



Phosphorus and Eutrophication

The Owasco Lake Watershed Management Council



Where does phosphorus come from?

All organisms require phosphorus for basic life processes. Phosphorus is naturally found in rock, soil, and organic material. It binds itself to sediment and can be used by vegetation. Due to this, phosphorus is used as a fertilizer for lawns and crops and is found in greater concentrations surrounding human activity. An excess of phosphorus can wreak havoc on aquatic systems.

How does phosphorus enter water?

Rain events cause sediment-bound phosphorus to runoff into aquatic systems such as lakes, streams, and the ocean. Phosphorus can exist in water in a particulate phase or a dissolved phase. Particulate matter includes precipitates of phosphorus, phosphorus adsorbed (attached) to particulates (i.e. sediment), and amorphous phosphorus. In water, phosphorus is typically found in the form of phosphates (PO_4^{-3}). Phosphates can exist in inorganic forms such as orthophosphates and polyphosphates, or in organic forms, such as organically bound phosphates.

What is organic phosphate?

Organic phosphate is phosphate that is bound to plant or animal tissue and is formed by biological processes. Humans contribute to this form of phosphate through sewage, body waste, and food residue. They may also be formed through the breakdown of pesticides used on lawns or in farming applications. They can exist in a solution, in the bodies of aquatic organisms, or as loose fragments within the environment.

What is inorganic phosphate?

Inorganic phosphate is phosphate that is not associated with living organisms, biological processes, or organic material. These types of phosphate include orthophosphates and polyphosphates.

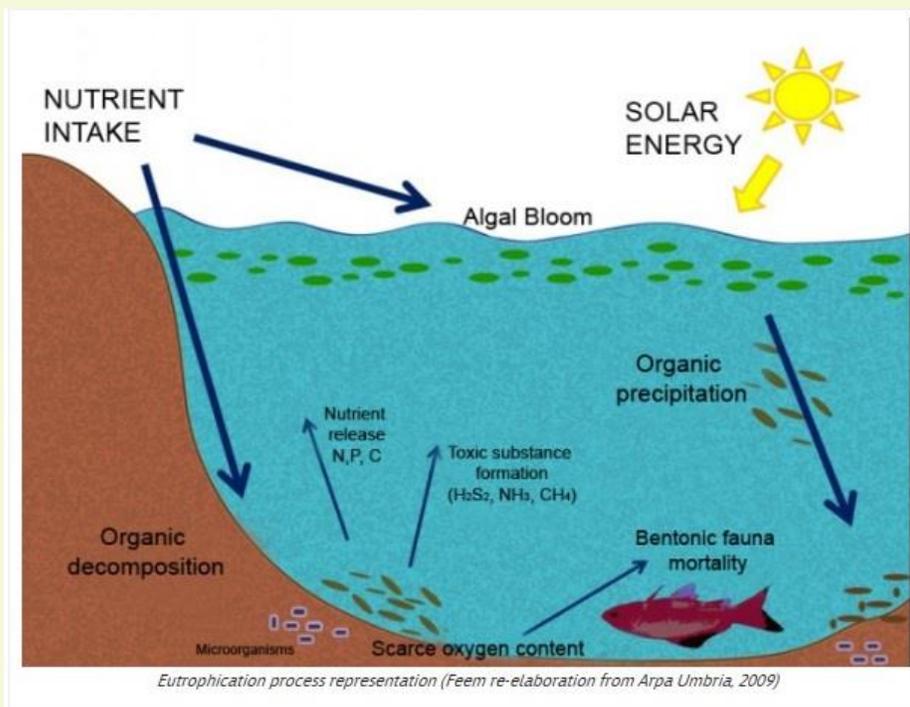
Orthophosphates are often referred to as “reactive phosphorus,” and are the most stable form of phosphorus. It is the form used by plants, is produced by natural processes, and is found in human sewage.

Polyphosphates are known as metaphosphates or condensed phosphates. In aquatic systems, polyphosphates are unstable and eventually convert to orthophosphates.

Are phosphates toxic, and how do they cause eutrophication?

Phosphates are not toxic to people or animals unless they exist in very high concentrations.

In freshwater, phosphorus is often the growth-limiting factor because it is found in the least amount relative to the needs of plants. Aquatic environments with high concentrations of phosphorus cause algae and plants to be produced in enormous quantities. When algae die, bacteria decompose them, and use oxygen in the water. This process is known as eutrophication. Dissolved oxygen concentrations in the water can drop low enough to inhibit the fish population from breathing, causing fish kills. Decomposition of fish by bacteria can lower dissolved oxygen in the water as well. When oxygen is lost, trapped phosphorus at the bottom of the water body can be released from sediments, further increasing available phosphorus. This positive feedback loop can produce HABs repetitively if nutrient loading isn't controlled.



When oxygen is lost, trapped phosphorus at the bottom of the water body can be released from sediments, further increasing available phosphorus. This positive feedback loop can produce HABs repetitively if nutrient loading isn't controlled.

How is phosphorus measured?

Phosphorus can be measured in several ways.

Total phosphorus (TP) is a measure of all forms of phosphorus such as dissolved phosphorus or particulate phosphorus.

Soluble reactive phosphorus (SRP) can measure orthophosphate, or the filtered fraction of phosphorus such as soluble and inorganic phosphorus. This is the form of phosphorus that is used by plants.

Phosphorus and orthophosphate are measured through a colorimetric method, which involves analyzing the color of the water sample to determine phosphorus concentrations. If TP is measured, all forms of phosphorus are converted to dissolved orthophosphate through the use of acid, persulfate, and heat. A chemical is then added to the sample which will affect its color. The darker the color appears to be, the more phosphorus is present in the water sample. This test can

be done visually or by comparing the sample to a set of reference colors. The most accurate representation of phosphorus is determined by using an electronic colorimeter, which uses a low light source and a photodetector to determine the concentration of phosphorus by the amount of light absorbed by the sample.

What are the greatest contributors to phosphorus loading in aquatic environments?

1. Wastewater and Septic Systems

- a. Organic phosphates are formed by biological processes and improperly functioning septic systems can leach phosphorus into water.

2. Detergents

- a. Orthophosphates and some polyphosphates exist in commercial cleaning products.

3. Fertilizers

- a. Many fertilizers contain orthophosphate.
- b. Phosphate is not very mobile in soil due to the fact that it remains bound to sediment. However, an overuse of fertilizers can cause phosphates to be carried out to surface water during storm events or snow melts. These fertilizers can be from farm use or residential use.
- c. Soil erosion from either of these locations can carry additional phosphorus in the particulate form to nearby water bodies and streams.

4. Animal Waste

- a. Phosphorus is essential in metabolism, so it is present in all animal waste.
- b. Phosphate runoff from locations with livestock can be problematic to nearby water bodies and streams.

5. Development

- a. Development can lead to soil erosion, releasing sediment-bound phosphorus to nearby water bodies and streams.
- b. If wetlands are drained for development, the sediment that was buried could be exposed and released.
- c. Phosphorus concentrations in runoff can increase due to a lack of natural filters such as trees that have been removed after development and take up water and phosphorus.

6. Industrial Discharge

- a. Polyphosphates are commonly added to water to reduce the possibility of iron oxides or calcium carbonates from forming.
- b. If this water is released, polyphosphates can enter nearby water bodies and streams and convert to orthophosphate.

7. Phosphate Mining

- a. Areas in which phosphate is mined, concentrated, or processed can contribute to phosphorus loading in nearby water bodies and streams.

b. The mineral apatite contains a significant amount of phosphorus.

8. Drinking Water Treatment

a. Orthophosphates and polyphosphates are added to some water supplies throughout treatment.

9. Forest Fires

a. Forest fires can cause soil erosion and release sediment-bound phosphorus to nearby water bodies and streams.

10. Synthetic Materials

a. Organophosphates are often added to construction materials, flame retardant, and plasticizers.

b. Insecticides and some synthetic organic chemicals can contain reduced forms of phosphorus.

What are the water quality standards of phosphorus?

The EPA recommends that TP should not exceed 0.05 mg/L in a stream at a point where it enters a lake and should not exceed 0.1 mg/L in streams that do not discharge to lakes (Muller and Helsel, 1999).

References

Heidel, Katherine & Roy, Sujoy & Creager, Clayton & Chung, Chih-fang & Grieb, Tom. (2006). Conceptual Model for Nutrients In the Central Valley and Sacramento-San Joaquin Delta. 10.13140/RG.2.2.13466.13769.

Muller, D. K. & Helsel, D. R. (1999). Nutrients in the nation's water--Too much of good thing? Circular 1136. U.S. Geological Survey, Denver.

Murphy, S. (2007). General Information on Phosphorus. Retrieved from <http://bcn.boulder.co.us/basin/data/NEW/info/TP.html>