



GETTING THE MOST FROM CHEMICAL P-REMOVAL: OUR EXPERT OPINION

Phosphorus is crucial nutrient with widespread use domestically, in industry and agriculture. However, high Phosphorus levels in the environment have led to increased eutrophication of surface waters throughout Europe, threatening water quality and biodiversity. As a result, legislation in the form of the Urban Waste Water Treatment Directive (UWWTD) sets statutory limits on the concentration of phosphorus that can be discharged into the environment from waste water treatment works.

Dr Mick Dawson, Engineering Director, explains how to get the most from Chemical P-Removal, to meet both legislation and commercial/operational objectives.



Tougher targets

Hitherto P consents for sensitive water discharges have been 2mg/l for works between 10,000 and 100,000 PE and 1mg/l for works > 100,000 PE with no limit on works below 10,000 PE. However, the Water Framework Directive has set standards and timescales for water bodies to achieve 'good status'. In England 65% of rivers fail to meet 'good status' with Phosphorus being the biggest single factor in non-compliance. As a result, the P consents are being introduced for <10,000 PE works and progressively tightening for larger works.

Total P removal challenges

There are two methods of achieving Total P removal. Chemical P removal (CPR): achieved by dosing a coagulant (usually metal based) into the wastewater and Enhanced Biological P Removal (EBPR): achieved by configuring Activated Sludge Plant in a suitable layout and with additional recycles.

Currently EBPR cannot be achieved on bacteria bed, RBC or SAF sites. The vast majority of UK works employ CPR with either iron or occasionally aluminium coagulants to form metal phosphates which then settle out and can be removed in the sludge. An estimated 400,000-600,000 tonnes of iron products costing over £100 million are used in the UK per annum. In addition, iron has been classed as a specific pollutant meaning that dosing it automatically leads to an iron discharge consent (typically 1mg/l) being applied to the works.

The double challenge facing Water PLCs is that tighter P standards require higher iron doses which are themselves being subjected to tighter standards. A Tertiary Solids Removal process is often required to ensure compliance with the iron standard.

CPR will also result in an increase in sludge production. The best estimate of extra sludge on a CPR scheme is 15 – 25% on sites where chemical is dosed into an ASP, and 20 – 30% on sites where the chemical is dosed into the raw sewage or humus tank. Therefore sludge treatment and disposal capacity and costs must also be assessed as part of a CPR scheme.

Mixing matters

One of the essential characteristics of CPR frequently cited in the literature is the need to achieve rapid metal coagulant mixing. Iron or aluminium hydrolyses very fast (< 1-2 s) in the key initial reactions (Thisleton 2000). Phosphorus has to be captured in these fast hydrolysis reactions for effective precipitation. Hydroxyl and phosphate ions compete for the metal ions at the point of addition.

Pre-hydrolysed coagulants will still remove P by substitution with OH groups. However, the pre-hydrolysed coagulant reaction is much slower and the Fe:P ratio for a given percentage P removal up to 3 times higher than with fresh coagulant (Denham 2007).

As a result, potential savings of at least 25% of metal coagulant dose have been achieved (Farrimond and Upton 1993).



So what sort of savings can be made?

Simply by 'getting the mixing right' a saving of £50k per annum could be achieved on a typical 15,000 PE works, with annual iron coagulant costs in the order of £200k (approx. £15 PE per annum iron coagulant cost).

In addition, iron consents could be more easily met and sludge treatment and disposal costs reduced. There is therefore a very significant saving that can be made by 'getting the mixing right'.

Coagulant dosing can be carried out in different places dependent on the site configuration, this needs to be assessed on a site by site basis. As rapid coagulant mixing is an essential part of successful CPR it must therefore be assessed on every chemical P scheme.

Getting the mixing right in practice

However, 'getting the mixing right' is much easier said than done. Firstly, the 'right mixing' has to be quantified. Liquid blending rate is defined as the time taken between (coagulant) dosing and achieving a defined mixture quality. Mixture quality is defined using coefficient of (concentration) variation (CoV) with a value of $CoV \leq 0.05$ being the industry standard for 'good mixing'. A typical asset standard for coagulant mixing in potable treatment is $CoV \leq 0.05$ within 5 seconds of dosing, this standard also applied to CPR.

CPR is most frequently being applied to existing WWTW which were seldom designed with rapid mixing installations or equipment. The challenges of rapid mixing for CPR include highly variable plant flows which mean that mixers that must be sized for high plant flows provide overkill at low flows unless mixing intensity can be adjusted.

OUR EXPERTISE

BHR's expertise is founded on 20 years of research and consultancy specific to water & wastewater mixing.

This gives us the right skillset to design or recommend the optimum CPR mixing system on a site by site basis.

With BHR's CPR mixing assistance service the pay back for design and installation will be a matter of months based on coagulant dose savings alone.

References

Farrimond, M. & Upton J. (1993) 'A Strategy to Meet the Nutrient (N and P) Standards of the Urban Wastewater Directive.' *Water Science and Technology*, 27 (5-6), 297-306

Thistleton, J., Berry, T. A., Pearce, P. and Parsons, S. A. (2002) 'Mechanisms of Chemical Phosphorous Removal II: Iron (III) salts.' *Trans IChemE*, 80, Part B.

Denham, K (2007) 'Chemical Phosphorous Removal and Control Strategies.' Cranfield University School of Water Sciences, MSc Thesis



Image of Ferric dosing

WWTW frequently have low available head to drive the flow through static mixers, limiting the achievable mixing performance. In addition, process water and power supplies can be restricted at smaller works. Finally, ragging and blockage is always a serious issue particularly when dosing into raw sewage.

Certain dosing and mixing installations that are commonly used for CPR are quite incapable of achieving the required rate of rapid mixing ($CoV \leq 0.05$ within 5 seconds of dosing) to reap the benefits of lower coagulant consumption. Simple dose pipes or sparge bars, gas mixers and most flume & weir dosing arrangements are just not good enough. They might be cheap and expedient to install but they mix too slowly and are a false economy. Stirred tanks can mix fast enough but typically do so at the expense of very high energy costs compared with pipe or channel mixers.

Static mixers in pipes or channels are the mixers of choice to achieve rapid coagulant mixing in potable water treatment where the risk of fouling and blockages are low however that is not the case in CPR. Some specific static mixer types are designed to minimise fouling and they may be employed effectively under the right circumstances. Channel jet mixers are an excellent solution when head is limited and ragging potential high but there are currently no 'off the shelf' designs commercially available.