Acid rain

An introduction to the Acid rain

Acid rain is a major problem for our health and even our existence. Human started poisoning the atmosphere with acid gases since 1730, at the height of the Industrial Revolution. Although, it was first recognized in 1872, approximately one hundred years after the beginning of the Industrial Revolution, when an English scientist, Robert Angus Smith (1817-1884), pointed out the problem. In 1962, the Swedish scientist Svante Oden brought the acid rain quandary to the attention of the press, instead of the less popular scientific journals. He compiled records from the 1950s indicating that acid rain came from air masses moving out of central and western Europe into Scandinavia. In 1984 it was reported that almost half of the trees in the famous black forest in Germany had been damaged by acid rain. In 1988 United nations agreed to reduce the emissions of these acids into the atmosphere. In 1990 changes to the Clean Air Act set rules to cut down the release of sulfur dioxide from power plants down to 10 million tonnes by January 1, 2000

The Meaning and Creation of Acid Rain

Acid rain is a term that describes the fall of the quantity of acids, staying in the atmosphere. We can use the term “ Acid deposition’ to be more specific. Acid deposition separates in two parts: wet and dry.

Wet deposition refers to the acidic rain, fog, and snow. As the high-acidized water flows over and through the ground, affects badly most of the earth’s flora and fauna. The danger of this effect depends on many factors like the acidity of water, the capacity of the soil and the types of flora and fauna that depend on water.

Dry deposition refers to the acidic gases and their particles. It is known, that most of these acidic gases falls from the atmosphere to the earth through this procession (dry deposition). After that, the wind blows these dangerous particles on trees, cars, buildings etc. Trees are also infected due to the rainstorms, because they absorb the water from the storm. When this fact happens the high-acidized water adds these acids to the acid rain, which makes it more acidic than the rain that already falls.

Prevailing winds blow these chemical compounds, which cause both wet and dry deposition, across the lands (hundreds of miles).

The most important and harmful compounds are sulfur dioxide (SO2) and nitrogen oxides (NOx) which are created mostly from electric power generation made through the burning of fossil fuels like coal.

The acidity of acid rain is made through the following reactions of sulfur and nitrogen oxides with the oxygen from the atmosphere and the water from the rains

$S + O_2 \rightarrow SO_2$

$SO_2 + O_3 \rightarrow SO_3 + O_2$

$SO_3 + H_2O \rightarrow H_2SO_4$

$SO_2 + H_2O \rightarrow H_2SO_3$

$2NO_2 + H_2O \rightarrow 2HNO_3 + NO2$

$NO + O_2 \rightarrow 2NO2$

Natural effects

Nature also harms herself. Acid gases, produced by emissions from fires, volcanic eruptions, bacterial decomposition and lightening, are released in the atmosphere, increasing the amounts of nitrogen oxide. The major biological source of sulfur containing compounds is Dimethyl sulfide.

Gas Phase chemistry

Sulfur

Sulfur dioxide reacts with the hydroxyl radical. Then the product reacts with the oxygen from the atmosphere and creates sulphur trioxide. Sulfur trioxide, when water is present, reacts and produces sulphuric acid. (See reaction table No1)

Now, sulphur dioxide, like carbon dioxide, reacts with water, when clouds are present, through the procession of Hydrolysis. It dissolves in water in a series of equilibrium reactions (See reaction table No2)

1. $SO_2 + OH\cdot \rightarrow HOSO_2$

   $HOSO_2\cdot + O_2 \rightarrow HO_2\cdot + SO_3$

   $SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (l)$

   $NO_2 + OH\cdot \rightarrow HNO_3$

2. $SO_2\ (g) + H_2O\ SO_2\cdot H_2O$

   $SO_2\cdot H_2O\ H^+ + HSO_3^-$

   $HSO_3^-\ H^+ + SO_3^{2-}$

Nitrogen Oxide

Nitrogen oxide reacts with OH to form nitric acid

$NO_2 + OH\cdot \rightarrow HNO_3$

Oxidation

There is a large amount of reactions where sulfur is oxidized from S(IV) to S(VI) that leads to the formation of sulphuric acid.

The most important oxidation reactions are with ozone, hydrogen peroxide and oxygen (reactions with oxygen are catalyzed by iron and manganese in the cloud droplets).

Measure and effects

To measure the acidity of acid rain, we use the pH scale. Pure water has a pH of 7. 0.

Normal rain has a pH of 5. 5 due to the dissolve of carbon oxide into it. The most acidic rain was fell in USA in the year 2000. It had a ph of 4. 3

This acidity affects every living thing on the planet. The following tasks explain exactly this affection:

1st Effect: On Plant life

Roots of flowers and trees are destroyed, such as nutricients, which are very important for their lives. Useful microorganisms, which release nutrients from decaying organic material, are killed. Acid rain also damages the waxy layer of the plants, which makes the plant vulnerable to diseases.

Plants that survive are weak and without the ability to survive through tough conditions such as a short dry period, a heavy rainfall or a strong wind. The reproduction is also affected.

2nd Effect: On soil

The decrease of pH damages or kills some microbes, which produce important enzymes. These enzymes, after the damage of microbes, change shape and lose the ability to function. Also cation exchange creates a serious problem. The ions of some metals (magnesium, potassium, and other metals) are attached to the clay and humus particles in the soil. The attractive forces of positive metal ions to the negatively charged clay particles are strong enough to hold the metal ions in the soil despite the passage of water through the soil.

Hydronium ions from acid rain mobilize toxins like aluminium and leach away nutrients like magnesium.

3rd Effect: On animals, humans, and aquatic life

Humans depend on food (animals, fishes). Fishes on the lakes and the seas are poisoned or infected by aluminium and mercury, that is leached from soil and rocks. Soil and water have the ability to neutralize the acidity of the rain water. But as the acidity becomes stronger, the pH goes lower.

pH 5. 5- Plankton population begins to die

pH 5. 0 – Fish population begins to die

pH lower than 5. 0- All the fishes have died

This effect is called ‘’Acid Shock” and prevents also the reproduction of the population.

Animals, like all the living organisms, interdependent on each other. The habitants that depend on plants and fishes begin to extinct. Other animals

that depend on the animals, who depend on fishes and plants, begin to extinct. The food chain is affected dangerously.

4th Effect: Corrosion of buildings and sculptures.

The sulfur dioxide reacts with limestone and marble. This reaction creates a black crust on buildings and sculptures, composed by gypsum. Gypsum is composed by the reactance of calcite, water and sulfuric acid. It may be white, but in the crystals of the network of its composition, dirt and pollutant are trapped, so it looks black

$CaCO_3 (s) + H_2SO_4 (aq) \rightarrow CaSO_4 (aq) + CO_2 (g) + H_2O$

Acid rain also increases the oxidation rate of metals, especially copper and bronze

One good result

Researches have resulted that Acid rain restricts global warming by reducing methane emissions from wetland areas. This study also showed that sulfur in the acid deposition limits global warming by counteracting the natural production of methane gases by microbes in wetland areas. Heating these microbes increases the speed of producing more methane, which is mitigating by the sulphur pollution from the industries. This fact is happening because of the sulphur-eating bacteria, which are living in wetlands, and compete the methane-eating microbes.

Experiments have shown, that releasing the sulphur deposits causes decrease of methane by 30%, due to the activation of sulphur-eating bacteria

Acid rain: Problems and solutions

An important solution is the remove of sulphur from the stack gases, made from coal-burning power plants of the industries. This will be able to be done with the use of FGD (flue gas desulfurization). This plan is commonly uses in the U. S. A and many other countries. An example of FGD is the wet scrambler.

Wet scrambler is a reaction tower equipped with a fan that extracts hot smoke stack gases from a power plant into the tower. Lime or limestone in slurry form is also injected into the tower to mix with the stack gases and combine with the sulfur dioxide present. The calcium carbonate of the limestone produces pH-neutral calcium sulfate that is physically removed from the scrubber. That is, the scrubber turns sulfur pollution into industrial sulfates.

In some areas, where he purity of calcium sulphate is high, the sulfates are sold to chemical companies as a gypsum. In other areas they are placed in landfill. However, the effets of acid rain can last for generations, due to the change of the pH level. Chemicals continue leaching in water, killing off all the living organisms and blocking the restore of life.

Another solution refers to the trading of emissions. Industries can then install pollution control equipment, and sell portions of their emissions allowances they no longer need for their own operations. This plan saves the economy and decreases the capital cost for these equipments. The intention is to give operators economic incentives to install pollution controls.

Prevention

Step 1·

Reduce emissions from mining, smelting and generating electrical power. Consumers can help by using fewer mined resources and reducing electrical power usage, as well as campaigning for government regulation of emissions in their area.

Step 2·

Reduce emissions produced by oil operations and oil-fueledtransportation. Consumers can help reduce emissions produced by oil operations by buying less oil, buying from companies with higher emissions regulations and driving cars with lower emission rates.

Step 3·

Reduce the amount of carbon dioxide and nitrogen oxides produced by reducing use of coal and wood burning as well as natural gas.

Step 4·

Cut back on your use of products that produce chlorofluorocarbons, or CFCs. Air conditioning, refrigeration and many aerosol products use or contain CFCs. Reduce the use of air conditioning by using fans and use a single, energy efficient refrigerator per household. Conserve cooled air by not leaving doors open when the air conditioning is on and by not leaving the refrigerator open for extended periods of time.

Step 5·

Reduce production of sulfur dioxide by conserving paper. Sulfur dioxide is produced in paper production, so read newspapers online rather than buying

a newspaper everyday, use the front and back of paper and use recycled paper.

Step 6·

Reduce the emissions produced by your car by car pooling, planning ahead to combine long trips, biking or walking for short trips and keeping your car well maintained to be sure nothing is leaking.

Step 7·

Increase energy efficiency in your home by using fluorescent lights, turning lights off when not in use, shutting down utilities when you’re on vacation, closing off vents to rooms that are not in use and operating large appliances like dishwashers, washers and driers only when full.

Step 8·

Reduce your use of manufactured materials such as packaging and other disposable products and recycle as much as you can. Producing new materials and disposing of waste materials are responsible for a large number of the pollutants that cause acid rain.