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Opinion

Solving the Crisis of Harmful Algal Blooms

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Introduction

The main cause of harmful algal blooms is the presence of nutrients, like phosphates, from surface water runoff, septic fields, municipal wastewater treatment plant effluents and from industries. The presence of nutrients, sunlight and warmer temperatures result in the growth of these harmful algal blooms of naturally occurring phytoplankton. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Some algal blooms are harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water.

Background

Various methods have been used for phosphate removal from wastewater, including biological treatment, adsorption, chemical precipitation, ion exchange, electrodialysis, and membrane filtration [1-5]. Because the efficiency of phosphate removal through biological treatment does not exceed 30%, complementary techniques are required for removal of the residual phosphate in wastewater effluent. Chemical precipitation can also be used; however, this method has several disadvantages, including high capital and operational costs, sludge production in high volumes, the requirement for additional manpower, and application of chemical compounds. In addition, when aluminum and iron are used as coagulants in chemical precipitation, alkaline conditions must be maintained during the operation. Ammonia removal is also achieved by biological nitrogen removal (BNR), air stripping, and ion exchange. BNR is the common treatment for low ammonia concentrations in wastewater. Nevertheless, this method is not effective when high concentrations are present because high levels of ammonia inhibits the process. Moreover, these processes are not capable of significantly reducing the ammonia concentrations. Furthermore, transferring the pollutants to another media poses high operational costs.

Needed to fertilize crops, the bulk of phosphorus comes from nonrenewable phosphate rock. While China mines the most - producing almost half the world's phosphorus - Morocco alone controls three-fourths of global phosphate rock reserves. Year by year those global reserves dwindle, leaving phosphate rock that's ever lower in quality and ever harder to extract. At the same time, as agriculture expands over the coming decades, experts project increasing demand for mineral phosphorus. Recycling only 37 percent of domestic phosphorus can fertilize all the corn production in the US. Furthermore, about 90 percent of the world's mined phosphorus ends as the crucial ingredient in fertilizers. With the planet's population heading towards 9 billion people by 2050, we must ensure adequate supplies of phosphorus-enriched fertilizers to grow food.

Wastewater treatment facilities are commonly required to implement treatment processes that reduce effluent nutrient concentrations to levels that regulators deem sufficiently protective of receiving waters. As nutrient issues continue to persist, requirements will become increasingly important and more stringent. Although nearly all wastewater treatment plants provide a minimum of secondary treatment, conventional secondary treatment processes typically do not remove enough phosphorus to meet water quality standards in nutrient-sensitive environments. To meet regulatory requirements, facility operators may retrofit a plant to enhance the biological treatment processes or add chemical treatment for precipitating phosphate. This additional stage of treatment is a form of tertiary treatment.

Treatment plant modifications can remove nitrogen and phosphorous through carefully designed biological and chemical processes that generate easily isolated products such as precipitates and gases. As mentioned above, phosphorus can be removed from wastewater through biological uptake by microorganisms (or enhanced biological phosphorus removal, EBPR) and by chemical precipitation with a metal cation. Depending on the target concentration, a facility might employ both technologies. This combined approach might be of particular benefit if the target concentration is very low and the starting concentration is high. In such a case, EBPR is used to remove the bulk of the phosphorus, and chemical polishing follows to achieve the final effluent concentration. This approach (referenced here as EBPR+C) maximizes the ability of the existing biological population in the wastewater to assimilate phosphorus while reducing chemical sludge formation. Most of the EBPR processes greatly increase uptake of phosphorus by organisms that are later removed as solids.

There are two possible approaches for reducing nutrients in wastewaters:

a) Nutrient Recovery
b) Nutrient Destruction

Nutrient destruction utilizes biological nitrification and denitrification reactions to destroy nitrogen and precipitates phosphorus biologically. Use of biomedia to grow biofilms, such as in Integrated Fixed Film Activated Sludge (IFAS) enables simultaneous nitrification and denitrification within the same vessel. However, nutrient destruction involves significant aeration costs, is impacted by ambient temperature and involves major equipment modifications. Further, nutrients have "value" that can be exploited for economic gain.

Alternative nutrient recovery processes include the following:

a) Recovery of struvite (magnesium ammonium phosphate) from digester supernatant.

b) Production of biosolids-enhanced granular inorganic fertilizers

c) Air stripping of ammonia followed by gas absorption to produce ammonium sulfate; and

d) PRD Tech's Membrane process for directly converting ammonia in water to ammonium sulfate using a membrane contactor.

Only 5-15% of nitrogen is recovered through phosphate-based precipitation processes. Stripping and gas absorption are well-known methods to remove nitrogen from wastewater but require large towers and significant air flows to achieve the needed reductions and only reduce nitrogen, not phosphorus. There is a need for simultaneous recovery of both nitrogen and phosphorus from wastewaters.

Chemical Complexation Enhanced Adsorption for Nutrient Recovery and Reuse

In this short paper, a chemical complexation mechanism is used to recover and reuse nutrients from a wide variety of wastewaters. The mechanism involves the use of pellets, NutrabindTM, which can simultaneously remove nitrates, nitrites, ammonium and phosphates from the water, and then these NutrabindTM pellets can be tilled in the soil to provide the nutrients for farms. These pellets can be deployed in floating buoys in existing ponds, lakes, rivers as well as used in packed beds for recovering nutrients from wastewater treatment plants effluents and surface water runoff from farms. This is the most cost-effective method for preventing the growth of harmful algal blooms in water bodies.

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