planted with emergent plants such as bulrushes, reeds or sedges. In subsurface or "gravel-bed" designs, the wetland is filled with gravel or similar substrate, and the plants grow rooted in the gravel (although some of the subsurface wetlands had never been planted).

Constructed wetland designs have gradually developed as more information and practical experience has become available. Designs are often also adapted to take account of different site characteristics, treatment requirements and ancillary objectives such as provision of wildlife habitat. Surface-flow wetlands are increasingly being favoured because they are cheaper to construct and have higher wildlife habitat values.

Subsurface-flow wetlands, however, tend to be more effective at filtering out solids and removing BOD per unit land area. Because the wastewater remains below the surface in these systems, there is less possibility for human or wildlife contact with wastewaters and less potential for insect infestation. The use of hybrid designs incorporating both surface and subsurface-flow sections is now becoming more common.

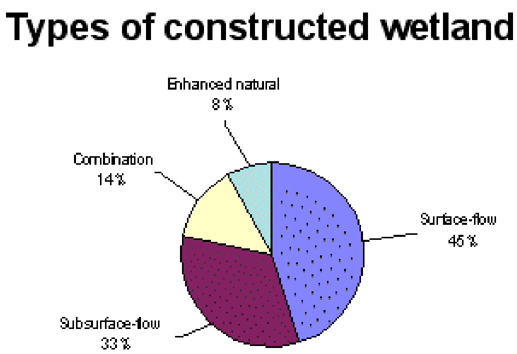
Results of the survey

Full details were not found for every constructed wetland, and for about 30% we were able to learn little more than they existed. However for those where details were available, some interesting trends were found. Surface-flow wetlands were the most common (45%, see Fig. 2), probably due to their cheaper construction costs. The average size of these wetlands was 2.2 ha, with an inflow volume of 3'384 m^3 per day.

Subsurface-flow designs represented 33% of the wetlands, and on average they were much smaller (0.4 ha with an inflow of 856 m3 per day), although their loading rate was higher than the surface-flow wetlands (0.21 m^3 m^{-2} vs. 0.15 m^3 m^{-2} respectively). Around 14% were described as hybrid wetlands, including both surface and subsurface-flow sections. The average size of these systems was only 0.1 ha with an inflow of 134 m3 per day (0.13 m^3 m^{-2}).

There was a fourth type of wetland identified in the survey, described as "enhanced" natural wetlands (8%). These tended to be larger (average 3.5 ha) and with relatively lower inflow volumes (242 m^3, or 0.007 m^3 m^{-2}) than all other types. Enhancements included construction of earthen embankments to modify flow paths, dispersion of the inflow to increase residence time in the wetland, and plantings to increase biodiversity.

Figure 2. Relative proportions of wetland types.



Nutrient enrichment of natural wetlands (particularly those that have developed under low nutrient conditions) through wastewater application will often cause changes in their plant and animal communities, reducing habitat and intrinsic values. As 85% of the original wetlands in New Zealand have already been lost through drainage, conservation of our remaining wetlands should be a high priority, and the use of vulnerable wetlands for wastewater treatment or polishing should be avoided.

The most common pre-treatment systems used before treatment wetlands were septic tanks and oxidation ponds, although for some sites the wetland operated as a final polishing system after activated sludge, trickling filter and UV treatments. The smallest wetland site was a subsurface-flow system of only 60 m^2, treating the waste from a community of about 20 people. The largest wetland was 20 ha in size and received 17'000 m^3 per day of treated wastewater from Whangarei, a town of 44'000 people.

Perceptions of the effectiveness of constructed wetland and expectations of their performance varied considerably among respondents. Discharge consent requirements set by Regional Councils for constructed wetlands are summarised in Table 1.

Table 1: Range of consent requirements issued for constructed wetlands.

Parameter	Mean	Range	Number of sites
BOD	24	10 - 50	24
Suspended solids	28	10 - 50	23
Total Nitrogen	18	10 - 25	10
Ammonia-N	10	1 - 20	8
Nitrate-N	3.5	2 - 5	2
Total Inorganic-N	15	10 - 20	2
Total Phosphorus	9.5	8 - 10	4
Dissolved Reactive P	5.5	5 - 6	2
pH		6.5 - 9	3
Dissolved oxygen	4.2	1 - 6	10
Faecal coliforms	6800	14 - 80'000	24

Note: All values g m^{-3}, except faecal coliforms (number per 100 ml) and pH.

Performance rating and problems

With performance of constructed wetlands rated on a scale of 1 to 5 (with 1 = not meeting, 3 = meeting, and 5 = more than meeting requirements), the median score from Regional Council personnel was 3 (average 2.9). This suggested that, in general, constructed wetlands were meeting requirements (Fig. 3).

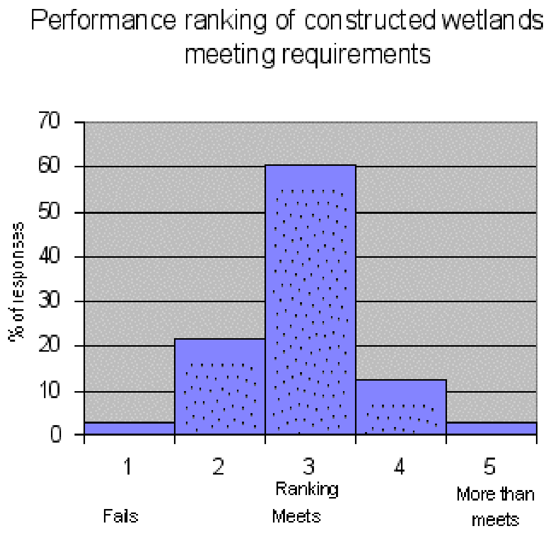
In some cases, inadequate treatment performance appeared to be related to gradually increasing expectations since the wetland had been built. Construction or persistent management problems, particularly those resulting in poor plant establishment, sometimes affected perceptions of the adequacy of wetland performance. Where large areas of wetland area remain bare due to poor plant establishment, weed ingression was also common. This suggests that plant establishment and ongoing weed control are important management issues for constructed wetlands.

Poor distribution system design and/or inadequate maintenance, resulting in channelling or clogging, was the next most common problem, sometimes associated with carry-over of sludge from upstream treatment stages. Although retention of such organic sludge provides valuable protection of receiving waters, it contributes high BOD and nutrient loads to wetlands. This can reduce their long-term performance and service-life considerably.

Sludge removal is particularly problematic in gravel-bed type wetlands, as it often infiltrates the gravel inlet zone. Removal by scraping off the sludge/gravel matrix is generally impractical, unless the sludge is only of limited distribution and commonly no removal is undertaken unless performance is markedly impaired (i.e. outside consent requirements). Because wetlands are predominantly anaerobic environments, sludge breakdown is often a slow process taking several years.

Drying and aeration of the surface by lowering the water level or diversion of wastewater through adjacent wetland cells can accelerate this process. Deeper unplanted settling zones at the inflow point can protect the downstream wetland and facilitate ready removal of accumulated sludges. However, such solutions generally require foresight at the design stage, as well as hands-on management of the site. Management input was generally minimal except at the larger, more recently constructed sites.

Figure 3. Approval rating for constructed wetlands.



Conclusion

So where do wetlands lie in the range of waste treatment systems available? For small communities they can provide effective treatment as a stand-alone system or in combination with septic tanks, but generally they are most suited to providing advanced secondary or tertiary treatment after waste stabilisation ponds, package treatment plants etc.

For larger communities, they cannot compete with highly mechanised plants in terms of performance per unit area, generally requiring large land areas. However, wetlands can effectively polish and buffer final discharges, whilst providing an aesthetically pleasing bridge between the hard lines of a mechanical treatment plant and the softer lines of nature. In many cases their value lies principally in their perceived naturalness and simplicity - people can relate to them.

Selected references on constructed wetlands in New Zealand:

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