

## Student Reading 2 - *Understanding Nutrient Limitation: Questions and Answers*

The following is an excerpt from the MD Department of Natural Resources website. (<http://www.dnr.state.md.us/bay/monitoring/limit/index.html>)

The following series of questions and answers will help you to understand nutrient limitation as it relates to reduction efforts, the keystone program to restore the Bay.

### What is nutrient limitation?

Like all plants, phytoplankton (microscopic algae) need resources such as light and nutrients (e.g. nitrogen, phosphorus, carbon) to grow. When light can freely penetrate the water column, phytoplankton will continue to grow as long as there are nutrients being added to the water. Nutrients are added from both non-point and point sources, as well as regenerated from the Bay sediments under certain conditions such as anoxia. However, unless the nutrients are available in adequate amounts relative to each other (generally a ratio of nitrogen to phosphorus of 16:1), phytoplankton growth is **nutrient limited** by one or the other nutrient. If both nutrients are added in enough excess (regardless of the relative proportion of them), phytoplankton will not be limited even when they are growing as fast as they can, and the system is **nutrient saturated**.

When water is described as being **nutrient limited**, this does not mean that there is not enough nitrogen or phosphorus in the water or that water quality is good. Nutrient limited only indicates that the two nutrients are out of the appropriate balance. **Phosphorus limitation** occurs when there is proportionally less phosphorus than nitrogen, i.e. there is **excess nitrogen**. Phosphorus limitation occurs in some locations in the spring when lots of nitrogen is available from stormwater flow. **Nitrogen limitation** occurs when there is proportionally less nitrogen than phosphorus, i.e. there is **excess phosphorus**. Nitrogen limitation often happens in the summer and fall when stormwater flows are lower (so less nitrogen is being added to the water) and some of the nitrogen has been used up by phytoplankton growth during the spring. If both nutrients are available in amounts well in excess of the needs of the phytoplankton, the system is **nutrient saturated**.

### How is nutrient limitation measured?

Water samples are collected from sample locations for example from the Patuxent. These water samples are tested using a bioassay. The results of these laboratory tests are used to determine if a sample is:

- Nitrogen limited (excess phosphorus)
- Phosphorus limited (excess nitrogen)
- Nutrient Saturated (excess phosphorus and nitrogen or inadequate light).

### What is a bioassay?

Nutrient bioassays are conducted to measure the effects of a known nutrient on a water sample containing plankton. A bioassay procedure uses water samples collected from a sampling site (for example from the Patuxent) which are subjected to a variety of laboratory controlled experiments.

Treatments to determine the limiting nutrient are:

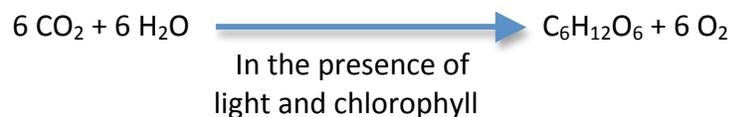
- The addition of nitrogen
- The addition of phosphorus
- A combination of nitrogen and phosphorus additions

By experimentally adding nutrients to a sample, we expect to see algal growth far more than samples that have no nutrients added. This is the basis for the bioassay measurement, comparing growth of algae between untreated (control) samples and treated (nutrient addition) samples.

Treated samples are then allowed to grow for a period of time. The subsequent growth of the algae is measured at the end of the experiment and comparisons between the controls and treatments are made to assess which nutrient or combination of nutrients is limiting the growth of the algae.

### What are other limiting factors of phytoplankton growth?

If we look at the equation for photosynthesis we can determine which additional factors can limit the growth of phytoplankton:



**Carbon** may be a limiting factor. Saturation levels of carbon dioxide are lower when temperature and salinity are high. In addition, some species of phytoplankton may be limited by their tolerance to temperature and salinity.

If the water is clouded or colored by sediments, this lowers the amount of **light** that can reach the algae and can also limit the growth of algae. Growth is often nutrient saturated in the winter when light levels are low (due to high run off of sediments) and water temperatures are low (which slow phytoplankton growth).

Over the past two decades it has been suggested that **iron**, and other trace metals, may be a limiting factor in phytoplankton growth in the oceans. The iron hypothesis, has been explored in several large-scale experiments. The most recent open ocean trial of

ocean iron fertilization, dubbed LOHAFEX, was conducted from January to March 2009 in the Southern Ocean (Atlantic Sector). These experiments have demonstrated a connection between the short-term iron fertilization of marine ecosystems and phytoplankton growth. This connection has inspired some to suggest that largescale iron fertilization of oceans may be a potential way to ameliorate some of the effects of human carbon consumption.

### **Why is determining nutrient limitation important?**

Determining what nutrient is limiting phytoplankton growth is important for many reasons. These measurements have been made since August 1990, so we can compare the results over time to track changes due to management efforts or changes in watershed use and inputs.

In several areas, the Chesapeake Bay Monitoring Program has shown that nutrient concentrations in the Bay have been reduced, but phytoplankton have not yet responded (e.g. Patuxent Estuary). The nutrient limitation data has shown why the expected response has not yet occurred and given managers confidence that we are still on the right path to restoring the Bay but have not yet reduced nutrients sufficient to limit algal growth.

Determining patterns of nutrient limitation can also be used to define future watershed management needs and priorities, and help determine what management strategies are most likely to have desired effects on controlling excess algal growth and associated negative impacts on the ecosystem.

In addition, the data from Nutrient Limitation monitoring efforts are used to develop predictive models that use routinely measured water quality components (total nitrogen, total phosphorus, dissolved inorganic nitrogen, dissolved inorganic phosphorus, salinity and water temperature) to estimate the nutrient limitation status for locations where bioassay samples are not collected. This model has been applied to determine annual patterns of nutrient limitation for all of the Maryland DNR Long-term Water and Habitat Quality Monitoring Program sample locations.