

The use of simultaneous chemical precipitation in modified activated sludge systems exhibiting biological excess phosphate removal

Part 2: Method development for fractionation of phosphate compounds in activated sludge

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Abstract

An experimental investigation was conducted into the use of a simple fractionation (extraction) procedure for distinguishing chemically and biologically stored phosphorus compounds in activated sludge. For this purpose, it was necessary to select appropriate methods for measurement of total phosphate (total P) and orthophosphate (orthoP) and to make approximations in respect of the nucleic acid content of activated sludge. The selected fractionation procedure appeared to be capable of broadly distinguishing between chemical and biological forms of stored phosphorus in activated sludge systems. Satisfactory agreement was obtained with results for biological polyphosphate (polyP) accumulation predicted using a mathematical model applied to such systems. The recovery of chemical phosphate precipitate formed *in vitro* was found to be satisfactory, although the addition of metal precipitant appeared to cause particular artefacts in the fractionation pattern which need to be taken into account when interpreting the data. It was concluded that the chemical fractionation procedure developed would be useful for assessing the relative sizes of biological and chemical phosphorus "pools" in activated sludge simultaneously dosed with chemical precipitants (typically iron or aluminium salts).

Introduction

This series of papers presents an investigation into the effect of simultaneous chemical addition on the biological excess phosphorus removal (BEPR) mechanism in activated sludge systems. The aim was to measure the extent to which the P removal could be ascribed specifically to the biological mechanism, as opposed to a chemical mechanism. Pilot- or laboratory-scale activated sludge systems are most suitable for such research, and were used in this study. Identical systems were operated under identical conditions in the laboratory, with the exception that one unit (the test unit) was dosed with chemical precipitant (e.g. alum or iron salt), while the other served as the control unit (De Haas et al., 2000b,c). Phosphate removal could then be measured in both units from the difference between influent and effluent total P. Phosphate removal in the test unit would be attributable to the combined chemical-biological mechanisms, while that in the control would be mainly due to the biological mechanism. However, cations naturally present in domestic sewage could make a contribution to the P removal of the control (Arvin, 1983, 1985; De Haas, 1989). Therefore, in this investigation it was considered essential to have a phosphorus fractionation procedure which, when applied to activated sludge mixed liquor from both the test and control units, would be capable of estimating the relative magnitudes of phosphate fractions bound chemically vs. those stored biologically. Fractionation procedures used for this purpose have been reviewed in **Part 1** (De Haas et al., 2000a).

The aim of the work described in this paper was to test one phosphorus fractionation procedure, namely that based on cold

perchloric acid. This procedure has been applied to activated sludge in various forms (*inter alia* Kerdachi and Roberts, 1985; Mino et al., 1987; De Haas, 1989; Blonda et al., 1994). The intention here was to consolidate and simplify the method where possible, as well as to validate it. Validation of the chemically-removed fractions would be attempted by means of batch tests in which known amounts of chemical precipitant and phosphate are added to samples of activated sludge drawn from laboratory-scale units exhibiting BEPR, followed by application of the fractionation procedure to determine recovery of chemically-bound phosphate. Validation of the biological fractions would be attempted by comparing the fractionation results for the control unit, under defined conditions, with the concentrations of biologically-stored polyphosphate (polyP) predicted by a mathematical model (Wentzel et al., 1992). Moreover, to correctly apply the fractionation procedure, it was necessary to give special attention to the methods for total P and orthoP determination, specifically in samples of activated sludge or the extracts obtained.

Experimental investigation and results

OrthoP method

Vanadate-molybdate spectrophotometric method

This method was most often selected since it has been reported to obey Beer's Law up to 300 mgP/l (Burke et al., 1986), which is a suitable range for mixed liquor samples of activated sludge. It was also suitable for influent and effluent samples from the laboratory-scale plants used in this study since phosphate was added to the influent in most experiments. The performance of the method was only tested up to 100 mgP/l, which was adequate for the experiments performed in this investigation and gave absorbances up to ca. 0.9 and 0.6 respectively for orthoP and total P (see Fig. 1).

The method used was that described by Burke et al. (1986). A colour reagent was prepared as follows:

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