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Larry M. Antosch, Ph.D.

The State of the Science Report is published periodically to provide an update on Ohio and national water quality research and emerging issues. The July edition explores two very important questions:

- Why are agricultural systems considered leaky?
- What is the natural aging process for lakes and ponds?

Before these questions can be answered, a basic understanding of the concept of ecological succession and a fundamental principal of ecology – material cycling is needed.

Agriculture is a Leaky System

Ecological Succession

In its purest simplest form, ecological succession is the gradual process that takes place by which ecosystems develop, change and mature over time. Succession often involves a progression from plant and animal communities that have a lower degree of species diversity to communities with higher species diversity and complexity. This change continues until the community of plants and animals reaches a steady state referred to as a "climax community." The climax community is composed of plants and animals best adapted for the conditions in the area and is one in which all of the resources are efficiently used and recycled within.

By their very nature, agricultural ecosystems are not climax communities. The original pre-agricultural community of plants and animals has been replaced by what can be considered a "leaky" agricultural system. Human activities disturb and disrupt agricultural systems on an ongoing basis, This continual human interaction keeps agricultural ecosystems from achieving steady state. As a result, resource utilization does not take place at maximum efficiency and material recycling is incomplete. Nutrients for example, are lost from the system as harvested crops and through erosion and must be replaced by fertilizer. The supply must be continuously supplemented to replace what has "leaked" from the system.

Farm Material Movement and Cycling

To illustrate material cycling, a fundamental principal of ecology, the modern grain cash-crop farm is an example. In a typical grain cash-crop farm, there is a standing stock of nutrients present in the farm fields. Routine soil testing determines the amount. Additional nutrients come into the farm in the form of fertilizers and other materials that are applied to the crop fields. During the year as the plants grow, they take up a portion of the soil nutrients and incorporate them into their tissues. A portion of the nutrients are removed from the farm when the plants are harvested, sold and transported to the elevator. Additional nutrients are lost via surface runoff and erosion. The change in the nutrient stock on the farm is the difference between the nutrient inputs (fertilizer) and the nutrients that leave the farm (crops and soil loss).

Take Away Messages

- All ecosystems evolve and go through a natural aging process. If left undisturbed, the communities of plants and animals will reach a steady state known as a climax community.
- Resources (nutrients, carbon, etc.) are efficiently used and recycled within a climax community.
- Non-climax communities are “leaky;” resources are lost from the system and must be replaced.
- Agricultural systems are not climax communities and thus are classified as leaky systems.
- Leaky systems are not bad; they just require the addition of resources to replace those that have been removed.
- Because agricultural systems are leaky systems, additional nutrients must be added to replace those that have been removed by crops and/or transported downstream via erosion and runoff.

Life and Evolution of Lakes and Ponds

Over time, all ecosystems evolve and go through a natural succession or aging process. Freshwater ecosystems (lakes and ponds) are no exception. This process is referred to as *“eutrophication”*.

Eutrophication

Eutrophication is a natural process that occurs in freshwater ecosystems. It is a part of the normal aging process and occurs as bodies of water gradually build up their concentration of plant nutrients. As lakes and ponds age, their ability to grow aquatic plants and animals changes due to the input of material from their drainage area and the atmosphere. The speed of this “aging” process is different for each lake or pond and is dependent on the physical and chemical nature of the lake and its watershed. For example, a lake located in a fertile, productive watershed will receive a rich supply of nutrients resulting in a productive lake. Whereas, a lake located in a watershed of low productivity will receive lower amounts of nutrients resulting in a lake with a low level of productivity.

The quantity of biologically available nutrients (nitrogen and phosphorus) dissolved in the water determines the trophic (nutritional) state of the lake. When the concentration of these limiting nutrients increases over time, they trigger higher plant growth and an increase in the lake's overall productivity or trophic state.

Eutrophication is not necessarily harmful or bad, and the word itself is often translated from the Greek as meaning "well nourished."

Trophic State

Productivity or nutrient richness of lakes serves as the basis for the trophic status concept of lake classification. This classification system is based on the age or degree of productivity within the lake and ranges along a continuum from nutrient poor (oligotrophic) on one end to nutrient rich (eutrophic) on the other. The lakes in the middle containing moderate levels of nutrients are classified mesotrophic. Lakes generally change trophic state slowly, becoming more eutrophic over time.

Both natural and human-made factors might influence the trophic state of a water body. If the lake is located in a region that has a high level of nutrients, the lake will naturally be in the eutrophic state. Sewage entering the lake intentionally or accidentally, agricultural runoff from crop fields, or fertilizers leached into the waters are the different ways in which nutrients are added to a water body due to human activities.

Trophic States of Lakes

Oligotrophic

Oligotrophic bodies of water are considered new or young in the overall scheme of things. Oligotrophic lakes and ponds contain low concentrations of nutrients required for plant growth (nitrogen and phosphorus) resulting in a low level of productivity. A small quantity of organic matter grows in an oligotrophic lake. Phytoplankton, zooplankton, attached algae, macrophytes, bacteria and fish are all present but only as small populations. Oligotrophic lakes have clean, clear water, no aquatic weed problems and poor fishing.

Mesotrophic

Mesotrophic bodies of water are considered middle aged, geologically. Mesotrophic lakes fall in the middle, between oligotrophic and eutrophic lakes. They have more nutrients and, therefore, more plant, algae, and fish growth than oligotrophic lakes and ponds, but less than eutrophic bodies of water. The water is moderately clear and fishing is reasonably good. Mesotrophic lakes have enough nutrients to produce plants and algae.

Eutrophic

Eutrophic bodies of water are considered old aged. Eutrophic lakes and ponds are rich in plant nutrients (nitrogen and phosphorus) leading to a high level of productivity. The richness of available nutrients results in the production of elevated levels of phytoplankton, zooplankton, minnows and other small fish, and larger fish. Abundant plant and algae growth can increase to the point where it can attain nuisance levels. The elevated numbers of phytoplankton and zooplankton result in cloudy water with limited clarity. Eutrophic lakes typically have weed beds and a robust fishery.

Take Away Messages

- All ecosystems evolve and go through a natural aging process. In lakes, this is known as eutrophication.
- As lakes age, their overall productivity increases due to the input of sediment, nutrients and organic matter from the watershed and the atmosphere.
- The quantity of biologically useful nutrients like phosphorus and nitrogen dissolved in the waters of a water body determine the trophic (nutritional) state of the water body.
- Productivity or the nutrient richness of lakes serves as the basis for the trophic status concept of lake classification.
- This classification system places lakes along a continuum from nutrient poor (oligotrophic) on one end to nutrient rich (eutrophic) on the other. The lakes in the middle containing moderate levels of nutrients are classified mesotrophic.
- Ohio's lakes, especially Lake Erie, are complex systems undergoing continuous changes due to changing weather patterns and introduced exotic species. Ohio's rich productive landscape naturally leads to nutrient-rich, productive eutrophic lakes.

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