

ACID RAIN

What is acid rain?

- More accurate term may be acid d_____
- Occurs in two forms
 - < w_____ deposition (acidic rain, fog, and snow)
 - < d_____ deposition (acidic gases and particles)
- Principal c_____ are SO_x and NO_x
- About _____ of SO_x and _____ of NO_x comes from power plants (most are coal burning)

How do we measure?

- pH of “natural” rain water is _____ ($\text{pK}_{a1} \text{H}_2\text{CO}_3$ is 6.35)
- m_____ by two networks, both supported by EPA
 - < The National Atmospheric Deposition Program measures w_____ deposition, and its Web site (<http://nadp.sws.uiuc.edu/>) features maps of pH
 - < The Clean Air Status and Trends Network (CASTNET) measures d_____ deposition (<http://www.epa.gov/castnet/>)

Effects of acid rain:

- damage to forests and soils, fish and other living things, materials, and human health.
 - < acidification of l_____ and s_____

In a National Surface Water Survey (NSWS)

– effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams believed to be sensitive to a_____

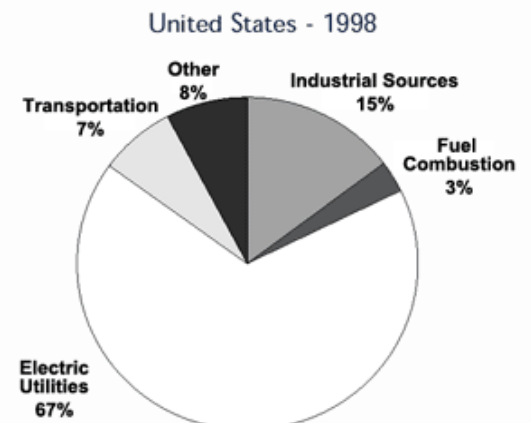
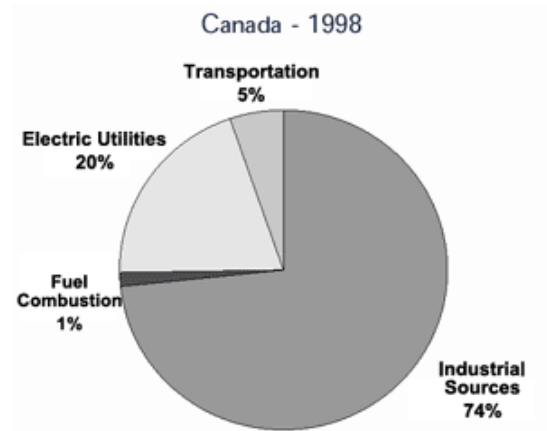
- acid rain caused acidity in _____ percent of the acidic lakes
- acid rain caused acidity in about _____ percent of the acidic streams
- U.S. regions containing many of the s_____ w_____ sensitive to acidification include:

- the Adirondacks and Catskill Mountains in New York state,
- the mid-Appalachian highlands along the e_____ c_____.
- the upper M_____, and mountainous areas of the Western

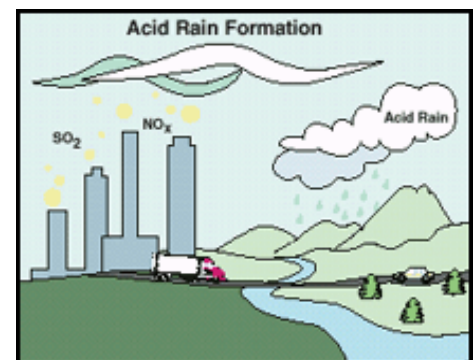
United States.

– In areas like the Northeastern United States, where s_____ buffering capacity is poor, some lakes now have a pH value of less than _____.

- One of the most acidic is Little Echo Pond in Franklin, NY with a pH of _____.
- also a problem in lakes smaller than 10 acres that were not included in the NSWS (may increase the number up to f_____ - fold).
- < approximately _____ percent of sensitive lakes in the Adirondacks are at risk of e_____ acidification (brief periods of low pH)
- < low b_____ streams: _____ of the streams in the Mid-Atlantic Coastal Plain are acidic, in the New Jersey Pine Barrens, over _____ percent of the streams are acidic (highest rate of acidic streams in the nation), and over _____ of the streams in the Mid-Atlantic Highlands (mid-Appalachia) are acidic, primarily due to acidic deposition.
- < Canadian government has estimated that _____ lakes in eastern Canada are acidic.



<http://www.ec.gc.ca/acidrain/acidfact.html>



Affects Fish and Aquatic Species

- < acid rain causes a c_____ of effects that harm or k_____ individual fish, reduce fish p_____ numbers, e_____ fish species, and decrease b_____
- < increased a_____ levels cause chronic stress that may not kill individual fish, but leads to lower body weight and smaller size and makes fish less able to compete for food and habitat.
- < generally, the y_____ of most species are more sensitive to environmental conditions than adults. At pH 5, most fish e_____ cannot hatch. At lower pH levels, some adult fish die.

	pH 6.5	pH 6.0	pH 5.5	pH 5.0	pH 4.5	pH 4.0
TROUT	Light Blue	Light Blue	Light Blue	Light Blue	Dark Blue	Dark Blue
BASS	Red	Red	Red	Dark Blue	Dark Blue	Dark Blue
PERCH	Blue	Blue	Blue	Blue	Blue	Dark Blue
FROGS	Green	Green	Green	Green	Green	Dark Blue
SALAMANDERS	Light Green	Light Green	Light Green	Light Green	Dark Blue	Dark Blue
CLAMS	Yellow	Yellow	Dark Blue	Dark Blue	Dark Blue	Dark Blue
CRAYFISH	Magenta	Magenta	Magenta	Dark Blue	Dark Blue	Dark Blue
SNAILS	Olive	Olive	Dark Blue	Dark Blue	Dark Blue	Dark Blue
MAYFLY	Red	Red	Red	Dark Blue	Dark Blue	Dark Blue

Tree and Forest Damage

- < damage of trees at high e_____ (for example, red spruce trees above 2,000 feet) and many sensitive forest soils.

Water Quality Impacts

- < n_____ impacts on water quality due to eutrophication (o_____ depletion, a_____ blooms, d_____ in the health of fish and shellfish, loss of s_____ beds and c_____ reefs, and ecological changes in food webs): 10-45 percent of the nitrogen produced by various human activities that reaches e_____ and coastal e_____ is transported and deposited via the atmosphere. _____% of nitrogen in the Chesapeake Bay comes from atmospheric deposition.

Materials and Building Decay

- < a_____ the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage.
- < acid rain can s_____ automotive coatings
- < Acid rain and the dry deposition of acidic particles contribute to the c_____ of metals (such as bronze) and the deterioration of paint and s_____ (such as marble and limestone).
- < some car manufacturers use acid-resistant paints, at an average cost of \$_____ for each new vehicle (\$61 m total/y)

Affects visibility (as in photochemical smog from NO_x)

- < Sulfate particles account for _____ percent of the visibility reduction in the eastern part of the United States

Acid Rain Reductions

- < EPA's Acid Rain Program caps SO₂ emissions from power plants at _____ million tons/yr
- < 1990 Acid Rain Program under the Clean Air Act set goal to achieve reductions of _____ million tons of sulfur dioxide (SO₂) and _____ million tons of nitrogen oxides (NO_x).
- < When fully implemented by the year 2010, the public health benefits of the Acid Rain Program are estimated to be valued at \$_____ billion annually, due to decreased m_____, h_____ admissions, and emergency room visits. (for more details see: <http://www.epa.gov/airmarkets/progress/arreport/acidrainprogress.pdf>)

Air Quality Concentrations	
1981-00	50% decrease
1991-00	37% decrease
1999-00	4% decrease
Emissions	
1981-00	27% decrease
1991-00	21% increase
1999-00	6% increase
Worth Noting:	
SO ₂ concentrations have been reduced by over 50% over the past 20 years (1982-2001) and approximately 35% over the more recent 10-year period (1992-2001) nationwide. Reductions in SO ₂ concentrations since 1990 are due, in large part, to controls implemented under EPA's Acid Rain Program beginning in 1995.	