Phosphate

What is phosphate?

Phosphate (PO_4^{3-}) is an ionic (water-soluble) form of phosphorous. Phosphorus can be measured as total phosphorus (TP) or as soluble reactive phosphate (SRP), which is also called phosphate (PO_4^{3-}) or orthophosphate (ortho-P). Phosphate represents the fraction of TP that is available to organisms for growth and is the fraction that is usually measured in water quality studies. Phosphate, PO_4^{3-}, is measured in terms of mg/L (parts per million, ppm) or $\mu g/L$ (parts per billion, ppb). Phosphate phosphorous, PO_4^{3-}P, is equivalent to a phosphate measurement divided by 0.3261, which is the ratio of the atomic weights of phosphorus to phosphate (30.97 g/mol / 94.97 g/mol).

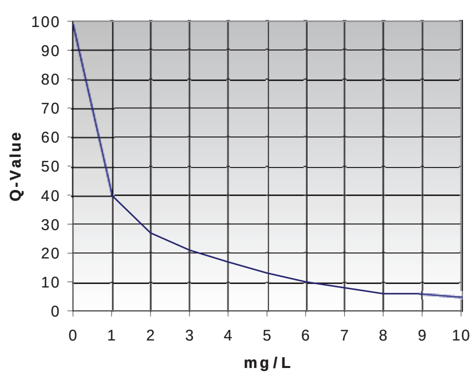
Phosphate is one of the major nutrients required for plant and animal growth and is essential for life. Phosphate is used by all aerobic organisms (organisms that require oxygen to live) in the production of energy-storage molecules, and it is a constituent of cell membranes and other intracellular molecules and structures, including DNA.

Why measure phosphate?

Phosphate is generally the rate-limiting eutrophication reagent. That is, in most circumstances, of all the nutrients required for freshwater plant growth, phosphate is the one that is used up first. Therefore, when there is no more phosphate, plant growth stops. Conversely, when phosphate is present, plant growth is stimulated. The presence of excessive amounts of phosphate stimulates excessive plant growth.

Excessive plant growth in aquatic environments stimulated by excessive nutrient content, called accelerated or cultural eutrophication, interferes with water use and is considered a nuisance. Algal growths impart undesirable tastes and odors to the water, interfere with water treatment, become aesthetically unpleasant, alter the chemistry of the water supply, and contribute to the phenomenon of accelerated or cultural eutrophication. Eutrophication often leads to anoxic conditions that occur when plant material is broken down by bacteria, and the dissolved oxygen is consumed during bacterial respiration. Most of the eutrophication problems are associated with lakes or reservoirs, rather than streams and rivers.[1]

Chart 8
Phosphate Results



(Note: If phosphate > 10.0, Q=2.0)

The impact of phosphate levels on water quality is illustrated by the phosphate Q-value curve for determining a water quality index as shown in this graph (see also the Water Quality Index section).

The Q-value curve for phosphate that is used in the calculation of a water quality index illustrates that water quality declines dramatically as the concentration of phosphate increases.

Of all the elements required for aquatic plant growth, phosphorus is the most easily controlled, and measurement is the first step in that control.[1] The presence of high levels of phosphates may indicate a point source of pollution that could be better managed.

What factors affect phosphate values?

Phosphate comes originally from phosphate rock, or phosphorite, a non-detrital sedimentary rock. The phosphate rock beds lie within a few feet of the surface, and mining is accomplished by use of hydraulic water jets and a washing operation that separates the phosphate from waste materials, a process similar to strip mining. Runoff from such operations can cause elevations in aquatic phosphate levels.

Phosphates are present in human and animal waste including bird guano, so untreated sewage causes increases in phosphate levels. Phosphate detergents used to be significant sources of aquatic phosphate, but environmental concerns have prompted the development of nonphosphate-containing laundry detergents. Nevertheless, some phosphate cleaners and other domestic chemical preparations containing phosphate are still in use and can enter natural waters through urban runoff. Some industries, such as potato processing, have wastewaters high in phosphates. Crop, forest, urban, and idle land contribute varying amounts of phosphates from surface runoff of rainfall, effluent from drainage pipes, or return flow from irrigation. Fertilizers, cattle feedlots, concentrations of domestic duck or wild duck populations, tree leaves, and fallout from the atmosphere are all contributing sources.[1]

Once phosphates are consumed by algae and other aquatic plants, they are removed from the water. When the plants decompose, some of the phosphates are released into the water again through bacterial catabolism. However, much of the phosphates in decomposing plant matter settles to the bottom, becomes consolidated with other material on the bottom, and is bound permanently so it will not recycle into the system, with the net effect of a reduction in phosphate levels in the water.[1]

What are ideal phosphate values?

Most relatively uncontaminated lakes are known to have surface waters that contain from 0.03 to 0.09 mg/L phosphate. However, in lakes or reservoirs, phosphate levels as low as 0.08 mg/L may stimulate excessive or nuisance growths of algae and other aquatic plants during the spring when nutrients are cycling to the surface. Streams or other flowing water are somewhat less susceptible to accelerated or cultural eutrophication, so a desired goal for them is a concentration of phosphate of less than 0.3 mg/L. In areas where streams enter lakes or reservoirs, the desired phosphate level is less than 0.15 mg/L.[1] However, it should be kept in mind that phosphates in streams and rivers may end up in a lake or reservoir downstream.

Phosphate is not regulated by the U.S. EPA because it is not toxic to humans or animals, and it is not considered a nuisance chemical in drinking water.

Further information is available from the references below or from the Recommended Reading and Resources section.

Measuring Procedure

The measuring procedure for phosphate uses the Water Quality Colorimeter and the Phosphate ezSample Test Kit as follows:

1. **Plug the Water Quality Colorimeter into the data collection system.** �(2.1)

   Task Result: On some data collection systems, a digits display will appear, by default, for ammonia.

2. **Calibrate the Water Quality Colorimeter.** �(3.1)

Taking measurements

SAFETY PRECAUTIONS

- ❖ Wear safety glasses and protective gloves.
- ❖ Review the MSDS for each of the Phosphate ezSample reagents, and have them available for reference.

1. **Follow the included Test Procedure instructions for the Phosphate ezSample Test Kit for sample preparation.**
2. **If required for your data collection system, begin by building an experiment. Otherwise, set the display to show Phosphate measurements.** �(2.2)
3. **Set your data collection system to Manual Sampling.** �(2.3)
4. **Place the prepared test ampoule in the Water Quality Colorimeter and cover it with the black cap.**

   Note: Handle the ampoule by the tip, and wipe the outside glass lens clean with a non-abrasive cleaning tissue.

   Task Result: The phosphate reading will automatically appear in the display. There may be slight fluctuations, so wait until the reading settles around a point.
5. **Record the phosphate reading.** �(2.4)

   Note: The units *mg/L* and *ppm* (parts per million) are equivalent.

Disposal of the test vial

1. **The ampoules may contain very low levels of potentially toxic substances (see the MSDS), so check with your local regulatory agency regarding disposal procedures.**
2. **Carefully pour the test water down the drain. Shake the glass tip remaining in the sample cup into the solid waste container.**
3. **Thoroughly rinse the sample cup with deionized or distilled water.**

Accuracy, resolution, and practical detection limit (PDL)

The accuracy of the Phosphate ezSample Test Kit is ±10% at 75% of full scale range. Accuracy may be compromised if test results are outside the stated test ranges. The lower limit of the stated test range is the "practical detection limit (PDL)," defined as the lowest concentration at which less than ±30% error is routinely obtained. For the Phosphate ezSample Test Kit, the range, accuracy, PDL, and resolution are shown on the table below.

Phosphate ezSample Test Kit: Accuracy, resolution, and PDL (mg/L)

Range	Accuracy	PDL	Resolution
0–1 (low)	0.05	0.05	0.01
1–8 (high)	0.1	1	1

Note: If your test result is at the maximum of the test range, dilute the sample with distilled water and re-test, then make the correction for the dilution. For example, dilute 10 mL of sample with 10 mL of distilled water, and then multiply the test result by 2 for the final concentration.

References

1. *Quality Criteria for Water (Red Book)*. Washington, D.C.: U.S. Environmental Protection Agency; 1976.
2. National Science Foundation. *Water Quality Index*. 2004.