Lake Learning

Right now, lakes are like layer cakes

Have you noticed lately while swimming that the surface water in the lake is very warm and deeper water is cooler? At this time in the summer, the lakes are separated into vertical layers like a cake; limnologists call this phenomenon stratification. Stratification is a major reason our Minnesota lakes behave the way they do. To understand lake stratification, we first must address the relationship between water density and temperature. Water is unique in that it is denser as a liquid than a solid; therefore, ice floats. If ice sank, our lakes would behave much differently in the winter!

Water is most dense at 39 Fahrenheit (4 degrees Celsius), and as water warms or cools from that mark it gets less dense. This has implications for a lake's structure because the denser water is heavier and will be at the bottom of a lake while the less dense water is lighter and will generally be at the top of the lake.

In the summer in Minnesota, the sun heats the top layer of a lake (called the epilimnion) which causes it to become less dense. The bottom layer of the lake (called the hypolimnion) does not receive sunlight and therefore remains cold. Since the top layer of the lake is less dense, it floats on top of the bottom layer and the two do not mix. The thermocline or metalimnion is the dividing area between the top and bottom layers.

Since the sun penetrates the top layer of the lake, it is where plants and algae grow. Algae and plants produce oxygen as a byproduct to photosynthesis. This oxygen is important for fish and other aquatic animals to survive.

When algae and zooplankton die, they sink to the bottom of the lake. Invertebrates and microbes living at the bottom of the lake recycle and decompose this dead material. This recycling process uses up oxygen. Since the lake does not mix during the summer, the top layer of the lake where the oxygen is produced by algae and plants is cut off from the bottom layer of the lake. In a long stretch of hot calm weather, the bottom of the lake can become anoxic (lacking oxygen) during the summer in a mesotrophic or eutrophic lake. No oxygen at the bottom of the lake has implications for fish and other living things. Fish that need cold water and high oxygen, such as cisco/ tullibee, can't survive these conditions and it results in a summer fish kill. This happened on some lakes around Fergus Falls a couple years ago.

There is another implication to having no oxygen at the bottom of the lake in the summer. When the bottom of the lake is anoxic, chemical processes cause phosphorus to be released from the sediments. This phenomenon is called internal phosphorus loading, meaning that the phosphorus is coming from inside of the lake. The way this phosphorus originally got into the lake sediments is from erosion and runoff in the watershed. When the lake mixes again, this increased phosphorus fuels algae growth.

In the fall in Minnesota, the sunlight is not as strong and the nights become cooler. This change in season allows the top layer of the lake to cool off. As the water cools, the density difference between the top layer of the lake and bottom layer is not as great. Wind can then mix the layers.

In addition, when the top layer cools it becomes denser and sinks into the bottom layer, mixing the layers. This mixing allows oxygen and nutrients to be distributed across the whole water column again.

In the winter in Minnesota, the lakes are covered with ice. Under the ice, the water cannot mix because it is not exposed to wind. Most of the lake remains 39 Fahrenheit (4 degrees Celsius). There is a thin layer of water under the ice that is colder and therefore less dense.

As in the summer, in the winter the hypolimnion is cut off from oxygen, so as decomposition takes place at the bottom of the lake oxygen gets used up. When the bottom becomes anoxic in the winter it is called winter kill because fish and other living organisms that need oxygen die. As in the summer, when the bottom of the lake is anoxic, chemical processes cause phosphorus to be released from the sediments. When the ice melts in the spring and the lake mixes again, this increased phosphorus fuels algae growth.

In the spring in Minnesota, the ice melts off the lake, the wind picks up and the lake mixes again. This is called spring turnover. Oxygen and nutrients get distributed throughout the water column as the water mixes. Then, as the weather becomes warmer, the surface water warms again and sets up summer stratification.

Most lakes in Minnesota are considered dimictic, meaning they mix twice a year - spring and fall. Shallow lakes behave differently and can mix more often.

Next week, I will discuss more implications of lake stratification such as its effect on algae growth and secchi depth (water clarity).

Until next week, enjoy the lakes!

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