Natural wetlands and waste water treatment – a sustainable practice?

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IT HAS LONG been recognised that wetlands have the ability to trap, transfer, and even permanently remove certain pollutants from waste waters. There are many examples, especially in the USA, where waste waters (particularly primary treated sewage) are discharged into natural wetlands in order to "polish" the effluents, prior to discharge into rivers or coastal waters. However, increasing recognition of the importance of wetlands as ecosystems in their own right, has led to a general rejection of this practice. The alternative has been to construct wetlands to mimic the conditions operating in their natural counterparts. The results of many studies of these "constructed wetlands" were published in the 1980s. They demonstrated that constructed wetlands could achieve high removal rates of a number of pollutants, and by the same processes which operate in natural wetlands.

Phosphorus removal not always predictable

While this may be so in general, we still do not fully understand the removal processes for some pollutants. An example is phosphorus. Although this is a plant nutrient, it can be a pollutant when it is discharged into nutrient deficient waters, because it stimulates the growth of nuisance algae. For a number of years researchers have assumed that the main "removal" process for phosphorus in wetlands is adsorption to the surfaces of the wetland sediment and decaying plant materials. Several USA studies found good relationships between the capacity of a range of wetland sediments to adsorb phosphorus, and the phosphorus removals observed at a range of loading rates. And, in most wetland systems, the phosphorus removal rate declined markedly with increasing loading rate and/or time since waste water was first discharged. A likely explanation for this was that the adsorption sites became saturated. In other words, phosphorus removal was not sustainable in wetland treatment systems. However, there were still cases reported where the amount of phosphorus removed was much greater than expected from the adsorption capacity of the sediment.

Recently published results from Ecosystems Division, NIWAR (see accompanying list of publications: Cooke 1992a; Cooke, Stub and Mora 1992), may have shed some light on this puzzling incongruity.

Research on a natural wetland system, near Paihia, receiving oxidation pond effluent, showed that this system did not fit the sediment adsorption model suggested in the USA studies. Phosphorus removal rates were much higher than expected, even though the wetland had received large amounts of phosphorus for more than a decade. Analysis of sediment cores from all over the wetland provided the first hints of an explanation. We began to suspect the answer lay in parts of the wetland which weren't even in contact with the sewage impacted area. Cores taken from below the confluence of sewage impacted and unimpacted wetlands contained much higher concentrations of inorganic phosphorus than all other cores. Subsequent sediment trap studies showed that very high phosphorus deposition took place in these post-confluence zones. In laboratory tests, we demonstrated that the deposition was caused by a chemical reaction between the sewage wetland waters (containing high phosphorus concentrations) and the natural wetland waters (containing both iron and humic material). We also showed that the hydrologic conditions (i.e. the water flows) controlling the supply of iron from the natural wetlands regulate the rate and spatial distribution of phosphorus deposition.

So, the particular configuration of the Paihia wetland seems to explain why such high phosphorus removal occurs. If the effluent were to pass through the same area of wetland *without* the input of iron-humic material from unimpacted wetlands, then there would probably be very little phosphorus removal. At Paihia, however, the rate of phosphorus removal appears to be sustainable.

The results of this study show that any

Some recent NIWAR publications on wetlands and wastewater treatment

Cooke, J.G. 1991. Conservation guidelines for assessing the potential impacts of wastewater discharges to wetlands. Department of Conservation Science and Research Series Publication No. 31. 49 p.

Cooke, J.G. 1992a. Phosphorus removal processes in a wetland after a decade of receiving a sewage effluent. *Journal of Environmental Quality 21*: 733-739.

Cooke, J.G. 1992b. Nutrient transformations in a natural wetland receiving sewage effluent and the implications for waste treatment. In: Proceedings of International Specialist Conference on *Wetland Systems in Water Pollution Control*, University of New South Wales, Sydney, Australia. pp. 50.1-50.8.

Cooke, J.G., Cooper, A.B. and Clunie, N.M.U. 1990. Changes in the water, soil, and vegetation of a wetland after a decade of receiving a sewage effluent. *New Zealand Journal of Ecology 14*: 37-47.

Cooke, J.G., Hickey, C.W. and Tanner, C.C. 1992. A critical review of techniques for the reduction of ammonium in rural point-source discharges. Auckland Regional Council Environment and Planning, Technical Publication No. 6.

Cooke, J.G., Stub, L. and Mora, N. 1992. Fractionation of phosphorus in the sediment of a wetland after a decade of receiving sewage effluent. *Journal of Environmental Quality 21*: 726-732.

Cooper, A.B. 1992. Coupling wetland treatment to land treatment: an innovative method for nitrogen stripping? In: Proceedings of International Specialist Conference on *Wetland Systems in Water Pollution Control*, University of New South Wales, Sydney, Australia. pp. 37.1-37.9,

Hickey, C.W., Quinn, J.M. and Davies-Colley, R.J. 1989a. Effluent characteristics of dairy shed oxidation ponds and their potential impacts on rivers. *New Zealand Journal of Marine and Freshwater Research 23*: 568-584.

Hickey, C.W., Quinn, J.M. and Davies-Colley, R.J. 1989b. Effluent characteristics of domestic sewage oxidation ponds and their potential impacts on rivers. *New Zealand Journal of Marine and Freshwater Research 23*: 585-600.

Quinn, J.M. and Hickey, C.W. 1992. Ecological effects of sewage oxidation pond effluent discharge to rivers. In: Proceedings of the New Zealand Water Supply and Disposal Association Annual Conference "Integrated Environmental Management", Christchurch, 1992.

Tanner, C.C. 1992. Treatment of dairy farm wastewaters in horizontal and upflow gravel-bed constructed wetlands. In: Proceedings of International Specialist Conference on *Wetland Systems in Water Pollution Control*, University of New South Wales, Sydney, Australia. pp. 21.1-21.9.

Williams, B.L., Bleeker, F., Cooke, J.G. and Cooper, A.B. 1990. The transport of wastewater through a natural wetland. In: Proceedings of the New Zealand Water Supply and Disposal Association Annual Conference, Tauranga, 20-22 August 1990. pp.95-104.

proposal to discharge waste waters into natural wetlands needs to be assessed on its own merits. The ecological costs of changes to the plant communities need to be weighed up against the benefits of lower pollutant exports, and low waste treatment costs to the community. In the Paihia situation, while considerable ecological change has taken place in the sewage impacted wetland, the area so impacted is small relative to the total amount of wetlands. We also have to consider that the huge variety of chemical and biochemical conditions found in a natural wetland is very difficult to reproduce economically in an artificial water treatment system.

The results of this study offer opportunities for ecological engineering where phosphorus removal is an important consideration. For example, we could create small areas of constructed wetland downstream of natural wetlands of the type found at Paihia. The role of the constructed wetlands would simply be to provide sites for reaction and settling. Outflow from the natural wetlands could be introduced to the constructed wetlands in order to provide a source of reactants for phosphorus removal from the wastewater. In this way natural wetlands could be used for waste treatment without themselves being ecologically degraded. ■

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New Zealand has strong presence at international wetlands conference

AT A RECENT conference in Sydney, scientists and engineers from New Zealand demonstrated a strong commitment to research into wetlands as a vehicle for water pollution control.

Three scientist from Ecosystems Division, NIWAR, presented papers at the International Conference on Wetland Systems in Water Pollution Control in December 1992.

Jim Cooke gave a paper on "Nutrient transformations in a natural wetland receiving sewage effluent and the implications to waste treatment" which described some strategic research on a wetland system near Paihia. This research has identified processes operating which have major implications to the sustainability of nutrient removal in such systems (see the preceding article in this issue). Bryce Cooper's paper; "Coupling wetland treatment to land treatment: an innovative method for nitrogen stripping?" described some of the scientific investigations which he carried out prior to the commissioning of the Rotorua Wastewater Purification Scheme. Chris Tanner's paper, "Treatment of dairy farm wastewaters in horizontal and up-flow gravel-bed constructed wetlands" described investigations which will eventually lead to design criteria being developed for the treatment of dairy-shed wastewaters (see pages 5-6 in this issue).

The papers illustrated the breadth and depth of knowledge on this topic available within NIWAR. Both ecological and waste treatment objectives are being addressed in the NIWAR studies, which is rare, even from an international perspective.

The increasing importance now attached to both constructed and natural wetlands in New Zealand was reflected in other New Zealand presentations to the conference. Albert van Oostrom (Meat Industry Research Institute of New Zealand) presented a paper on denitrification of meat works waste; Brian Duncan (Bruce Wallace Partners) reviewed New Zealand's experience with constructed wetlands; Gary Venus (Tonkin & Taylor Ltd) described the Whangarei City wetland project and in particular identified the aesthetic and amenity benefits of the scheme, and Judy van Rossem (Environment Waikato) presented a poster paper showing the future directions for management of wetlands in the Waikato.

A workshop on the Hamilton Lake problem

AN ITEM in *Water & Atmosphere 1*(1) (pages 18-19) described why some Hamilton residents are worried about what is happening to the town's lake. It outlined the reasons, put forward by Dr John Clayton of Ecosystems Division, NIWAR, Hamilton, for the lake's changing ecosystem.

In response to the current public concern, scientists, including Dr Clayton, met at a technical workshop on 23 November 1992. As a result of the workshop, much valuable information about the lake and some of the changes that have happened is now being summarised into a report. As well as reviewing past research, the workshop identified future research requirements and discussed the best management methods for helping to avoid algal blooms. The participants also agreed that Hamilton Lake is an ideal study site for researching issues of national importance, such as:

- What causes submerged plants to die and algae to take over?
- What other changes occur in a lake ecosystem when submerged plants are lost?
- Can desirable submerged plants be restored?

Weeds fouling Hamilton Lake (Lake Rotoroa) in 1959.

All this interest in Hamilton Lake is by no means new! The photograph above was taken in the 1950s after introduced oxygen weed had become a major problem. For over 30 years both mechanical and chemical methods had to be used to control it. At one stage even the army was called in to assist, as the weed was preventing both people and boats from using the lake. Today, oxygen weed has all but died out – but unfortunately has been succeeded by a different kind of problem. So we are now looking at new research into both old and new problems. Progress will be reported in future issues of *Water & Atmosphere.*