EFFECTS OF ACID RAIN ON AQUATIC ECOSYSTEMS

A lake is the landscape's most beautiful and expressive feature. It is earth's eye: looking into which the beholder measures the depth of his own nature.  

*Henry David Thoreau*

The most dramatic reports of acid rain damages in the early 70s, were those of Ontario lakes having irreversible fish losses. Dead fish were washing up along the beaches, and the term "wet desert" was being used to describe the clear, blue, fishless lakes. Ontario now has over 100 fishless acidified lakes. Species such as lake trout (see top, wall-eye, burbot and smallmouth bass have disappeared from most of these lakes. Starting in 1981, 202 lakes were monitored in Ontario, Quebec and the Atlantic Provinces, and in 1994, 33% showed some improvement in acidity while 11% were worse. The remaining 56% had stable acidity levels.

Ontario lakes are especially sensitive to acid rain because of the hard bedrock of the Canadian Shield (an ancient sheet of Precambrian granite) and the poor soil cover which has poor buffering ability. It was first believed that the fish deaths were caused by the acids themselves, however, research has since shown that the high levels of aluminum (a toxic heavy metal) that were leached from the soil, was the real cause of the deaths. Aluminum can be acutely toxic to fish at pH levels that are not normally considered toxic to humans. A concentration as low as 6.2mg/L is known to kill fish.

There are two ways in which aluminum kills fish. Firstly, it is able to reduce the ion exchange through the gills and subsequently causes a salt depletion. Aluminum also precipitates in the gills and interferes with the transport of oxygen and other ions, so that the fish literally dies of suffocation. Secondly, the fish will exude mucus to combat the aluminum in their gills. This mucus builds up and clogs the gills so that oxygen and salt transport is inhibited. Research has shown that dead fish had low levels of Na+ and Cl− in the blood. This means that they were unable to regulate their body salts.
<table>
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| 3.5 - 3.0 | ● toxic to most fish  
● some plants and invertebrates can survive such as the waterbug (Hemiptera and Heteroptera), water boatmen (Corixidae) and white mosses (Sphagnum)  
* salmonids are fish that belong in the Family Salmonidae. They include trouts, whitefish, salmon and smelts. |
| 4.0 - 3.5 | ● lethal to salmonids |
| 4.0 - 4.5 | ● harmful to salmonids, tench, bream, roach, goldfish and the common carp  
● all stock of fish disappear because embryos fail to mature at this level |
| 5.0 - 4.5 | ● harmful to salmonid eggs, fry and the common carp  
● the lake is usually considered dead and a "wet desert"  
● it is unable to support a variety of life |
| 6.0 - 5.0 | ● critical pH level, when the ecology of the lake changes greatly  
● the number and variety of species begin to change  
● salmon, roach and minnow begin to become less diverse  
● less diversity in algae, zooplankton, aquatic insects, insect larvae  
● rainbow trout do not occur and molluscs become rare  
● there is a great decline in salmonid fishing  
● usually there is a high concentration of aluminum present  
● the fungi and bacteria that are important in organic matter decomposition are not tolerant so the organic matter degrades more slowly and valuable nutrients are trapped at the bed and are not released back into the ecosystem  
● most of the green algae and diatoms (siliceous phytoplankton) that are normally present disappear. The reduction in green plants allows light to penetrate further so acid lakes seem crystal clear and blue  
● snails and phytoplankton disappear |
| 9.0 - 6.5 | ● harmless to most fish |
| 9.5 - 9.0 | ● harmful to salmonids, harmful to perch if persistent |
| 10.0 - 9.5 | ● slowly lethal to salmonids |
| 11.0 - 10.5 | ● lethal to salmonids*, carp, tench, goldfish and pike |
| 11.5 - 11.0 | ● lethal to all fish |

Other organisms are also affected by acidic water. Low pH often stunts the growth of frogs, toads and salamanders. However, some acid-tolerant species like the smooth newt (Triturus vulgaris) can tolerate the acidity and can occupy and outcompete toad and frog niches. The acid rain not only kills off species, but also alters and decreases the food supply for higher fauna. For example, a decline in benthos (bottom-dwelling organisms) can lead to a decline in the number of species of flies, mosquitoes, craneflies, midges and mayflies. This puts a stress on aquatic carnivores (such as insect-eating fish). Predatory birds like flycatchers can eat the fish and end up with high concentrations of aluminum. The
birds will then produce eggs with soft shells and the young rarely survive.

Another devastation to the ecosystem may occur in changes in the chemistry of the water. For example, phosphates can be complexed (attached) to the mobilized aluminum and will reduce the primary production of the aquatic plants. Phosphate is a limiting nutrient for plants. The decrease in plant food will thereby limit the populations higher in the food chain.