Emerging ISSUES

# Phosphorus

*Essential Nutrient Can Pose Problems for Wastewater Treatment*

Phosphorus is a naturally occurring element, found in water, food, and the human body, especially our teeth and bones. It is a vital nutrient for humans, plants, and animals.

Phosphates are natural compounds: salts containing phosphorus and other minerals, and are used in baking products, toothpaste, and carbonated beverages. Phosphates and phosphoric acid are used in fertilizers.

Phosphate is a common ionic form of phosphorus consisting of one phosphorus atom bonded to four oxygen atoms, and is represented chemically as $PO_4^{-3}$. Because the phosphate ion has a negative charge, it readily combines with positively charged ions to form numerous compounds. For example, when combined with hydrogen it forms phosphoric acid, $H_3PO_4$. Because phosphorus is commonly found in the form of phosphate, the terms "phosphorus" and "phosphate" tend to be used interchangeably.

As an essential plant nutrient, phosphorus is a key component of fertilizer for agriculture in the form of concentrated phosphoric acids. Global demand for fertilizers led to large increase in phosphate production in the second half of the 20th century, resulting in the agricultural industry being heavily reliant on fertilizers that contain phosphate, mostly in the form of superphosphate of lime.

Photo source: Thinkstock.com

*Phosphorus is a key component of fertilizer for agriculture.*

## Why are phophates and phosphorus an issue?

Because it is a plant nutrient, phosphorous and phosphates trigger algal blooms that deplete the receiving waters of oxygen under certain conditions, killing the aquatic life. This process is called eutrophication and, although reversible and based on natural effects (plant nutrient, plant development), has become a significant environmental problem. In many surface waters, algal blooms can have considerable detrimental impacts on leisure activities, tourism, and fish and other organisms. Algal blooms also impact the source water quality for drinking water utilities. Although fertilizer runoff is a big contributor to eutrophication, domestic sewage also contributes to the problem.

Photo source: Thinkstock.com

*The Chesapeake Bay watershed continues to deal with excess phosphorous and other nutrients.*

## Reducing Phosphorus From Wastewater Discharges

The removal of phosphorus during sewage treatment process has become an area of interest as more and more regional regulations take effect. The Chesapeake Bay, where the U.S. Environmental Protection Agency has established the Chesapeake Bay Total Maximum Daily Load calling for a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus, and 20 percent reduction in sediment, is one example of a regional regulation.

The biological removal of both nitrate and phosphate is often the best method. However, biological removal is not possible in most situations so wastewater treatment plants have to resort to chemical and more elaborate means to deal with phosphorus.

Treatment technologies currently available for phosphorus removal include those categorized as physical (e.g., filtration and membrane technologies), chemical (e.g., precipitation and physical-chemical adsorption), and biological (e.g., assimilation and enhanced biological phosphorus removal).

Physical treatment with sand filtration is similar to a sand filter in a drinking water plant. Membrane technology is also being employed and can include micro-, nano-, ultra-filtration or reverse osmosis. In these processes, the membranes physically filter some of the phosphorus.

Chemical treatment for phosphorus or chemical precipitation has been used for many years. The chemicals used include compounds of calcium, aluminum, and iron. The most commonly used chemical is ferric chloride or ferrous sulphate. Other chemical-physical processes can include enhanced coagulation where the chemical addition helps settle the phosphorus out.

Biological treatment is the most commonly used process. Traditionally, this involved treatment ponds containing planktonic or attached algae, rooted plants, or even floating plants (e.g., water hyacinths, duckweed). Enhanced biological phosphorus removal (EBPR) is becoming a popular treatment for phosphorus removal. EBPR has the potential to achieve low (<0.1 mg/L) effluent phosphorus levels at modest cost and with minimal additional sludge production.

EBPR features an anaerobic tank (nitrate and oxygen are absent) prior to the aeration tank. In the anaerobic tank, bacteria called polyphosphate-accumulating organisms are selectively enriched in the bacterial community within the activated sludge. These bacteria accumulate large quantities of polyphosphate within their cells, enhancing the removal of phosphorus.

Removal of traditional carbonaceous contaminants (biological oxygen demand), nitrogen, and phosphorus can all be achieved in a single system, although it can be challenging to achieve very low concentrations of both total nitrogen and phosphorus in such systems. The phosphate in EBPR is removed in the waste activated sludge, which might have five percent or more phosphorus (dry weight) as opposed to only two to three percent in non-EBPR sludges.

Regardless of the method used, removing phosphorus is necessary to assure healthy aquatic and plant life, as well as protecting the water that becomes drinking water.

## References


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## For More Information

The National Environmental Services Center magazine *Small Flows* has a juried article titled "Cost and Affordability of Phosphorus Removal at Small Wastewater Plants" online at www.nesc.wvu.edu/pdf/ww/publications/smallflows/magazine/SFQ_FA04.pdf (beginning on page 36 in the publication).

NESC has two *Tech Briefs* related to filtration. The first, an overview of different processes, can be viewed and downloaded at: http://www.nesc.wvu.edu/pdf/dw/publications/ontap/2009_tb/filtration_DWFSOM51.pdf. The second, covering membrane filtration, is available at: www.nesc.wvu.edu/pdf/dw/publications/ontap/2009_tb/membrane_DWFSOM43.pdf.


Tech Brief

Filtration

Filtration Keeps Water Safe


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Membrane Filtration