h. Phosphorus, Phosphates

i. Why is this test important?

Phosphorus (P) is an element and is abundant in the earth's crustal material. About 12% of the earth's crust is P, chiefly as calcium phosphate. It is an important plant nutrient that helps root and flower development. If you buy a bag of fertilizer at the store, the middle number on the bag is the percent of phosphorus by weight. For example, a hundred pound bag of 12-10-10 fertilizer will contain 10 pounds of phosphorus.

Phosphorus makes plants grow in lakes & streams. A pound of phosphorus entering a lake or stream can lead to 500 pounds of "seaweed" or algae growth in that lake or stream. When those plants die, they rot. That decomposition process uses up oxygen so there is not as much available for fish and other life in the water. Too much phosphorus can also lead to algae blooms in the water. Some kinds of algae are toxic to humans and pets. There have been cases of pets getting sick or dying from drinking lake or pond water with toxic algae.

Because of these issues, several communities in Michigan (Allegan, Bay, and Ottawa Counties) and the entire state of Minnesota have banned phosphorus from lawn fertilizers. It has already been banned from laundry detergents and dishwasher detergents.

Phosphorus gets into streams mostly through soil erosion. Phosphorus does a good job of "sticking to" particles of soil and wash into the stream. Phosphorus can also enter a body of water through fertilizers, animal manure (including from pets, wildlife, or farm animals), and decomposing plant material.

Understanding the difference between phosphorus, phosphate, and orthophosphate can be confusing.

Phosphorus, is an element (P) that rarely exists in its pure form in nature. Phosphorus occurs in natural waters almost always as phosphates, the oxidized form of P.

Phosphates are classified as orthophosphates, condensed phosphates and organically bound phosphates. They occur in solution, in particles and in the bodies of aquatic organisms. The most common forms of orthophosphates are PO_4, HPO_4 and H_2PO_4 depending on the pH of the water.

The test method for determining phosphates is LaMotte Method 3121-01. The method is simple and can be run in about 7-10 minutes. The method is specific for orthophosphates in solution. It is a colorimetric method meaning that chemicals are added to the water sample which turns the water a color, which is proportional to the amount of phosphate in the water. The method has a lower detectable limit of about 0.1 mg/l or ppm, representing a "faint" color. Results from the testing method should be reported to within 0.5 mg/l.

If an extremely light, or faint color is produced, view the sample down the length of the test tube. By looking down the length of the tube, the color is concentrated five to ten times, depending upon the **height** of the liquid column.

ii. Water Quality Standards

Water quality standards allow for only a small amount phosphates in water. The EPA water quality criteria state that phosphates should not exceed 0.05 mg/l if streams discharge into lakes or reservoirs, 0.025 mg/l within a lake or reservoir, and 0.1 mg/l in streams or flowing waters not discharging into lakes or reservoirs to control algal growth (USEPA, 1986). Surface waters that are maintained at 0.01 to 0.03 mg/l of total phosphorus tend to remain uncontaminated by algal blooms. The natural background levels of total phosphorus are generally less than 0.03 mg/l. The natural levels of orthophosphate usually range from 0.005 to 0.05 mg/l.

iii. How to conduct the test

- Test should be run on clear samples only. Filter the sample if necessary.
- Best results are obtained when solution temperatures are 23-25 degrees Celsius.
- Obtain the water sample from the river, stream or lake.

PART 1: TEST PROCEDURE INSTRUCTIONS

Note: This Test Determines Levels of Orthophosphates Only

1. Fill the test tube (0843) to the 10mL line with the water to be tested for phosphate.

2. Use the 1.0 mL pipet (0354) to add 1.0mL of the *Phosphate Acid Reagent (PAR) V-6282 to the sample in the test tube and cap and mix until dissolved. *Note: The PAR contains sulfuric acid and an ammonium molybdate compound*.

3. Use 0.1 g spoon (0699) to add one level measure of *Phosphate Reducing Reagent (V-6283). Cap and mix. Wait 5 minutes

4. Remove cap from test tube. Place tube in Phosphate Comparator (3122) with Axial Reader (2071). Read Axial Reader Instruction Manual before proceeding

5. When entering the Q-Value on the WQI Form (Water Quality Index), multiply the **testing value (mg/l)** by 4 to determine the total phosphate level. This is based on the measured orthophosphate value.

In general, the deeper the blue color the more phosphate in the sample water.

NOTE: This set contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

PART 2 Collecting a Sample for GM Lab

Each classroom will be supplied a bottle to collect a sample for the phosphate test to be done at a GM laboratory**. Do NOT pre-rinse the bottles, or rinse the bottles at the rive**r -- Bottles supplied by GM via FRWC are usually **pre-treated with sulfuric acid—a small preservative**.

Obtaining a water sample should be done carefully and NOT obtained from the surface or bottom, but from the middle layer of the river.

Bottles do NOT need to be completely full.

Samples should be kept in a small cooler after sampling.

If using a bottle that has NOT been treated with sulfuric acid, the sample NEEDS to be kept cooled and analyzed within 48 hours. (Using the acid allows the sample to be tested within a 10-day period of when the sample was taken.)

Samples need to be identified and the teacher or mentors take samples to the Genesee Intermediate School District (GISD), Attention: Lisa Hook.

Identification includes:

1. Date When Sample was taken
2. School Name
3. Teacher's Name
4. Sample's Test (Total Phosphates, or Total Solids)
5. Water body sampled and place of sampling

The samples will be tested and the results sent to the Flint River Watershed Coalition (FRWC) for distribution to the teachers.

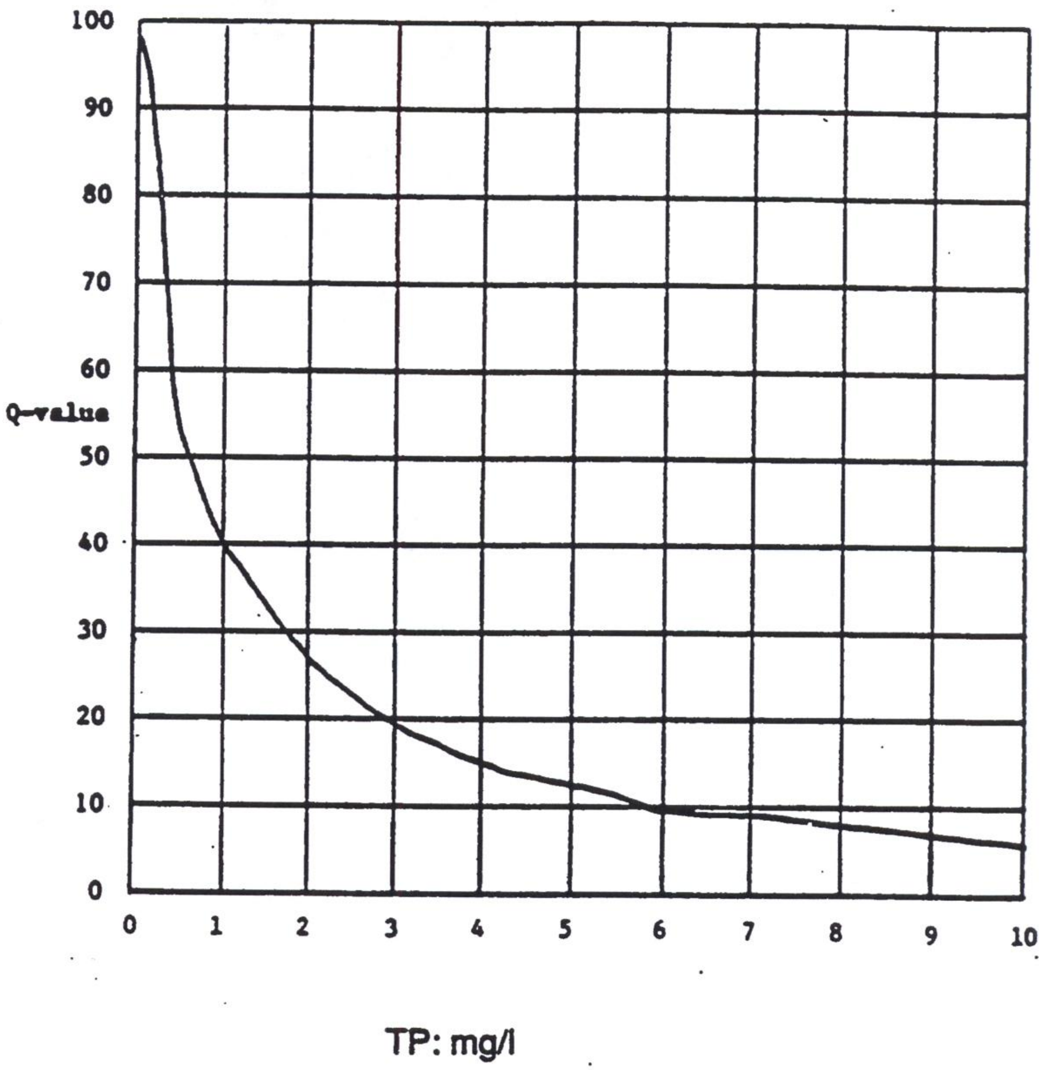
iv. Determining the Q-Value

Once the phosphate concentration is determined from the test method, the Q-value is determined directly by reading from a graph. The graph gives the highest Q-value for a phosphate level of zero and decreases rapidly as phosphate increases.

For example, at a value of 0.5 mg/l or ppm the Q-Value is only about 50. Interestingly, the highest Q-value is about 98 at a phosphate concentration of zero. Based on the chart from Earthforce, a value of 100 cannot be achieved even with a level of zero.

CALCULATING THE RESULTS

Total Phosphate Test Results



Note: if T-PO_4>10.0. Q=2.0

v. Why multiply the Q-Value by 4?

The value of 4 comes from a study of the Flint River system by the Mich. Dept. of Natural Resources (MDNR). The MDNR tested for orthophosphate and total phosphates. The FRWC GREEN Planning Team reviewed the MDNR data and found that total phosphate is about 4 times the orthophosphate.

For example, if you determine the level of orthophosphate is 0.2 mg/l the total phosphate is estimated to be 0.8 mg/l.

It is important that you record on the WQI data sheet, both the LaMotte test result for orthophosphate (in the *Field Data* column) and the estimate for total phosphates (in the *Units* column).

vi. What to watch for: Common Mistake

There are several potential errors when conducting this test. First, the most common error in this test is not waiting the required 5 minutes to assess the level of phosphates. Second, another common error is not filtering the sample if it contains a significant amount of solids. Third, is the importance of the location of the sampling site or the actual sampling. Sampling too close to the storm outfall presents challenges and in such cases the teacher or mentor should be consulted. Also, sampling of the water should be performed carefully so that the bottom of the stream or river is not impacted, nor just a surface sample of water taken by the student. The student must be aware that the sample collected must represent the overall condition of the water body.

There may also be confusion in reading the color of the result. Holding a white piece of paper behind the sample can help reduce colors from the environment making it difficult to read the sample.

Finally, there can be confusion about whether to report results for phosphate or phosphorus. As noted the reference test method is specific for orthophosphates. If the data must be reported as phosphorus (P) the results for phosphate should be multiplied by 0.3 to calculate the value of P. The value of 0.3 is the ratio of the atomic weights of P to PO_4. Note-the final WQI Data Summary Chart Form provided by Earthforce (and FRWC) lists Total Phosphorus (rather than Total Phosphate) as the testing pollutant of interest. If P is reported on this form and used to assess the water's overall WQI using the conversion factor mentioned above, the P data form should be footnoted.

vii. Consistency when doing multiple tests

Generally, three tests or more if time permits should be performed by the student. Test results should be plus or minor 0.5 units. The goal is to have data that is accurate and precise. Any result that is extreme should be questioned and perhaps discarded. The sample mode, which is the most common value should be reported, not the average or mean. For example, assume test values are determined to be

1.0, 0.5, 0.5, 1.0 and 0.5. The value of 0.5 should be used to assess the Q-Value, rather than 0.7 which is the mean. This results in a Q-Value of about 50.

viii. How to analyze why the results are good or bad

There are two key questions to answer to determine if the results are results are good or bad. First, is there confidence in the reported test results? From a statistical standpoint, we are asking if the data has precision and confidence. This first question is independent of the numerical value for phosphate and deals with having enough test data that is fairly consistent. This results in statistical confidence that the measured value of phosphate. The above example of phosphate data shows both precision and confidence. The data range is only 0.5 units which is good.

For a second example, consider the data set of 0.5, 1.0 and 1.5. In this scenario, there is no precision; no data mode and the results vary by 1.0 unit which is not attractive. Reporting the average of 1.0 is not correct. At this point there are two options: consider the results as "not available" or continue with more testing. If two more tests revealed a phosphate of 1.5, then the value of 1.5 is the mode and is the field sampling result.

The second question addresses if the reported test result is either an extreme value or a significant change from established norms for the test site. Basically, we are interested in data accuracy, but with an eye on possible changing trends. In the first above example, the reported test result was 0.5. If this value is within the normal historical range and what is reasonable for the specific site, then the value of 0.5 can be reported and can be assessed as "good."
In the second example above with a value of 1.5, the result can be questioned if it is indeed extreme or an outlier based on historical or long term data. The value of 1.5 maybe reported and still considered "good" provided this assessment is made to validate the data.

It should also be noted that extreme phosphate results of above 3-5 can indicate sampling or testing error, unique problems or changing conditions with the stream, river or creek flow. In this case, the teacher or mentor should be contacted about this issue. Sampling downstream of the major storm water outfall (discharge pipe) during or after rainfall can produce such unique phosphate results. As such, the presence of storm water outfalls should be determined by the teacher or mentor prior to the field exercise. Also, a review of historical data in the classroom prior to the field sampling may show the existence of a highly variable phosphate under unique environmental conditions.

Finally, it is extremely important that the reported data be as statistically valid as possible. First, some of the GREEN data is being used to satisfy NPDES storm water requirements for the Genesee Drain Commission and being used by other policy makers to make decisions. Second, if a water quality problem is identified and an action plan is developed for a civic approach to resolve or minimize the problem the GREEN data should be as accurate as possible. These are important considerations to keep in mind as the GREEN data is compiled.