

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

## Part 3: Experimental periods using alum

DW de Haas<sup>#</sup>, MC Wentzel\* and GA Ekama

Department of Civil Engineering, University of Cape Town, Rondebosch 7700, South Africa

### Abstract

An investigation was conducted into the effect of simultaneous alum dosing on biological phosphorus (P) removal in an activated sludge system at pilot scale. Two continuous flow (36  $\ell$ /d) activated sludge pilot plants were used to develop "semi-enhanced" biological excess phosphorus removal (BEPR) organism cultures of activated sludge by means of acetate supplementation of the feed. BEPR was strongly exhibited in these systems. One was used as a test system (to which alum was dosed), while the other served as control (no chemical addition). Additional removal due to chemical precipitation was measured as the difference in system P removal between the two systems. The extent of P release in the anaerobic reactors of the two systems was compared by mass balance, as one indicator of the "magnitude" of BEPR in the test system. Phosphorus fractionation of the mixed liquor suspended solids also served as an indicator of the respective biological and chemical mechanisms. Evidence was found that the BEPR mechanism is partially inhibited in the presence of simultaneous alum addition, even in the absence of effluent phosphate limitation. However, the degree of inhibition was relatively low, ranging 15 to 25% (approximately) for alum doses in the range ca. 5 to 9 mg/l as Al (50 to 100 mg/l as dry alum), at a system P removal of 20 to 30 mgP/l in the control. Alum dosing in this range was sufficient to produce additional P removal of the order of 3 to 7 mgP/l over periods of one to three sludge ages per experimental period. Sustained operation of the BEPR mechanism in the presence of alum was possible over a continuous period of 7 sludge ages.

### Nomenclature

$\Delta$	Delta, meaning "difference in" or "change in" (e.g. $\Delta M, P_{rem}$ - see also below)
AE1 or 2	Aerobic zone or reactor
Al~P~O	Aluminium phosphate oxide precipitate (theoretical) after ashing of aluminium hydroxy-phosphate
Al~P~OH	Aluminium hydroxy-phosphate
Alk.	Alkalinity (unless otherwise stated: bicarbonate alkalinity)
AN	Anaerobic zone or reactor
AX	Anoxic zone or reactor
BEPR	Biological excess phosphorus removal
COD	Chemical oxygen demand
DSVI	Dilute sludge volume index
$fP_{ta}$	Filtered total P in the anaerobic reactor
ISS	Inorganic suspended solids
$M, P_{rem}$	Mass of phosphate removed
$M, P_{rel}$	Mass of phosphate released (in anaerobic zone)
orthoP	Orthophosphate
PCA	Perchloric acid (fractionation studies)
polyP	Polyphosphate
$P_{ti}$	Influent total P concentration
$P_{te}$	Effluent total P concentration
$P_{trem}$	Total P concentration removed
$P_{rel}$	Total P concentration released (measured on filtered mixed liquor sample)
$Q_i$	Influent flow rate

$Q_s$	Return sludge flow rate (clarifier underflow)
rem	Removal/ removed
RES	Residue (in fractionation studies)
SD	Sample standard deviation
SUP	Supernatant (in fractionation studies)
TKN	Total Kjeldahl nitrogen
TSS	Total suspended solids
VSS	Volatile suspended solids

### Introduction

Aluminium sulphate (alum) is commonly used as a simultaneous chemical precipitant for phosphorus (P) removal in activated sludge systems. As discussed in **Part 1** of this series of papers (De Haas et al., 2000a), chemical addition is frequently required to supplement P removal in modified activated sludge systems designed to remove P biologically where such systems are unable to achieve the required effluent P concentration by biological means alone. However, a degree of uncertainty surrounds the question of possible inhibition of the biological P removal processes due to the simultaneous addition of chemical precipitants. Due to the relevance of the research topic to Umgeni Water and its operation of Darvill Wastewater Works (WWW) in Pietermaritzburg (South Africa), a pilot-plant facility was established at this works with a view to testing the effect of simultaneous chemical addition on excess biological P removal in activated sludge systems.

The initial phase of the research using pilot plants was aimed at dosing aluminium sulphate (alum) as simultaneous precipitant. At Darvill WWW, alum had been used as simultaneous precipitant with fair success over a period of approximately 18 months prior to the commencement of this study. The biological P removal mechanism was apparently still operative in the full-scale plant at Darvill WWW in the presence of alum dosing (as evidenced by P release in the anaerobic zone, for example). However, the absence of a

\* To whom all correspondence should be addressed.

<sup>#</sup> Formerly Umgeni Water, PO Box 9, Pietermaritzburg 3200.

☎(021) 650-2583; fax (021) 689-7471; e-mail: markw@eng.uct.ac.za

Received 10 November 1998; accepted in revised form 20 June 2000.