Making sewage bugs work harder

A simple, but radical, modification to the operation of sewage treatment plants, developed by a CSIRO scientist, could significantly improve their efficiency.

If trials at the Melbourne and Metropolitan Board of Works' 20 000-person-equivalent treatment plant at Brushy Creek reflect the success of an earlier trial at the smaller Yarra Glen plant, then operation of all the world's sewage plants could be turned on its head.

Sewage treatment engineers normally become anxious whenever their plant stops running — through a power failure, perhaps. They fear that, with the aerating pumps not working, aerobic bacteria on which they rely for sewage digestion will die.

They therefore find it hard to believe Mr Yen Ip's prescription for increased plant efficiency: turn off your aerating pumps for about 4 hours out of every 6.

'Don't worry about your aerobic bacteria', says Mr Ip, of the CSIRO Division of Chemical and Wood Technology. 'Bacteria that can digest sewage under both aerobic and anaerobic conditions will take over — and do it more efficiently.'

He has called his scheme AAA — alternating aerobic and anaerobic digestion. Not only does it save substantial power compared with the traditional process, but it can nearly halve the quantity of residual sludge, and reduce the amount of nitrogen in the effluent to one-half or one-quarter — all at no extra cost!

Municipal sewage is usually subjected to three levels of treatment. A primary treatment removes solids; a secondary one removes biochemical oxygen demand (BOD); and tertiary treatment removes nutrients (nitrogen and phosphorus). The AAA process works as a secondary process, but takes on a good deal of the tertiary as well.

The most commonly used secondary treatment is the activated sludge process, in which raw sewage is mixed with an activated (bacterially rich) sludge in the presence of oxygen (from the air). Aerobic bacteria proliferate and convert organic materials into more sludge and carbon dioxide.

While Mr Ip was undertaking post-graduate studies on the metabolism of sewage bacteria at the University of Melbourne's Department of Microbiology, Professor Nancy Millis of the Department pointed out to him an intriguing paper concerning the metabolism of

'facultative' bacteria. These bacteria can continue to eat and grow whether oxygen is present or temporarily absent — they choose a digestive route to suit either circumstance. Laboratory studies reported in the paper had found that such bacteria respire very rapidly when oxygen returns after a period without air.

Mr Ip saw the significance of this for the treatment of sewage. It means that after oxygen deprivation, the bacteria — like us after exertion — 'pant', and their rate of metabolism goes up.

He was inspired to see whether this meant that municipal sewage could be broken down more quickly, and set up some experiments at the Division's Lower Plenty field site to check. These involved feeding sewage to an 18-L digester tank and seeing how efficiently bacteria digested it under different regimes of air and no air.

Sewage contains naturally a large diversity of bacteria — some aerobic, some anaerobic, and some facultative. The proportion of time the aerating pumps are on, and the total time for an on–off cycle, must be chosen to favour the facultative bacteria.

Mr Ip found that a cycle time of 6 hours and an on–off ratio of 1 : 2 were about optimum. Under these conditions, the facultative bacteria respired quickest. And instead of converting carbon to biomass, they excreted extra carbon dioxide, thereby diminishing the amount of residual sludge that needs to be disposed of.

Furthermore, during the anaerobic phase these same microbes consume nitrates, breaking them down to nitrogen gas. Thus, the nutrient level of the sewage is sharply decreased.

This makes it easy to combine a tertiary treatment with the AAA process. Experiments at Lower Plenty with a 200-person-equivalent transportable plant provided by the MMBW have shown that the addition of small quantities of ferric chloride could reduce phosphorus levels from 8·5 mg per L to less than 1 mg per L. Investigations will be continued at Yarra Glen, where it is planned to remove phosphorus by using alum instead of ferric chloride.

Initial full-scale trials at Yarra Glen in co-operation with the MMBW have shown power reductions from 3400 kWh to 2800 kWh per quarter, and a lowering of sludge production from 7500 to 4000 mg per L. Nitrogen in the effluent decreased from 20 to less than 5 mg per L.

No deterioration occurred in the effluent's BOD level, suspended solids, or pH during an 18-month trial period. The ability of the sludge to settle remained unchanged.

The MMBW are keen to extend tests of the AAA process to other plants. These tests, in conjunction with Melbourne University, should be conducted soon.

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The development of the alternating aerobic/anaerobic completely mixed activated sludge system. S.Y. Ip. In 'Annual Review 1984 — CSIRO Division of Chemical and Wood Technology'. (CSIRO: Melbourne 1985, in press.)