Acid Deposition

What is acid deposition?

Acid deposition occurs when acid-forming pollutants in the air are deposited on the earth's surface. The main acid-forming pollutants are sulphur dioxide (SO_2) and oxides of nitrogen (NO_x). These substances interact with water in the atmosphere to form mild acids that return to the earth in four ways:

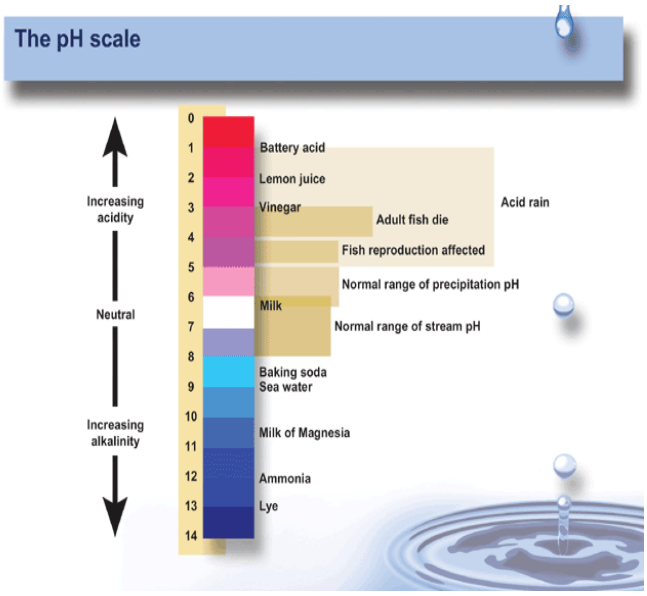
- mixed with rain to form acid rain;
- mixed with snow or hail, which form acids as they melt;
- as particles of solid matter, which form an acid when they mix with water in lakes and rivers; and
- as dry deposition of gases and particles.

What is an acid?

An acid is a substance that provides hydrogen ions (H^+) in a chemical reaction. A base is a substance that can accept hydrogen ions in chemical reactions. The acidity of a substance is measured using a **pH scale** that form pH 0 (strong acid) to pH 14 (strong base). A pH of 7 is neutral.

pH scale – ranging from 0 - 14, used to describe how acidic (0) or basic (14) a substance is.

Normal precipitation is naturally acidic and has a pH of 5.6. Rainfall with a pH less than 5.6 creates an environmental concern. Alberta's rainfall has a pH between 5.5 and 7.0. Rain with a pH as low as 3 (the acidity of vinegar) has been recorded in Scotland.



Where Do the Acids Come From?

Common air pollutants like sulphur dioxide and oxides of nitrogen form acids in water. Sulphur dioxide comes from smelters (such as the nickel smelters in Sudbury, Ontario), gas processing plants, oil sands plants, coal-fired power plants, and transportation (trains and vehicles). Oxides of nitrogen come from the same sources with nearly half of it coming from transportation sources.

The largest source of acid pollution in Alberta is from sour gas processing. Sour gas is a natural gas, which contains hydrogen sulphide (H_2S) that must be removed before the gas can be used for other purposes or burned as fuel. Alberta Environment and the Alberta Energy and Utilities Board require gas-processing plants to remove most of the hydrogen sulphide from the gas and convert it to sulphur. Sulphur is an important economic mineral used in many industrial processes and to make fertilizers. Hydrogen sulphide that can't be removed is burned in either an incinerator or flare stack, thereby converting it to sulphur dioxide.

Oxides of nitrogen are a byproduct of combustion and are formed when fuels, such as petroleum products, coal and wood, are burned at high temperatures. The major sources of NO_x are vehicles and reciprocating compressor engines used in gas processing plants and coal-fired power plants. Burning natural gas in home furnaces also emits significant amounts of NO_x.

What does acid deposition do?

Neutralize: to add a base to an acid until the pH is 7.0.

Transpiration: the loss of water by evaporation through the leaves and stems of plants. This process is vital for plants to produce food and maintain rigidity.

Leach: the process of water passing through the soil, which dissolves out various minerals.

Acid deposition has different effects in different areas of Canada. Southwestern British Columbia, northeastern Alberta, northern Saskatchewan, northern and eastern Manitoba, and most of Eastern Canada have naturally acidic soils. Acidic soils cannot **neutralize** acid; therefore acids build up faster in these soils. Other areas including parts of British Columbia, central and southern Alberta, southern Saskatchewan and southwestern Manitoba have soils that contain limestone, which reacts with acid deposition to neutralize it.

When acid rain falls on the leaves of plants it can damage the cuticle (the waxy outside layer that controls **transpiration**). Damaged cuticles allow acid to get into the leaves, which can kill plants. Tree species like white pine, jack pine, aspen and birch are sensitive to acids. Scientists use these species to monitor acid rain. Some farmers have also noticed an impact on their agricultural crops.

Acid rain produces complex changes in normal soil chemistry. Minerals like calcium, magnesium, potassium and sodium are **leached** from the soil and carried away. Toxic metals like aluminum, manganese, mercury, cadmium and lead become more soluble by the chemical action of the acids. This allows the

toxic metals to be absorbed by the plant roots and can cause serious damage or death to the plant.

Acid rain can affect microorganisms that break down plant debris. Plant material decomposition releases nutrients back into the soil, acting as a natural fertilizer. Acidic soils alter the release of these nutrients so the nutrients are no longer available for plants. This increases the stress on plants, which are already suffering from changes in soil chemistry.

Acid rain speeds up natural weathering processes. Scientists estimate that buildings have weathered more in the last 20 years than they did in the previous 2000 years.

Most lakes in areas with basic soils, such as in parts of British Columbia, central and southern Alberta, southern Saskatchewan and southwestern Manitoba, have a pH near 8.0. This means they are alkaline. The natural neutralizing ability of lakes can withstand several years of **acid rain.** However, long-term exposure to acid rain can lower the pH. At a pH of 7.0 (neutral) the carbonates in the water begin to decrease in their ability to neutralize acids and as the lake becomes more acidic, many changes take place. At a pH of 6.0 the microorganisms, which decompose the organic debris on the bottom of the lake, begin to die. The plankton, the base of the aquatic food chain, also begins to decline. Between pH 6.0 and 5.5 the number of insect species in a lake declines, most fish species cannot reproduce, and algae mats form along the shoreline.

Toxic: of, or having a poisonous nature.

At extreme acid levels, **toxic** metals like aluminum, mercury, lead, and cadmium are washed into the lakes from the soil and released from lake-bottom sediments by chemical action. These toxic metals collect in fish and other aquatic animals making them unsuitable or dangerous for people to eat. At a pH of 5.9, aluminum can start damaging the gills of some fish species and may eventually kill them. Acid tolerant plants will begin to grow in the lake. If the pH reaches 4.5, most of the fish, frogs, and insects will have died.

Acid rain even affects historical monuments, such as the Parthenon in Greece, Westminster Abbey in England and the Taj Mahal in India by turning the limestone and marble into a crumbly rock called gypsum. Modern day works like steel bridges, vehicles and other metallic structures corrode or rust at a much faster rate because of acid rain.

In Alberta, sour gas processing, thermal electric generation, vehicles, and oil sands processing produce acid forming particles. Fortunately, most of the soils in Alberta are alkaline and are fairly resistant to acid deposition. Our dry climate means fewer pollutants are trapped and returned to earth as acid rain or snow. It also means more of Alberta's pollution stays suspended in the air and the prevailing wind patterns push most pollutants east to Saskatchewan and Manitoba. Alberta in turn receives acid forming pollutants from British Columbia.

Some of the acid forming gases and particles are deposited dry, forming acids when they come into contact with soil moisture or when it rains. Sulphur is necessary for plants and animals to live but is poisonous in large amounts. It can

directly affect plants by entering tissues and affecting life processes. Sulphur may even replace essential trace elements, such as selenium, that are taken up by plants. This can lead to nutrient deficiency diseases in plants and affect the animals and people who eat them.

What is being done?

Alberta Environment routinely monitors air, rain, snow, water, and soils for acid deposition in various places throughout the province. Governments and industry are working together to reduce air pollution. Alberta Environment establishes ambient air quality objectives for major air pollutants including sulphur dioxide and oxides of nitrogen, as well as targets for acid deposition.

Alberta's air emissions guidelines for sulphur dioxide are some of the strictest emission control regulations in North America. Every major plant that may produce these pollutants must apply for an approval that limits the total amount of emissions released into the air. These approvals are monitored regularly and updated every 10 years. All new plants must use the best available technology while many older plants have been required to add new technologies, such as scrubbers and bag houses, to capture pollutants before they are released.

Specific examples include:

- The Suncor Flue Gas Desulphurization (FGD) installation in 1996 lead to a 75 per cent reduction of SO_2 emissions
- By 2009, the Syncrude Emission Reduction (SER) Project will reduce SO_2 emissions by 58 per cent and particulate matter emissions by 50 per cent
- All oil sands mining vehicles and engines must meet the latest U.S. EPA emission standards for off-road heavy-duty diesel vehicles
- The natural gas processing industry now removes more than 97 per cent of the sulphur from raw natural gas
- Alberta's Acid Deposition Management Framework has set targets for acid deposition for soils with low, moderate and high sensitivity

Electric Power Sector

- By 2009, achieve a 50 per cent reduction in mercury emission from 2003 levels
- By 2025, achieve a 51 per cent reduction in particulate matter, 46 per cent reduction in SO_2, and 32 per cent reduction in NO_x from 2003 levels

Flaring and Venting

- Reduced flaring of gas by 72 per cent from 1996 levels
- Reduced venting of gas by 49 per cent from 2000 levels

What can you do?

New vehicles emit 95 per cent less emissions than pre-1988 models.

It takes 95 per cent less energy to recycle one aluminum can than to make a new can!

Although most sulphur dioxide and oxides of nitrogen emissions sources are from large industries, vehicles emit significant amounts of pollutants. You can help by:

- Keeping your pollution control devices in good working order
- Reducing the amount of driving you do
- “Right” sizing your vehicle
- Trading that old beat-up car in for a new vehicle can reduce air pollution by 95 per cent

You can also help conserve energy by turning off lights and computers when they are not being used and by reducing, reusing and recycling products to help reduce the amount of pollution generated.

Conclusions

Acid deposition is a worldwide concern that is more serious in some places than in others. Scientists around the world are studying the effects of acid deposition and are looking for ways to prevent future damage.

In Alberta, many people in government, industry, and the public are working to make sure acid deposition does not become a problem. Although we do not know how to completely remove acid forming gases and particles from industrial process, we are working hard to minimize the impacts. We must continue to work towards developing ways to reduce pollution and manage our emissions to ensure our air is clean and safe, our water is clean and plentiful and our land is capable of sustaining our needs.

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Additional information on Acid Deposition is available on the Alberta Environment website at www.ESRD.Alberta.ca and search "Acid Deposition"