Effect of Fe Dosing for CPR on Biological Activity and Physical Characteristics of Activated Sludge

(Ph.D. Research)

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Introduction

Driven by the Urban Waste Water Treatment Directive (1991), phosphorus removal has become an important requirement for the UK's sewage treatment works discharging into designated 'sensitive waters'. Both biological and chemical phosphorus removal can be successfully applied in wastewater treatment and although BPR is more environmentally desirable, CPR has been also widely used mainly due its high stability. CPR relies on chemical precipitation of the soluble P, with iron, both in ferric (Fe+3) and ferrous (Fe+2) form, and aluminium-based salts being commonly used as coagulants.

Activated sludge is one of the best established wastewater treatment processes. It can be divided into two sections, the aeration tank in which wastewater is treated aerobically with a suspended, mixed culture of microorganisms, which are in a well-flocculated state and the settlement tank, in which the activated sludge is separated from the liquid phase by sedimentation and recycled back to the aeration tank. Coagulants can be added at several stages of the process, namely before the primary settlement tank (pre-precipitation), directly into the aeration tank (simultaneous precipitation) or after the secondary treatment (post-precipitation).

Fe dosing and effect on biological performance and physical properties of the activated sludge

Simultaneous precipitation with Fe salts has been established as an effective P removal practise in activated sludge and not major disruptions of the biological performance are expected from Fe itself as long as the side-effects of chemical precipitation, i.e. decrease of the buffering capacity of the aeration tanks or shortage of bioavailable phosphate are controlled. However, a number of studies carried out in laboratory or pilot-scale activated sludge plants suggest an inhibitory effect of the metal on the biomass activity, which could be related to a direct cytoxicity or to a retardation of substrate diffusion into the biomass due to the precipitate coating the cells.

Fe dosing reportedly affects the structure and physical properties of the activated sludge flocs. It is believed to improve the flocs settleability and filterability, although some research studies oppose this. The morphologies of Fe+2 and Fe+3-dosed sludges often differ and effluent turbidity problems due to flocs fragmentation can be observed.

As part of the present research project, the biological performance of a simultaneous precipitation activated sludge process was investigated by carrying out continuous flow trials in a bench-scale activated sludge plant in which Fe+3 and Fe+2 salts were continuously dosed. Apart from the regular monitoring of the COD and NH3 removal efficiency, the overall and nitrifying biomass activity were measured by means of respirometry to assess a possible inhibitory effect on cells viability and metabolism. Besides, changes of the morphological characteristics and the physical properties of the activated sludge flocs were recorded using optical and scanning electron microscopy, particle size analysis, settleability and dewaterability tests.

Results from the continuous flow trials

1. Both types of Fe similarly affected the biological performance of the plant in terms of COD, NH3 removal and biological activity.
2. Fe dosing slightly improved COD removal efficiency.
3. A mild inhibitory effect of Fe on the endogenous biomass respiration was observed.
4. Fe accumulation onto the flocs did not affect the respiration associated with the cells metabolism.
5. Excellent NH3 removal was recorded at two different sludge ages, 30 and 15 days.
6. Maximum NH3 oxidation rate was unaffected by Fe dosing.
7. Fe+2 and Fe+3 affected floc morphology in considerably different ways. The flocs dosed with Fe+2 demonstrated a compact and small, sometimes pin-point structure, with the precipitate accumulation on the surface vividly observed with light microscopy. On the contrary, Fe+3 formed loose and larger flocs, with no visual evidence of surface accumulation.
8. Both types of Fe improved sludge settleability, nevertheless the improvement was significantly more pronounced and rapid in the case of Fe+2 dosing.

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Plate 1: Photograph of the bench-scale plant

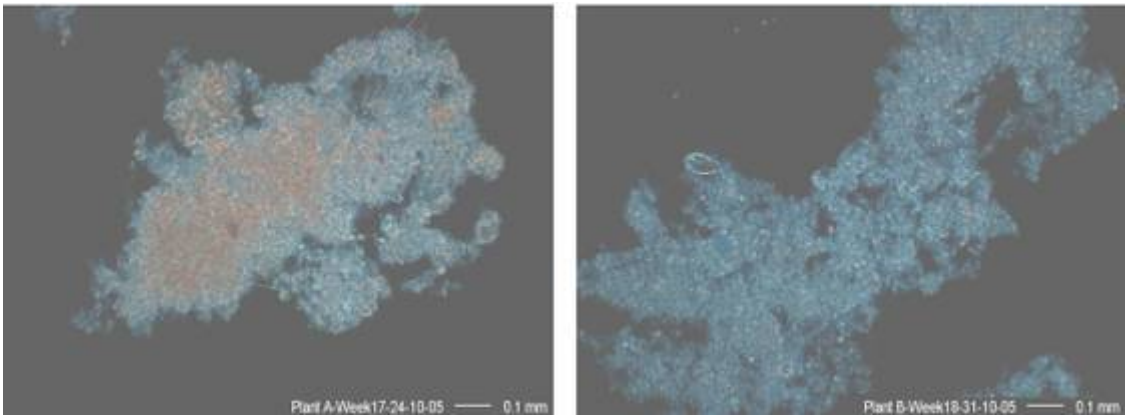

Plate 2: Phase contrast micrographs of typical Fe+2-dosed (left) and Fe+3-dosed (right) flocs

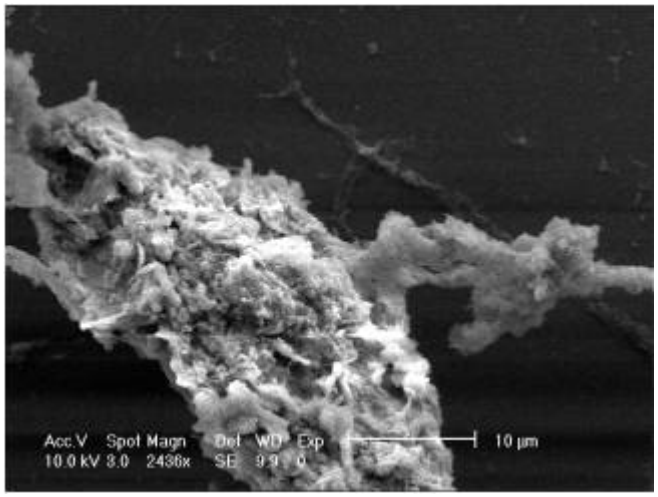

Plate 3: A scanning electron micrograph of a Fe-dosed floc