Acid rain

Acid rain is rain that is more acidic than normal, it refers to a mixture of wet and dry deposition from the atmosphere containing higher-than-normal amounts of nitric and sulfuric acids. It is formed from the combination of the pollutants and water vapor in the atmosphere. It has a pH less than 5.

The acidity of natural rain is due to the small amount of CO_2 that dissolves in rainwater and produces carbonic acid. Also, acid rain formation is a result release of SO_2 and NO_X from both natural sources, such as volcanoes, and man-made sources, resulting from fossil fuel combustion, oil refinery, electrical power plants that burn coal for energy. These gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds such as sulfuric acid and nitric acid, sun light increase these reactions. These acid dissolve in water droplets which fall as rain, this is called **acid rain** or **acid precipitation.**

$$S + O_2 \longrightarrow SO_2$$

$$SO_2 + 1\backslash 2\ O_2 \longrightarrow SO_3$$

$$SO_3 + H_2O \longrightarrow H_2SO_4 \quad \text{Sulfuric acid}$$

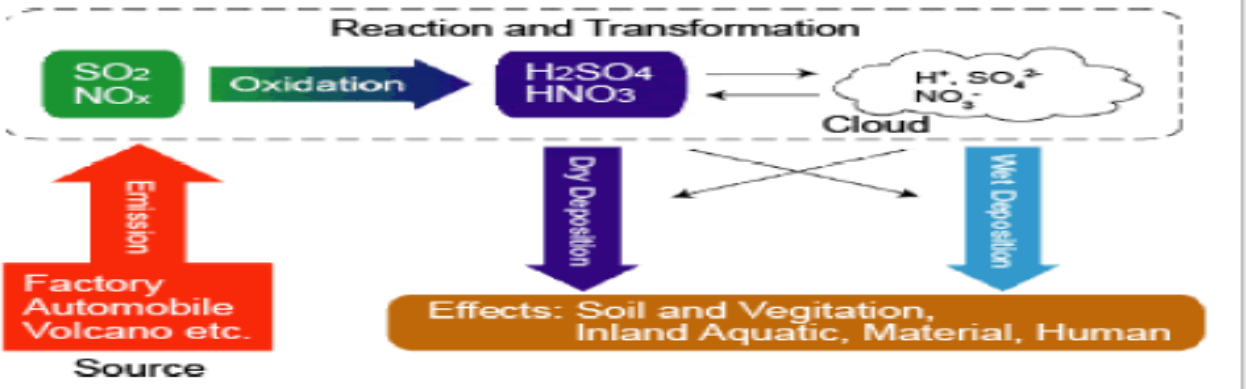

Figure 1: Flow chart that shows the formation of acid rain and its interaction with environment.

Acid rain is not only form of precipitation or snow but sometimes remain as a suspended form in air which is called **acid fog,** it surrounded the subjects with the high average of pH 3.4 , more acidic than the acid rain. Acid fog on mountain can be 10 times more acidic than rain fall nearby, for example, acidic rain in California in 1986 had pH 1.7.

Wet Deposition

Wet deposition refers to acidic rain, fog, and snow. If the acid chemicals in the air are suspend into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist. As this acidic water flows over and through the ground, it affects a variety of plants and animals.

Dry Deposition

In areas where the weather is dry, the acid chemicals may become into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, homes, cars, and trees. Dry deposited gases and particles can be washed from these surfaces by rainstorms, leading to increased runoff.

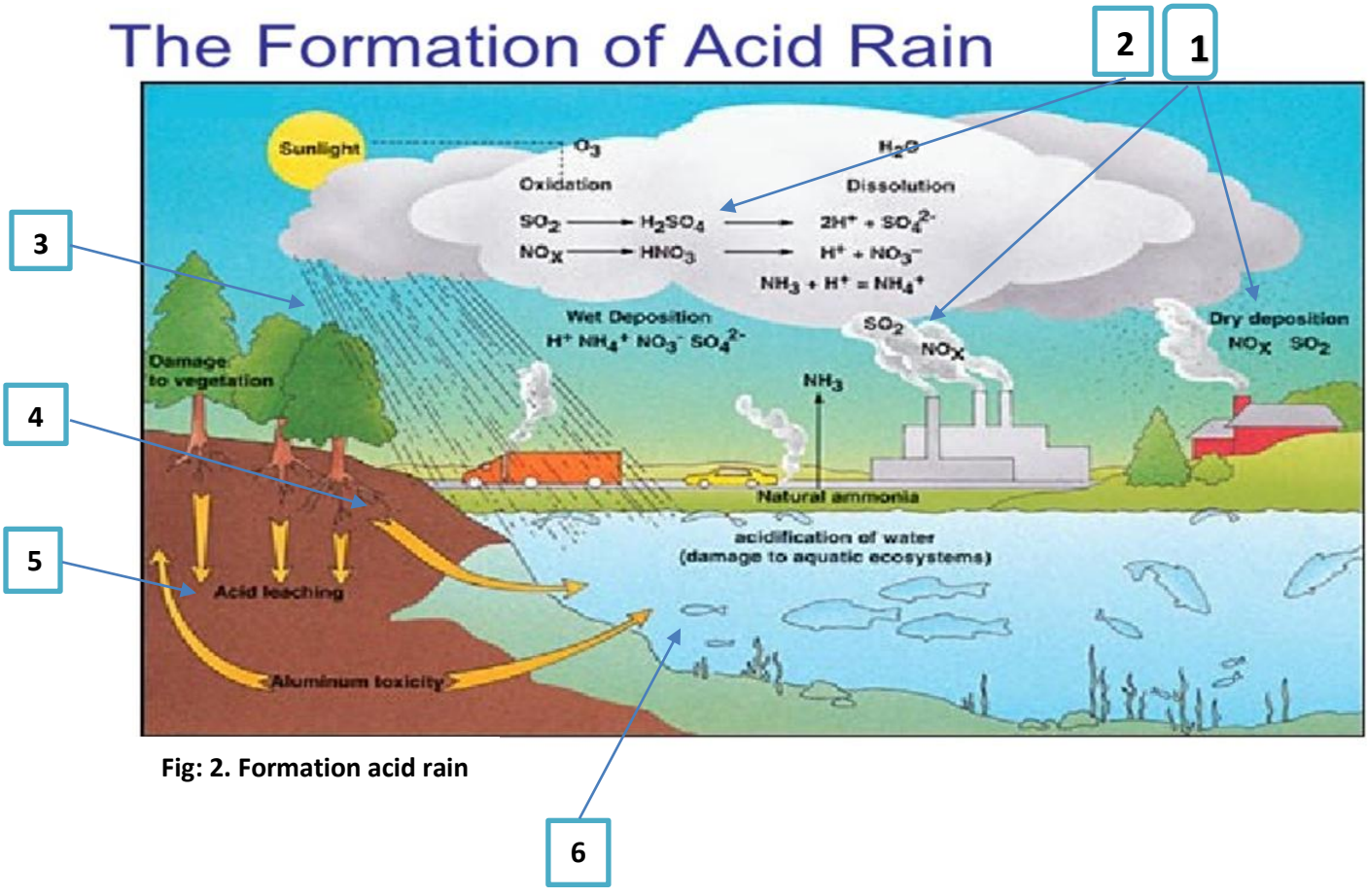

Fig: 2. Formation acid rain

According to figure 2:

1- Acid rain produced by release SO_2 and NO_X in to the atmosphere from factories and power station.
2- Gases combine with water to make H_2SO_4 and H_2NO_3, these acids can travel for long distance from the sources (for example as far as 600 miles or 1000km in win direction). Acid rain less effect to area which originated it if compare with the area which receive. The Scandinavian countries, acid rain is big problem, all rain fall on Sweden in 2000, had pH less than 5, this emission com from factories of United Kingdom (had pH more 5), or Canadian s acid rain problems originated in factories and power plants of United State.
3- Acid rain and snow fall on tress, which cause killing them. In some cases, acid rain effect on root plants by available of heavy metals for plants that kill them.
4- Acid rain run in to the river (surface water) that killing fish and other organisms in aquatic life.
5- Acidify water leach nutrients and heavy metal out of soil, this run in to the lake or ground that pollute it.
6- After arrived polluted water (acid rain) in to water body, it effects on aquatic life and in some cases completely destroy it and killing fish.

Effect of acid rain

1- Effect of acid rain on materials

- Damage the building, paint, structure and losing their feature and shape. Old building appears in black and dirty
- Damage historical monument (statue such as Taj mahal).
- Many metals will become oxidize (Iron rust).

Generally marble and limestone use in construction of building and monuments which composed calcium carbonate (CaCO3), the building and outdoor monuments are erode by chemical reaction between calcium carbonate present in marble or limestone and sulfuric acid in acid rain.

$$CaCO_3 + H_2SO_4 \longrightarrow Ca^{+2} + SO_4 + H_2O + CO_2$$

In this condition, SO_4 and CO_2 return to the atmosphere for second time act as a main pollutants factor to renewing acid rain.

2-Effect of acid rain on aquatic ecosystem

- Destruction of aquatic flora and fauna due to increase acidity, large amount of acid rain change ponds or lake s ecosystem and in some cases completely destroy it.
- It effects on food chain by killing plant, insect and invertebrates because fish depended on them for food.
- After arrived or leached heavy metal (mercury and aluminum) from the soil and rocky area in to water body which can kill living organisms in water if present in great quantities.
- pH affected on the function of all enzymes and hormones in the body of living organisms because organisms are more sensitive for change in pH.

Q\ Explain relation between pH and aquatic life ecosystem?

Water with low pH diminished the quantity and variety of life in lakes and streams. Most aquatic plant grow best in water with **pH 7 to 9**. When the pH is decrease, the aquatic plant life decline, reduce food for some water birds. **At the pH 5.5**, bacteria that decompose leaf litter and other debris begin to die. Aluminum leach from the soil by acidic water enter the lake in great quantities, fish population located under more stress. Young fish do not survive. Under acidic or metallic condition, fish female will not spawn and fish egg will not hatch. **If pH is less than 5,** the animal lives in harsh environment and create many problems such as diseases, below pH 5, adult fish die. **At less than pH 4.5**, the lake is entirely devoid of fish and organic matter remain in bottom of lake and sides of lake cover with moss.

Some organisms tolerate in acidic environmental stress such as plant, moss, black fly larvae. Frog can tolerate lower acidity than fish. Bird and mammalian population decline because they depended on fish and aquatic plant for food.

3-Effect of acid rain on forest and crops

- increase acid of soil that release heavy metals such as aluminum, mercury, lead and cadmium which kill trees directly, or may weaken them to exposed for cold or freezing, injury, diseases, insect attach and drought.
- High amount of acidity in soil which leading to loss of soil s nutrient such as calcium and magnesium which are very important for plant growth.
- Destruction of certain plants and trees due to loss of chlorophyll. Acid damage plant leaves, forming yellow color, blocked stomata and in high acid break dawn stomata. In this condition, pH change in plant that effect on mechanisms which take place in plant such as photosynthesis, transpiration, respiration and gas exchange, finally reduce product and killing plant (it has bad effect on roots, leaves and all parts of plant).
- Acid rain can destroy forest ecosystem, for example, reduce snail population, depletion calcium by acid rain which cause production egg with thin shell in some birds, produce weak bone, destruction of beneficial earthworms by accumulation toxic elements in the soil due to acid rain.

4- effect of acid rain on human health

- Accumulation of heavy metals such as lead, mercury in the tissue of fish and plant (these metals available for plant by acid rain and enter water body through leaching process from the soil) which eat by human and animal through food chain, these metals are toxic elements and killing them.
- After many metals enter into water body by leaching process from the soil and directly in to river or stream, these water body contaminated by metals which impossible as drinking water.
- Reduction of visibility, when smoke react with fog to forming smog that it found in industrial cities, this smog reduce visibility that cause some of transportation accidents.

- Acid is more harmful or extremely toxic for human health when present in the smog form because it has more concentrated pollutants that responsible of acid (few pH) especially SO_4. These pollutants forming many respiratory problems for human.

Reduce or control acid rain damage

1-reduce fossil fuel and factories plant which emission SO2 and NOx by using another energy source like solar energy, biofuel wind and hydroelectrical power. Use natural gas instead artificial gas.

2-use sulfur recovery techniques in industrial factories and fuel plants to minimize SO_2 emission.

3-use catalytic converter that found in all modern cars, it is used to reduce and oxidize pollutants such as SO_2. Catalyst is substance that increase the rate of chemical reaction without consumed in the reaction.

4-added lime or phosphate fertilizer into acidify lake or pond for neutralization of water. Lime is rock and soil that contain calcium carbonate added to acid water body for neutralize or buffering, this process is called buffering capacity.

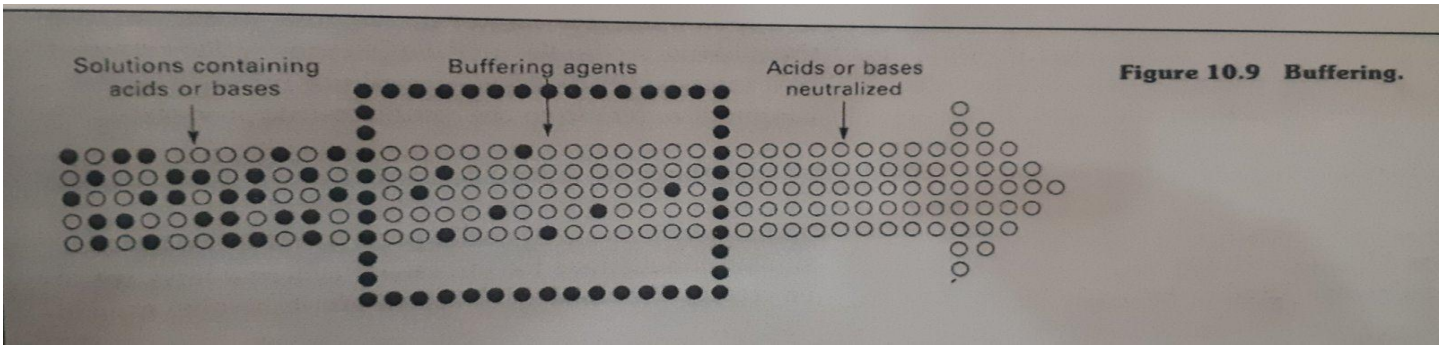

Figure 10.9 Buffering.

5- treatment of stock gases to eliminate SO_4 and NO_x emission.

6-restore the damage environment and older building to reduce SO_2 emission.

7- Increase the vegetation area by plant to create barrier for pollutants. Green plants are the lungs of nature with ability to purify impure air and reduce CO_2 by photosynthesis process.

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What Is Acid Rain?

It's when water and oxygen in normal precipitation mix with compounds such as sulfur dioxide and nitrogen oxides in the atmosphere. The chemical reaction turns clean rain which is naturally acidic dangerously so. Clean rain normally falls about 5.6 on the pH scale; acid rain falls below 4.5 pH.

Acid rain comes in two forms:

Wet. The compounds turn into acids in the atmosphere and fall down as rain, sleet, snow, fog, or hail.

Dry. This is when compounds produce acids and float down to the ground as dust and gas. Future rains can spread them even more.

What Causes Acid Rain?

Much of the acids originate from power plants that burn coal, oil, and other fossil fuel to generate electricity, as well as from exhaust from gasoline-powered vehicles.

Sulfur dioxide and nitrogen oxides can travel high into the atmosphere. When the emissions combine with precipitation, they turn into harmful sulfuric and nitric acids. Sometimes, the earth releases sulfur dioxide and nitrogen oxides naturally, like when a volcano or geyser erupts.

The acids produced in the acid rain can fall near the original source of pollution. Winds can also blow contaminated dust in the atmosphere even farther and it can fall there, blanketing more areas.

Can Acid Rain Hurt You?

Yes. But the danger doesn't come from swimming in a lake containing acid rain or getting wet from raindrops. The harm comes from breathing in particles from acid rain.

If you're exposed to high concentrations of nitric and sulfuric acid especially over time it can cause these problems:

Irritation to eyes, skin, and mucous membranes can come from contact with one or both acids.

Fluid in lungs, or pulmonary edema, can happen if you breathe in nitric acid.

Dental erosion. Both acids can wear down the enamel on your teeth.

The compounds released from burning fossil fuels (before they turn into acids) can cause:

Respiratory illnesses like chronic bronchitis, pneumonia, and asthma. (Acid rain chemicals can make existing respiratory ailments worse, too.)

Cardiovascular problems, such as worsening existing heart disease.

Lower birth weight, which might affect a child's growth and development.

Lung cancer. Pollution can cause cell mutations that can become cancerous.

How Does Acid Rain Affect the Environment?

Acid rain can not only harm human health, but it's also damaging to our lakes, plants, and buildings.

Soil. Generally, limestone (a base) in the ground helps neutralize the acid. But acid rain can affect soil that doesn't contain much limestone. Also, the chemicals can trickle into the water below to the groundwater. That can acidify major waterways, too.

Surface water. Acid rain can fall into a body of water like a lake or the ocean. It may build up more in waters that don't move as much, such as ponds. Over time, it can change the water's pH balance.

Animals. Acid rain can affect plants and animals that rely on the polluted water. That in turn affects bigger animals that feed on them. The result: Our foods may be contaminated.

Plants and forests. Acid rain can destroy nutrients like calcium and magnesium that keep trees healthy. It releases aluminum, which makes it tougher for trees to get water from the ground. Trees located at higher elevations are more prone to acidic clouds and fog as well.

Buildings. Chemicals from acid rain can break down stone and metal on structures. This can wear down surfaces and fade finishes.

What's the Link Between Acid Rain and Climate Change?

Both stem from pollution created by humans. Even though acid rain is a regional problem, it can eventually alter the chemical makeup of soil and water around the world.

Some compounds that cause acid rain, including nitrous oxide, are greenhouse gasses like carbon dioxide and methane that trap heat in the atmosphere. That contributes to global warming. In turn, the higher average temperatures are melting glaciers and setting off more and more extreme weather changes that are a sign of climate change.

Global warming can make acid rain worse because it speeds up the chemical reactions that produce acid rain.

What Can We Do About Acid Rain?

Many coal plants -- once a major source of acid rain are shutting down and more will be retired. There are no plans for new large-scale coal plants in the country, though other countries still build them.

Individual actions also can help prevent acid rain. You can:

Try battery-operated tools. Switch from gas-powered tools to ones with rechargeable batteries.

Drive an eco-friendly vehicle. Electric and hydrogen-powered cars don't produce air pollution, and hybrid vehicles burn less fuel than gas-powered ones. They can reduce fuel consumption and pollution. Low-emissions vehicles give off a lot less compared to other cars.

Conserve energy. Using less energy means producing less energy. Turn off electronics when you don't use them, lower the heat when you're not using it, and limit air conditioning.

Renewable energy. Add solar panels to your home. They create less pollution than fossil fuels. If you live in a deregulated state, you can choose an electricity provider that uses renewable energy instead of one that uses fossil fuels.

Drive less. Exhaust from cars, trucks, and buses spew nitrogen oxides and sulfur dioxide. Consider walking or biking somewhere instead of driving when you can, or use public transportation.

Burn better. If you have a fire, only burn wood not other waste, especially in cities that tend to have higher air pollution. Wood-burning fireplaces should only burn wood, too.