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Wastewater Nutrient Standards Becoming the Norm

Focus Phosphorus

Over the better part of the past four decades, secondary wastewater treatment has been the norm with only a small fraction of facilities having to meet more advanced standards. However, remaining water quality concerns are making nutrient standards common place, and over the next few years advanced wastewater treatment for phosphorus and/or nitrogen nutrient removal will become the norm.

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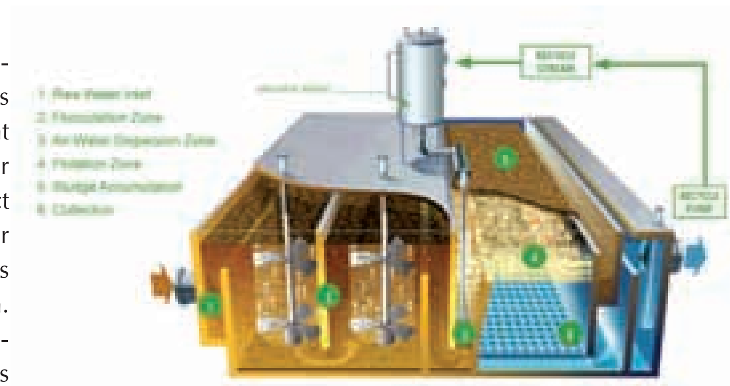

Schematic of AquaDAF® System installed in Hudson, MA Wastewater Treatment Facility to achieve 0.1 mg/l phosphorous standard.

For freshwater discharges, phosphorus is typically the nutrient of concern, while for discharges that impact marine environments or groundwater, nitrogen is the nutrient of concern. In freshwater environments, phosphorus is often the limiting factor for algae growth and can have significant impact on water clarity and oxygen levels. Where these water quality concerns exist, phosphorus standards are being imposed. Standards may range from 1 mg/l down to less than 0.1 mg/l depending on the receiving water quality limitations.

In the typical secondary treatment plant about one third of the influent phosphorus is removed via settling of insoluble forms of phosphorus and cell growth (typical cell is about 1.9% P on weight basis). To remove more phosphorus a couple of things have to happen. First, the remaining soluble phosphorus has to be converted to an insoluble form, and then the insoluble phosphorus has to be settled or otherwise captured.

Converting phosphorus chemically

The most common way to convert soluble phosphorus to an insoluble form is to chemically precipitate it with a metal salt, such as alum or ferric chloride. There are a number of factors that need to be considered in selecting the best chemical or combination of chemicals, the points of addition, and the appropriate dosage of chemicals. Chemical precipitation of phosphorus is well proven and easy to install and control. With this approach, it is relatively easy to convert the majority of the phosphorus to an insoluble form. However, the lower the phosphorus limits, the higher the chemical dose required. The downsides of chemically removing phosphorus include chemical costs, increased sludge production, and the difficulty of sludge dewatering. Chemical precipitation to low levels can be difficult if there is an unusual fraction of recalcitrant phosphorus. Accordingly, it is very impor-

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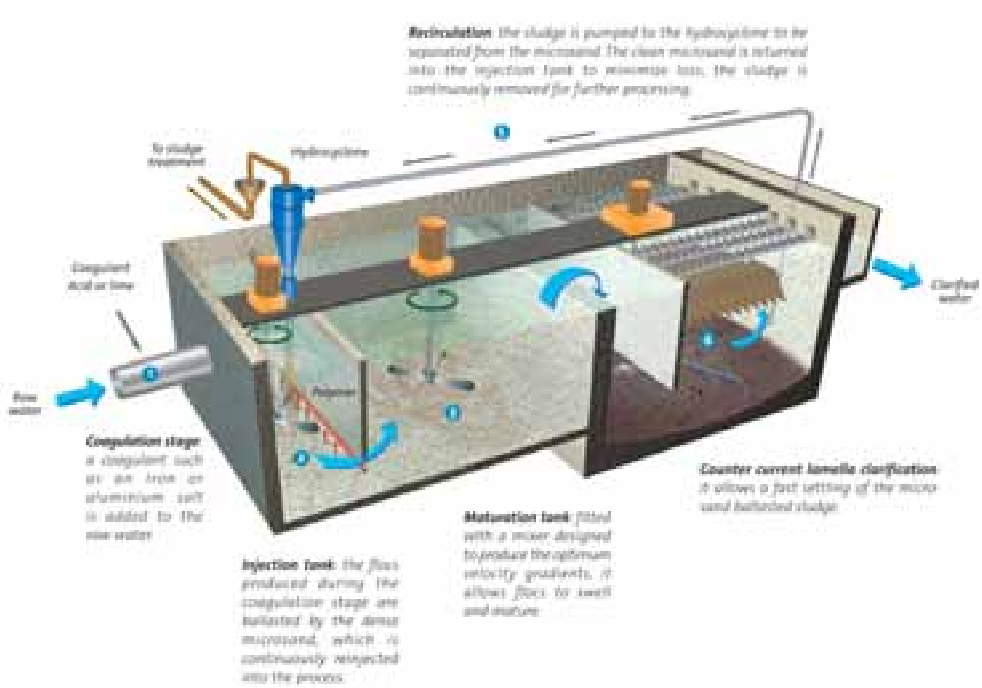

Schematic of the Actiflo® process, a ballasted clarification system historically used for water treatment and now also used in wastewater applications.

tant to understand the forms of phosphorus in the waste stream, particularly if you have to achieve very low levels.

Converting phosphorus biologically

You can also biologically convert soluble phosphorus to insoluble phosphorus. Typical wastewater microorganisms are about 1.9% P by weight. By subjecting the microorganisms to specific conditions (anaerobic conditions followed by aerobic) you can select for micro-organisms (poly-P bacteria) that have the ability to accumulate excess phosphorus, typically 3 to 15% P by weight. The advantages of biologically removing the phosphorus include less sludge production, no chemical cost, and improved settling due to filamentous bacteria control that results from the anaerobic zone. The typical disadvantages of biological phosphorus (bio-P) removal include higher installation costs, complexity of operation, and the inability to achieve as low soluble phosphorus concentrations as through chemical precipitation. Typically it is assumed that bio-P strategies will only get you down to the 0.5 mg/l range and if you need to go lower you will need to supplement with chemicals.

Separation of Solids

One of the most important issues associated with phosphorus removal is the solids separation system. Once the phosphorus is converted to insoluble forms (chemically and/or biologically), the solids need to be captured. Which solids capturing systems are employed is a function of the effluent phosphorus standard and other treatment issues.

Typical secondary clarifiers will remove suspended forms of phosphorus to achieve a phosphorus standard in the 0.5 to 1 mg/l range. Generally you have to consider advanced solids separation systems when you have to achieve limits less than 0.5 mg/l. The types of systems used are very similar to the typical equipment used for the treatment of potable water.

If you are faced with a phosphorus limit as low as 0.2 mg/l, filtration systems are commonly employed. These include a wide variety of sand, cloth and plastic media filters. If you have to achieve phosphorus limits as low as 0.1 mg/l, ballasted and buoyant clarification systems are common such as Kruger's Actiflo® process, Cambridge Water Technology's CoMag® process, and Degremont Technology's Densedag® and AquaDAF® processes. Filtration systems preceded by high rate settlers or dual filtration systems in series can also be utilized for limits as low as 0.1 mg/l.

To achieve even lower limits, membrane filtration or combinations of systems in series (such as a ballasted clarification system followed by sand filtration) would be considered. For very low standards, pilot studies are appropriate to prove a technology before selecting a preferred option.

Stringent phosphorus limits are on the increase. There are many options available to achieve phosphorus limits. The best solution is a function of the phosphorus limit currently and in the future, site specific issues, operational considerations, and cost. It is prudent to analyze all the options and to select a solution on life cycle cost analysis and operational considerations.

Sanford, ME Wastewater Facility uses both biological and chemical removal strategies to convert soluble phosphorous to insoluble phosphorus. The suspended phosphorous is removed with flocculation, lamella clarifiers, and sand filtration to achieve a phosphorous limit of 0.1 mg/l.