OPTIMISATION OF PHOSPHORUS REMOVAL AT WINMALEE SEWAGE TREATMENT PLANT

Paper Presented by :

Nelly Guevara

Authors:

Nelly Guevara
&
Greg Searle

Sydney Water Corporation

64th Annual Water Industry Engineers and Operators' Conference
All Seasons International Hotel - Bendigo
5 and 6 September, 2001

OPTIMISATION OF PHOSPHORUS REMOVAL AT WINMALEE SEWAGE TREATMENT PLANT

Nelly M.Guevara and Greg Searle, *Treatment Management Team,* Sydney Water Corporation

ABSTRACT

An optimisation programme was conducted at Sydney Water Winmalee Sewage Treatment Plant to determine the cost effective phosphorus removal in the sequenced batch reactors (SBR).

The different phosphorus removal mechanisms were evaluated and it was found that, simultaneous biological and chemical reactions were responsible for the phosphorus removal. The biological phosphorus removal represented the 32% whereas the chemical and adsorption mechanisms were represented by the 68% of the total phosphorus.

The addition of iron into the flow splitter reduced the SBR effluent phosphorus concentration from 1 mg/L to <0.5 mg/L and the 50 percentile final effluent total phosphorus was 0.1 mg/L, this was achieved with significant chemical cost reduction.

KEYWORDS

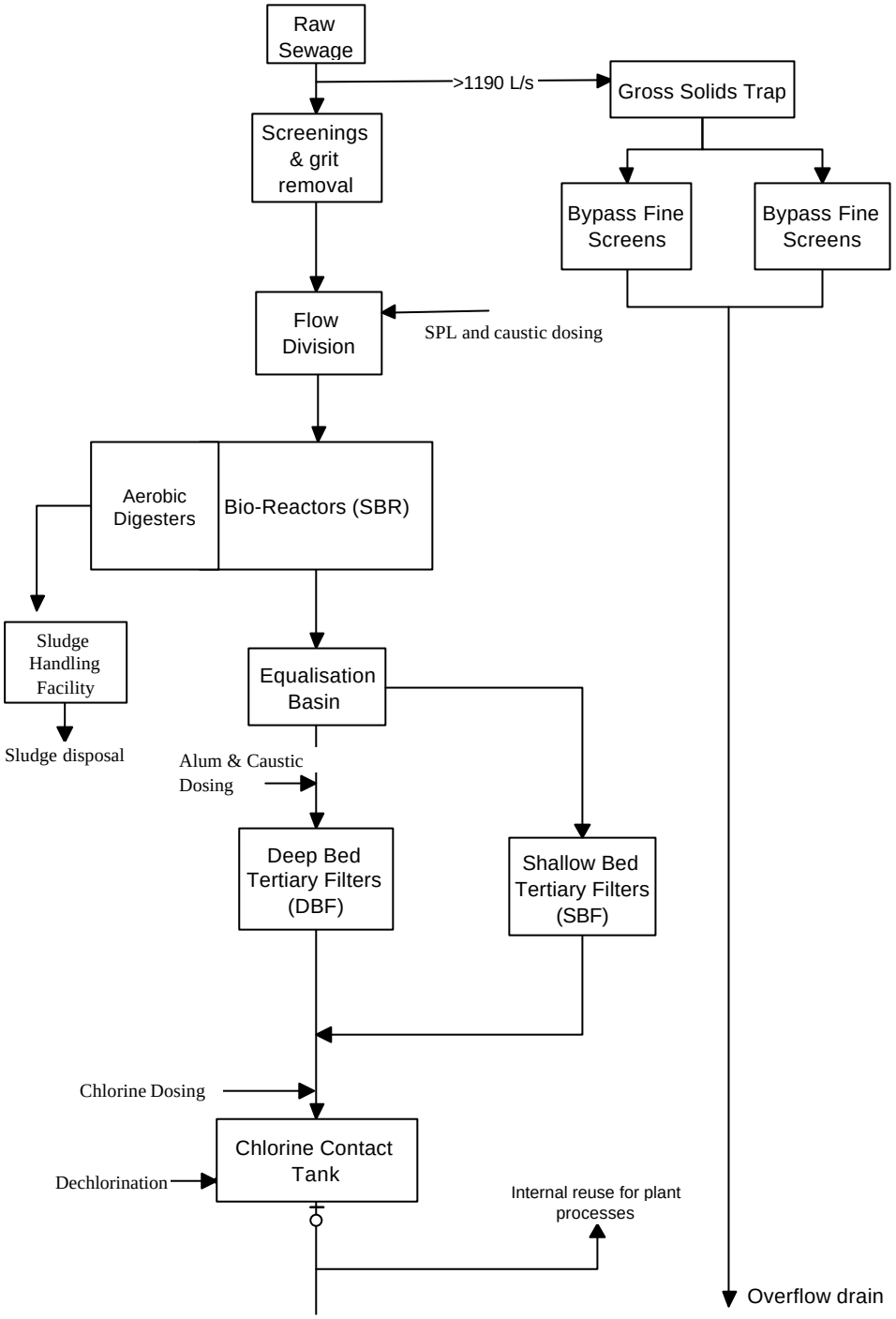
Activated sludge, biological phosphorus removal, chemical phosphorus removal, Spent Pickle Liquor (SPL), Sequenced Batch Reactor (SBR), Ortho Phosphorus (Ortho-P), Total Phosphorous (TP), Phosphorus Accumulating Organisms (PAO)

1.0 INTRODUCTION

Winmalee Sewage Treatment Plant was commissioned in May 1998 and it treats an average dry weather flow of 16 ML/d. Figure 1 shows its schematic process diagram and it consists of the following:

- Conventional preliminary treatment for screenings and grit removal.
- Sequenced Batch Reactor (SBR) activated sludge for solids and nutrients removal. The facility uses batch activated sludge processing with sequenced periods of aeration. This permits the use of a single vessel to accomplish both biological degradation reactions and solid-liquid separation.
- The plant has four SBR basins arranged to operate in two pairs. Each SBR operates with sequential phases of aeration, settle and decant.
- Tertiary treatment (ie. Filtration, chlorination and dechlorination) and
- Sludge dewatering process.

Figure 1: ***Schematic Diagram of Winmalee STP***



The SBRs at Winmalee STP were designed for biological and chemical phosphorus removal by the addition of alum at a concentration of 6 – 8 mgAl/L. An optimisation programme was carried out since September to enhance the phosphorus removal in the SBRs process by replacing alum with SPL (Ferrous solution) which is a by-product of steel manufacture at 160 g/L of Iron.

The SPL was dosed into the flow splitter where the screened degritted sewage flows upward, this action provides a turbulent flow which results in a suitable degree of mixing for the SPL and phosphorus chemical reaction.

This optimisation was based on studies carried out by scientists and researchers about the

interactions between chemical, adsorption and biological phosphorus removal in activated sludge.

During the optimisation, trials have been performed to determine the different phosphorus removal mechanisms, these are:

- Phosphorus removal by chemical precipitation.
- Phosphorus removal by adsorption.
- Phosphorus removal biologically by cell growth and PAO

1.1 Testing methods

All analysis were conducted on-site, using colorimetric methods for ortho-P, TP and total iron.

2.0 RESULTS AND DISCUSSION

The chemical phosphorus removal was optimised to determine the optimum SPL dose and it was found that, 50% of phosphorus removal is carried out in the early stages of the process particularly in the flow splitter with the remaining 50% occurring in the SBRs. Not all the phosphorus is removed by the addition of the SPL certain varieties of microorganisms utilise phosphate as an energy source for cell growth.

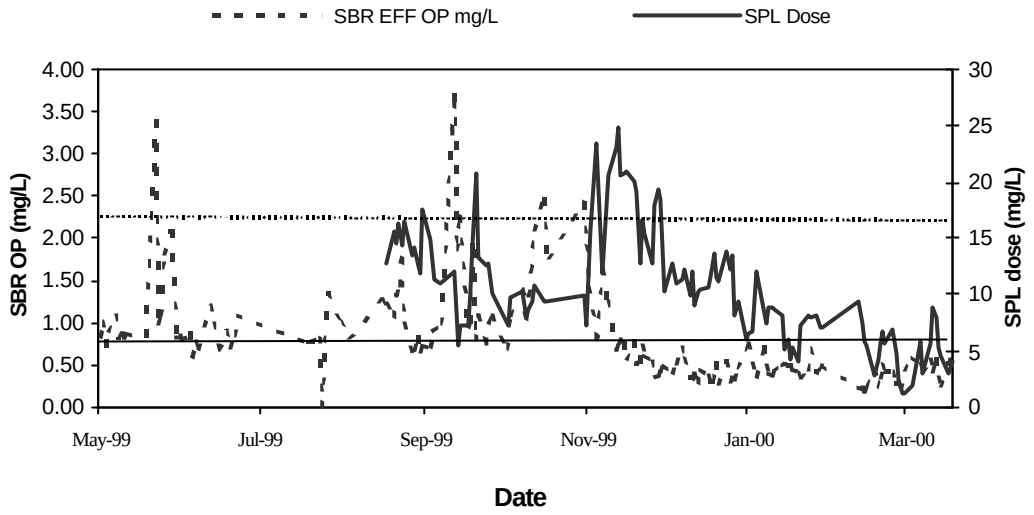
Jar tests and plant trials were carried out to found the optimum SPL dosage and found that, 8 –10 mgFe/L was the optimum dosage to achieve SBR ortho-P of <0.5 mg/L

The amount of phosphorus required for cell growth was calculated from the amount of phosphorus in the organic biomass wasted per day and it was found to be 42kg/d which represents 2.5 mgP/L of the incoming total phosphorus.

The phosphate adsorption capacity of the iron complex in the SBRs was measured in a laboratory scale trial and was found to be 0.00136 mgP/mgFe/d.

At this optimum operation the 50%ile SBR effluent ortho-P was <0.5 mg/L . Fig 2 shows the improvement in phosphorus removal using SPL .

Figure 2: ***SBR effluent ortho-P versus SPL dose***



The conversion to SPL for phosphate precipitation has overall been a positive move for the plant because the following benefits:

- Increases the average density of the activated sludge and improve its settleability.
- Reduces the alkalinity consumption, therefore reduces the need to add caustic to buffer alkalinity and pH.
- Low chemical usage and chemical costs savings.
- Low SBR effluent ortho-P concentration.

The Figs. 3 and 4 shows the alum usage and the chemical costs reduction respectively during the optimisation trials.

Figure 3: ***Daily alum usage***

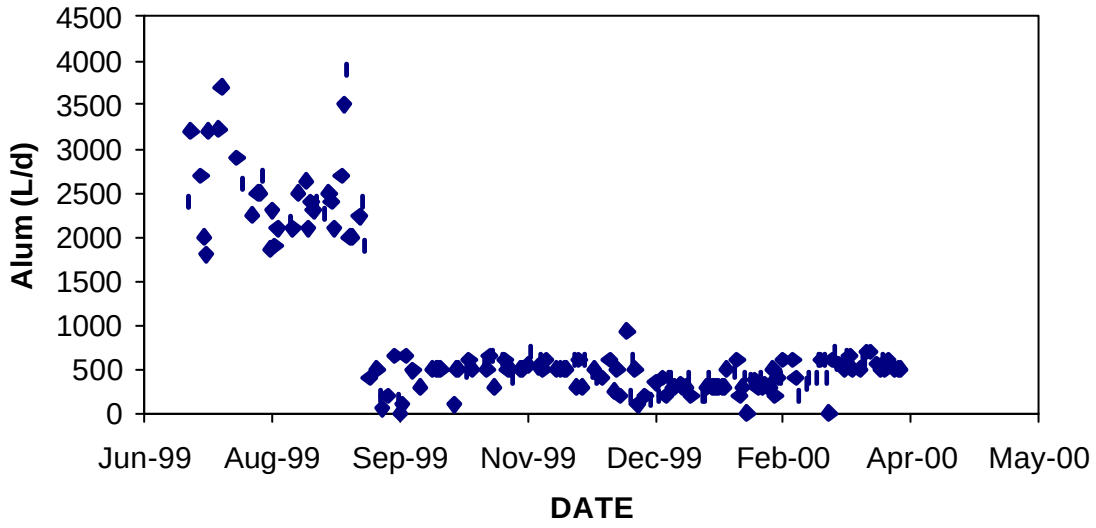
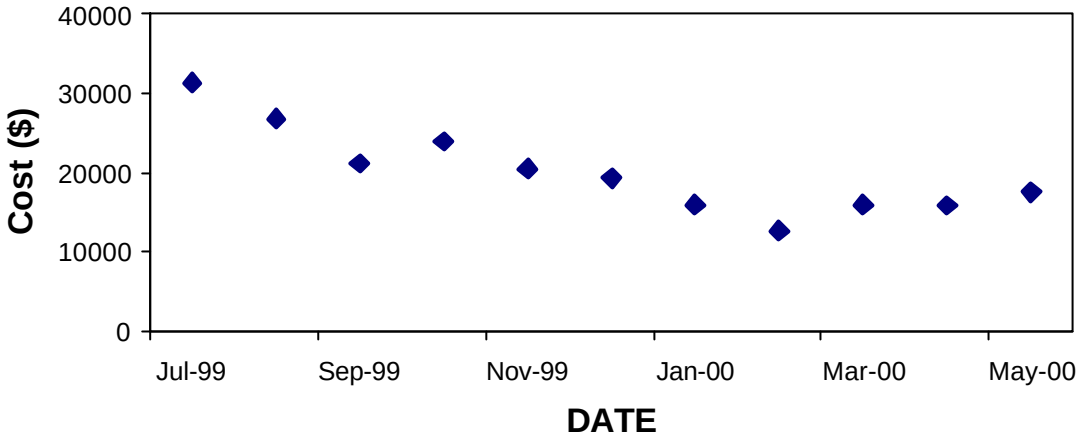


Figure 4: ***Monthly chemical expenditure***



3.0 CONCLUSIONS

The following conclusions are drawn from this optimisation trial.

- The addition of iron as SPL increased phosphorus removal , the SBR effluent ortho-P concentration improved from ~1mg/L to <0.5 mg/L.
- Simultaneous biological and chemical phosphorus removal was observed, it was found that, 60% of TP removed was by chemical precipitation, 25 % biologically for cell growth, 8% by adsorption and the remaining 7% biologically by Phosphate Accumulating Organisms.
- The alum usage for phosphorus removal was reduced by 80% with savings for the business of $120,000/year.

4.0 REFERENCES

He, Q.H., Leppard, G. G., Paige, C. R. and Snodgrass, W. J. (1996). Transmission electron microscopy of a phosphate effect on the colloid structure of iron hydroxide. *Wat. Res.* **30**(6) 1345-1352.

Roske, I. Schonborn, C. and Bauer, H. (1995) . Influence of the addition of different metals to an activated sludge system on the enhanced biological phosphorus removal. *Int. Revue Ges. Hydrobiol.* **80**(4), 605-621.

Roske, I. and C. Schonborn, (1994) . Interactions between chemical and advanced biological phosphorus elimination. *Wat. Res.* **28**(5) 1103-1109.

Sedlak, Richard, (1991) Editor of Phosphorus and Nitrogen removal from Municipal Wastewater, Second Edition

Spatzierer, G., Ludwig, C. and Matsche, N. (1985). Biological phosphorus removal in combination with simultaneous precipitation. *Wat. Sci. & Tech.* **17**, 163-176.