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Acid Precipitation: Old Problem, New Concern

From burning fossil fuels

Short smoke stacks → Tall smoke stacks, local problem becomes global problem

First warnings from Europe (W. Germany & Scandinavia)

In United States, no aquatic life in Adirondack lakes and streams; dead trees at higher elevations in Vermont and Blue Ridge Mountains

Concern in United States

1970s—Research & Measurements

Late 1970s—isolated measurements near Kane, PA, below pH 3

Typical measurements in PA now in 4s

Problem in most of eastern states & Canada

Forms of Acid Precipitation

Rain, snow, sleet, hail, & fog

Dry particulates will settle back to earth

Sources of Acid Precipitation

Burning of fossil fuels (mainly coal) to generate electricity & industrial applications—emit large amounts of sulfur dioxide (SO₂)

Automotive exhausts—emit nitrogen oxide (NO_x) & SO₂

Can combine with water vapor in atmosphere to form acids

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pH and Acidity

pH is a number used to measure relative acidity or alkalinity of aqueous solutions.

pH is represented on a scale showing 15 numbers (0 to 14).

Exactly 7 is neutral (neither acidic nor basic).

Numbers below 7 are acidic.

Numbers above 7 are basic.

A change from one whole number to another represents a tenfold increase or decrease in acidic potential.

Natural Rain: $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ (carbonic acid) pH = 5.6

Acid Rain: Any Rain or Precipitation Below pH of 5.6

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Effects of Acid Precipitation

Corrosion of metals—bronze monuments & steel structures

Dissolves limestone and marble—buildings, monuments, grave stones

Municipal water supplies—corrosion and leaching of metal from water pipes, can be toxic

Plant surfaces: Dissolves waxy covering from leaves, leaches nutrients from leaves, and causes yellowing of leaves. Can damage needles in extreme conditions. Acid fog (+4,000 ft in elev.) can compound these effects—constantly bathes plants.

Soil: Harmful to decomposers—nutrient cycle disrupted, forest litter accumulates.

Harmful to mycorrhizae (symbiotic fungi on roots of most trees): Can affect seed germination in some species—deciduous trees such as red maple and yellow birch. Eastern hemlock not affected; improved germination in white pine and white spruce. Leaches out necessary nutrients—calcium, magnesium, and potassium, carried away by groundwater or runoff water. Releases aluminum bound to clay particles—toxic below pH 5.4, destroys mycorrhizae, and root hairs, trees can't absorb nutrients and water.

Harms natural defense system against disease and insects—synergistic effects (other minimal effects will now cause harm).

Aquatic Effects

Acidity in surface waters

Aluminum enters surface waters.

Aluminum interferes with gills in fish and affects blood concentration. Rooted aquatic vegetation and algae are harmed. Fish eggs and fry are harmed.

Aquatic insects and other invertebrates may be killed before fish—fish no longer have food.

Amphibians harmed—breathe through skin. Rainbow trout (native to alkaline waters of west) are intolerant of acidity; PA Fish Commission will replace w/ brook trout (acid tolerant) on stocking lists. If acidity levels increase (pH decreases), all stocking ceases.

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Solutions

Natural Controls

“Buffering” or neutralizing of incoming acidity—measures capacity by alkalinity test of calcium carbonate present. Forms of buffering:

- From alkaline bodies of water
- From percolating through soils & rock structures—little buffering occurs from sandstone rocks on Allegheny Plateau, good buffering from limestone rocks in Ridge & Valley.

Naturally acidic ecosystems—coniferous groves and rhododendron/ mountain laurel thickets grow in acidic soils and add to that acidity), brook trout are adapted to acidic waters, but there is a limit to what organisms can take.

Manipulating natural ecosystems—adding limestone to acidic bodies of water, much research and successful applications for mine acid drainage.

Cultural Controls

Regulation of emissions—Amendment to Clean Air Act of 1990 added acid rain provision; some improvement; still have a long way to go

Electricity will be more expensive—must remove more particulates and gases

Alternative energy forms must be developed and implemented

Conservation measures/lifestyle changes are necessary.

We need to bring back those rainbow trout.