Letter to the Editor

Letter by M.R. Roberts, of Consulting Engineers, Stewart, Sviridov and Oliver, in connection with:

Limitations of biological phosphate removal mechanisms in mainstream activated sludge processes which are also required to remove nitrate from urban waste waters, as discussed in **Metabolic behaviour of *Acinetobacter* spp. in enhanced biological phosphorus removal – a biochemical model.**

by M.C. Wentzel, L.H. Lötter, R.E. Loewenthal and G.v.R. Marais, Water SA 12 (4) 209-224 (1986).

There is now a long history of treatment of urban waste water by South African mainstream (Phofix) activated sludge processes which incorporate anaerobic/anoxic/aerobic reactor sequences in the hope of enhanced removal of all forms of the nutrients nitrogen and phosphorus. In most cases, if not in all, the nett observed uptake of phosphate in anoxic zones has been insignificant. From this observation it is logical to assume that micro-organisms which play a major role in intracellular storage of polyphosphate do not play a major role in denitrification, and *vice versa*. It follows that the relatively limited quantity of organic carbon available in ordinary urban waste water must be shared between denitrifiers and polyphosphate storers in mainstream (Phofix) activated sludge processes which are required to remove both nitrogen and phosphate compounds.

This line of reasoning leads to the conclusion that the biological phosphate removal capability of a mainstream (Phofix) activated sludge process is limited by two important constraints, namely by the quantum of organic carbon available after satisfying the requirements of the denitrifying organisms and by the quantum of intracellular polyphosphate storage capacity available in polyphosphate-storing organisms.

Regrettably the authors provide no quantitative data in respect of these constraints.

The poor performance of most nutrient removing activated sludge systems, suggests that the few successes can be attributed to either enhanced biological P-removal due to unusual waste waters with favourably low nutrient/carbon ratios or enhanced precipitation and adsorption of P due to favourably high metal cation/nutrient ratios in the urban waste water concerned.

It is significant to note in this context that the authors have not yet found any substantive evidence to contradict the aforementioned conclusion. In the light of past experience, it seems most unlikely that the ongoing experiments referred to in the last paragraph on page 220 will support the author's speculative suggestion in the preceding paragraph on that page, to the effect that the rapid decrease of nitrate in anoxic zones may be attributable to rapid denitrification by *Acinetobacter* spp. which also play a major role in the uptake of excess phosphate.

The authors state, in their conclusion on page 221, that the anaerobic reactor selects an assemblage of facultative organisms able to ferment sugars to LFA via the glycolytic (Embden-Meyerhof) pathway which they say is not possessed by *Acinetobacter* spp. Is it possible that the authors are as wrong about the *Acinetobacter* not possessing the Embden-Meyerhof pathway as Fuhs and Chen (1975) were wrong about *Acinetobacter* not possessing the Entner-Doudoroff pathway? Possession by *Acinetobacter* spp. of the ability to convert sugars to preferred forms of organic carbon for anaerobic uptake, would obviate the need to postulate a symbiotic relationship between *Acinetobacter* spp. and an "assemblage of facultative organisms" able to ferment sugars.

Until such time as the authors or others working in this field of research can produce quantitative evidence to the contrary, it will be prudent for designers and operators to accept the fact that enhanced removal of both nitrogen and phosphate from urban waste water by mainstream (Phofix) activated sludge processes will not be reliable unless either the waste water has an unusually favourable high ratio of available organic carbon to the nutrients N and P or the biological phosphate removal is helped by precipitation and adsorption (with or without artificial addition of metallic cations such as iron or aluminium); or both.

It is high time the formal waste-water research fraternity in South Africa addressed itself to the difficult task of identifying quantitatively the relative roles of biological, precipitation and adsorption mechanisms in full-scale phosphate removal processes.

Laurraine H. Lötter replies as follows:

In responding to the comments in Mr. Roberts' letter it is necessary to clarify some misconceptions. Uptake of phosphate in primary anoxic zones in Johannesburg's Northern Works has been observed (Osborn *et al.*, 1986). These observations must lead one to the conclusion that some heterotrophic micro-organisms at least, are capable of polyphosphate storage and denitrification. The mechanism of sharing carbon substrate between denitrifiers and polyphosphate storers has not been satisfactorily resolved, and was not intended to form part of the article referred to. Furthermore the authors attempted to provide biochemical explanations for the quantitative observations of other researchers. The quantitative constraints mentioned by Mr. Roberts do in fact form the subject of other research projects.

The authors intended to address only the biological removal of phosphorus and therefore did not consider phosphate precipitation, a field which in itself is sadly lacking in quantitative data.

As far as the ongoing experiments are concerned only time will tell. When postulating mechanisms based on observations one applies known theoretical principles to experimental observations in an attempt to explain the natural phenomena as a function of the principle of a specific discipline. It is always possible that one can be wrong. Postulation is not intended to provide an absolute and definitive answer to a problem but rather to correlate a number of fragmentary observations in a cohesive whole, which facilitates future experimental planning. In defence of Fuhs and Chen (1975) more recent workers have confirmed Fuhs and Chen's finding that *Acinetobacter* do possess the Entner-Douderoff pathway (Juni, 1984).

Researchers in the field of waste water are working unceasingly to provide answers for the protection of our single most valuable resource. It would be extremely beneficial to this community if the wealth of data generated on biological phosphate removal could be equalled by data on chemical precipitation.

References

FUHS, G.W. and CHEN, M. (1975) Microbiological basis of phosphate removal in the activated sludge process for the treatment of wastewater. *Microbial Ecology* **2** 119-138.

JUNI, E. (1984) *Acinetobacter. Bergey's Manual of Systematic Bacteriology* 1 (Ed.) N.R. Krieg and J.G. Holt. Williams and Wilkins Baltimore.

OSBORN, D.W., LÖTTER, L.H., PITMAN, A.R. and NICHOLLS, H.A. (1986) Enhancement of biological phosphate removal by altering process feed composition. Report to the Water Research Commission. 137/1/86.

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Two examples of the presentation of references are the following:

Grabow, W.O.K., Coubrough, P., Nupen, E.M. and Bateman, B.W. (1984) Evaluation of coliphages as indicators of the virological quality of sewage-polluted water. *Water SA* **10**(1) 7-14.

Wetzel, R.G. (1975) *Limnology*. W.B. Saunders Company, Philadelphia, p 324..