TECHNICAL NOTE

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ChemScan® APPLICATION SUMMARY

BIOLOGICAL PHOSPHOROUS REMOVAL

BACKGROUND

Domestic wastewater generally contains substantial inorganic phosphorous resulting primarily from human excrement and polyphosphates contained in synthetic detergents. Industrial wastewater may contain a variety of phosphate compounds. (Although some industrial waste may not contain sufficient phosphorous to promote the growth of the organisms used in wastewater treatment. See the application summary entitled "Nutrient Balancing" for a discussion of this issue). Polyphosphates gradually hydrolyze in wastewater and revert to orthophosphate form. This reversion is a function of pH, temperature and the presence of bacterial enzymes.

Many wastewater treatment plants are required to remove phosphorous during the treatment process. This is done in order to inhibit the formation of algae and cyanobacteria in surface waters by limiting the amount of this essential nutrient in the treated wastewater.

TREATMENT PRACTICES

There are two basic approaches for removal of phosphorous from wastewater. One approach uses coagulation of soluble phosphorous to form an insoluble precipitate which can be removed by sedimentation or filtration (For additional discussion see ChemScan Application Summary #91 (Chemical Phosphorous Removal.) The other approach relies on naturally occurring microorganisms that release stored phosphorous under anaerobic conditions and subsequently remove soluble phosphorous under aerobic conditions (biological phosphorous removal). Some biological phosphorous removal processes also have supplemental chemical phosphorous removal capability for tertiary treatment.

BIOLOGICAL PHOSPHOROUS REMOVAL

A bioreactor can be managed in a way that promotes the development of naturally occurring microorganisms which release stored phosphorous under anaerobic conditions and remove dissolved phosphorous under aerobic conditions. These microorganisms can tolerate cyclic exposure to anaerobic and aerobic conditions, thus giving them a competitive advantage over other specialized microorganisms. These acclimated organisms store organics under anaerobic conditions and, therefore, do not need to compete for the small volume of soluble organics typically available in the aerobic zone. (See Figure 1).

PROCESS TYPES

There are two basic types of biological phosphorous removal processes. The first process type allows all of the influent wastewater and the return activated sludge to enter an initial anaerobic zone and then enter a subsequent aerobic zone. The DO and nitrate concentrations in the anaerobic zone must be minimized. During the anaerobic period, soluble phosphorous will be released into the mixed liquor, while SBOD will be oxidized. A control strategy which focuses only on DO will not be able to account for oxygen contributed by nitrate. If either DO or nitrate are present in significant concentration, the zone will not be truly anaerobic and later phosphorous removal in the aerobic zone will be inhibited. Metal salt coagulants may be added in the aerobic zone to increase phosphorous removal where stringent discharge limits apply. Sample points for full control would include the anaerobic zone, aerobic zone and final effluent.

The second process type allows only a portion of the return sludge to enter a sidestream anaerobic tank. (See Figure 2.) Soluble phosphorous liberated in the anaerobic tank is chemically precipitated or coagulated, while stripped biological solids from the anaerobic tank are returned to the main aerobic treatment tank, where the organisms in these solids uptake additional soluble phosphorous. The stripper tank can be monitored on-line to assure low soluble phosphate in the stripped sludge return flow compared to the soluble phosphate in the anaerobic tank influent, as a measure of soluble phosphate leaching efficiency. On-line monitoring of aerobic reactor samples and final effluent can also be used to verify overall process efficiency.

CONTROL ISSUES

The most important component of a control strategy for biological phosphorous removal is to assure that soluble phosphorous is being released in the anaerobic zone and is being removed in the aerobic zone.

Proper control is difficult to achieve using manual techniques such as grab samples and DO monitoring. There are several reasons for this difficulty:

- incoming phosphate concentrations can vary in unpredictable ways as a result of industrial contributions.
- incoming phosphate concentrations do not necessarily vary in proportion to flow.
- long acclimation periods are required to cultivate a population of organisms that can survive alternating anaerobic and aerobic cycles.
- high recycle nitrate concentrations can inhibit anaerobic zone processes. Thus, DO can be low but the anaerobic zone can be inhibited for other reasons.
- DO is not the best indicator of aerobic zone phosphorous removal performance. Reduction of soluble phosphate is the most direct and most reliable indicator.

MONITORING STRATEGY

The monitoring strategy will depend on the type of process being employed, as discussed above.

ChemScan Process Analyzers can be used to monitor dissolved orthophosphate from anaerobic tanks and aerobic tanks, in return sludge and in final effluent, as appropriate. A single system can monitor multiple sample points and can also monitor nitrogen components in full nutrient removal processes.

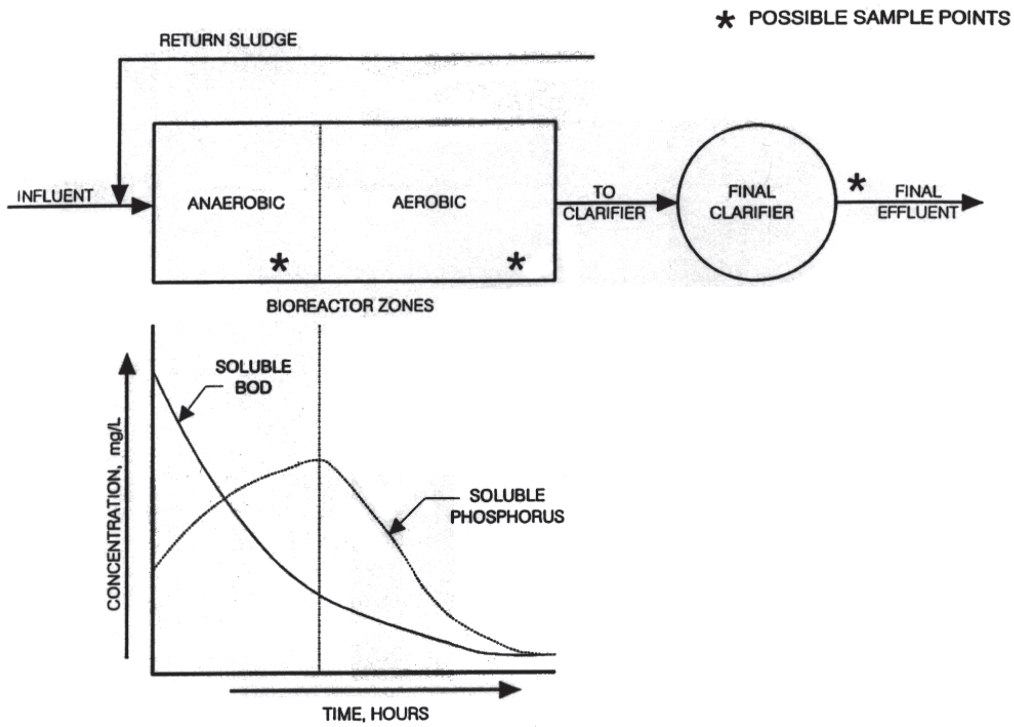

Figure 1. Soluble Biochemical Oxgen Demand and Phosphorous in Bioreactor
(Source: WEF Manual of Practice MOP 11, Operation of Municipal Wastewater Treatment Plants)

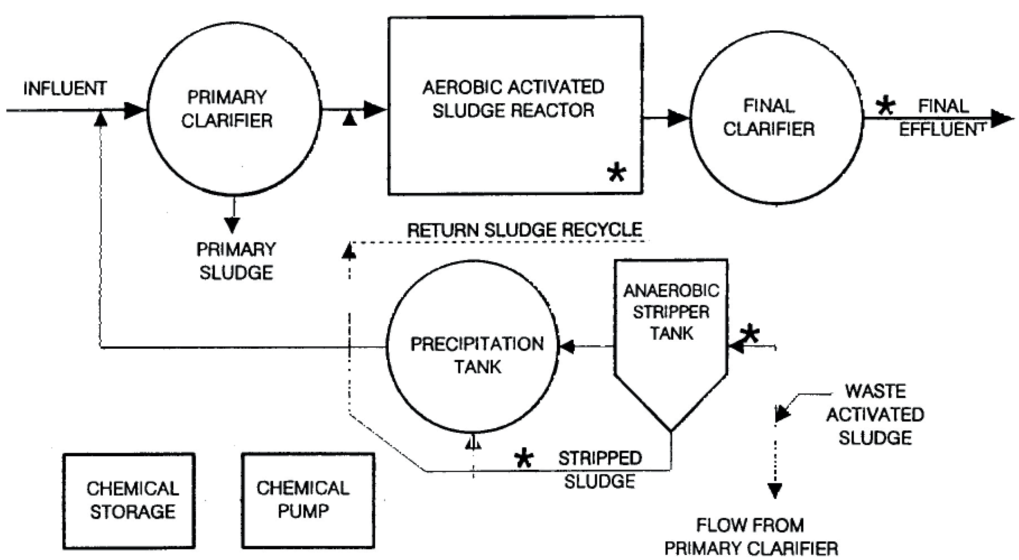

Figure 2. Sidestream Process for Biological Phosphorus Removal
Source: WEF Manual of Practice MOP 11, Operation of Municipal Wastewater Treatment Plants)

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