Bugs and bad things in oxidation ponds

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Can we rely on oxidation pond systems to treat sewage so that there are no undesirable effects on the waterways receiving their effluent? New research is investigating the processes at work in these ponds. An important aim is to explain why pond effluent quality with existing designs can be so variable.

OXIDATION ponds, or waste stabilisation lagoons, are used for treating domestic sewage in around 40% of New Zealand communities of 20,000 or more people. The proportion for smaller communities is probably even larger.

The main purpose of oxidation ponds, as their name suggests, is to oxidize organic wastes to form harmless materials. The waters into which the treated wastes are eventually discharged are then less likely to experience low oxygen levels and associated nuisances as a result of the discharge. The ponds also disinfect sewage by inactivating (though not necessarily killing) bacteria and viruses which can cause disease. Receiving waters should then pose minimal health risk to people using them for recreation. Ponds also remove some aesthetically unpleasant solids in sewage.

Most oxidation pond systems in New Zealand are constructed to a standard design which is described in a document published in 1974 (Ministry of Works and Development). This design comprises two ponds in series. The first performs most of the "treatment", by natural processes; the second, or "polishing" pond, provides a buffer, to some extent, against releases to the environment of poor quality effluent.

Sampling a typical oxidation pond treating domestic sewage in New Zealand.
(Photo: Rob Davies-Colley)

Past studies

A study of the performance of New Zealand sewage oxidation ponds (see Hickey *et al.* 1989), based on data from the Auckland, Manawatu and Southland regions, showed that quality of individual pond effluents varies substantially. There is also considerable variation between ponds. Effluent "quality" depends on:

- concentrations of faecal indicator bacteria, known colloquially as "bugs" – higher concentrations imply increased risk of infection;
- amount of suspended solids (mostly in the form of algae) – these reduce water clarity, and therefore aesthetic quality;
- concentrations of nutrients (phosphorus and nitrogen) – high nutrient content can promote nuisance growths of algae in receiving streams.

Recent work by NIWA researchers broadly supports the earlier findings. This research has also shown that pond effluents are seldom likely to cause problems with oxygen depression or slime growths except when they are discharged into receiving streams at low dilution.

The NIWA studies also looked at the impact of oxidation pond effluents on the invertebrate animals in receiving streams, a valuable indicator of stream "health" (see Quinn and Hickey 1993). They found that pond effluent discharges at low dilutions (less than 20 times) "stressed" benthic invertebrates. This resulted in a decline in species diversity and favoured pollution-tolerant animals, such as worms and snails, over animals such as mayflies that characterise "clean" streams. However, at higher than 20-fold dilution, the abundance of clean stream animals can actually *increase*, apparently because the extra organic solids act as a food "subsidy".

Optics of pond waters

Little work has been done internationally on the behaviour of light in oxidation ponds. This is surprising, because the penetration of light into pond waters controls algal photosynthesis and natural disinfection by sunlight. Also, the clarity of receiving waters may be affected by pond effluents. The recent NIWA work included investigating the optical character of pond effluents in New Zealand.

Oxidation pond waters strongly restrict light penetration. Therefore, the algae growing in these ponds are often light-starved and this limits their biomass. This is important because algae are responsible for producing most of the oxygen used by bacteria for the biochemical oxidization of organic matter. Pond effluents are also very murky (average visibility, measured with a "black disc", of about 100 mm) so an impact on the clarity of receiving streams is expected. Recent guidelines published by the Ministry for the Environment (MfE) recommend that visual clarity of receiving waters should be reduced by no more than 50%. New Zealand streams have a characteristic baseflow black disc visibility of 3.2 metres (the *median* value, so half are clearer and half are more turbid). To meet the MfE guideline would require a 100-fold dilution of oxidation pond effluent.

Most contaminants of environmental concern in pond effluents (including oxygen-demanding organic substances, suspended solids and ammonia) can be safely assimilated by receiving streams if the pond effluents are diluted by at least 40 times. However, at these dilutions, nutrient concentrations may still be very high. To avoid promoting growths of nuisance algae in receiving streams, it may be necessary to dilute effluent as much as 400 times, although sometimes other factors, such as riparian shading, invertebrate grazing or lack of suitable attachment surfaces, restrict algal growth.

Processes

Having identified problems in waters receiving oxidation pond effluents, the next step in research is to investigate oxidation pond