

Metabolic behaviour of *Acinetobacter* spp. in enhanced biological phosphorus removal - a biochemical model

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Abstract

A biochemical model is presented that explains the behaviour of *Acinetobacter* spp. in enhanced biological phosphorus removal activated sludge systems. The model modifies and extends the proposals of Comeau *et al.* (1985). Two key parameters are identified in controlling poly-P and PHB synthesis and degradation, the ATP/ADP and NADH/NAD ratios. The predicted behaviour appears to be consistent with that observed.

Introduction

Since the phenomenon of enhanced biological phosphorus removal in activated sludge systems *Fust* was observed (Srinath, Sastry and Pillay, 1959), attempts have been made to elucidate the mechanisms governing it. Over the years various hypotheses and models have been proposed; each successive model has been influenced in some degree by the models preceding it, but often the factors on which a model conceptualization has been based are not clear. In this paper we wish to trace briefly but critically, the evolution of these models. We then propose yet another model which we hope will resolve some of the difficulties that have become apparent with previous models.

The research papers that either directly or indirectly influenced the conceptualization of the respective models are extensive and it is not possible to include a critical evaluation of each; only those papers of major direct influence will be mentioned. For a detailed review of this topic, and related ones, the reader is referred to Marais, Loewenthal and Siebritz (1983).

Model evolution

Early observations

Harold (1966), in an authoritative survey, reported that phosphorus accumulation in the form of polyphosphate (poly-P) is widespread among micro-organisms, in bacteria, yeasts, fungi and photosynthetic algae. Harold, however, could not advance a substantive hypothesis as to what function was served by these accumulations. He noted that temporary limitations of the nutrients sulphur and nitrogen could result in accumulation of poly-P in certain bacteria.

Levin and Shapiro (1965) demonstrated accumulation of phosphorus in a mixed liquor sample from an activated sludge system, under aerobic conditions. Further, they noted that in the mixed liquor samples phosphorus (P) is released to the bulk solution when the dissolved oxygen level falls. Shapiro (1967) showed that this release of P under anaerobic conditions could be reversed on subsequent aeration.

Fuhs and Chen (1975) conducted a wide-ranging investiga-

tion into the phenomena of P release and uptake. They observed the following:

- Samples taken from a full-scale anaerobic/aerobic activated sludge plant (showing enhanced P removal) and from a laboratory-scale aerobic plant fed on an artificial sewage (not showing excess P removal) were dosed with radioactively labelled glucose and aerated. The results indicated that the organism assembly receiving artificial substrate under completely aerobic conditions metabolized the glucose via the Entner-Doudoroff pathway, whereas the organism assembly from the anaerobic/aerobic plant indicated metabolism via the Embden-Meyerhof pathway. They then changed operation of the laboratory scale plant from aerobic to anaerobic/aerobic; after two weeks operation the system still showed no P release or uptake. They concluded that this system had a different species composition from the full-scale plant.
- P removal appeared to be mediated by either a single micro-organism or several closely related forms. From a series of isolation tests Fuhs and Chen concluded that *Acinetobacter* spp. probably was the principal organism mediating the P removal.
- *Acinetobacter* spp. accumulated poly-P and poly- β -hydroxybutyrate (PHB). Fuhs and Chen speculated that PHB storage could serve as an energy source for poly-P formation.
- In studying the nutritional requirements of an *Acinetobacter* strain isolated from an enhanced P removal activated sludge system they found this strain could not use glucose or similar compounds but grew on lower fatty acids, LFA. (In this paper the terminology lower fatty acids (LFA) and volatile fatty acids (VFA) are used interchangeably). They concluded that anaerobic conditions preceding aerobiosis in sewage treatment could well be related to the appearance of *Acinetobacter* spp. - they saw the principal function of the anaerobic state as enabling a facultative anaerobic microflora to become established which produces lower fatty acids to serve as substrate for *Acinetobacter* spp. Furthermore, from pure culture studies, they concluded that the anaerobic state takes no part in enhanced P removal *per se* and can be excluded provided LFA are supplied to *Acinetobacter* spp. in the aerobic state. They found that if acetate was added to a pure culture of *Acinetobacter* spp. under aerobic conditions, P uptake took place.

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