Week 6: Lecture 11

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GLOBAL WARMING

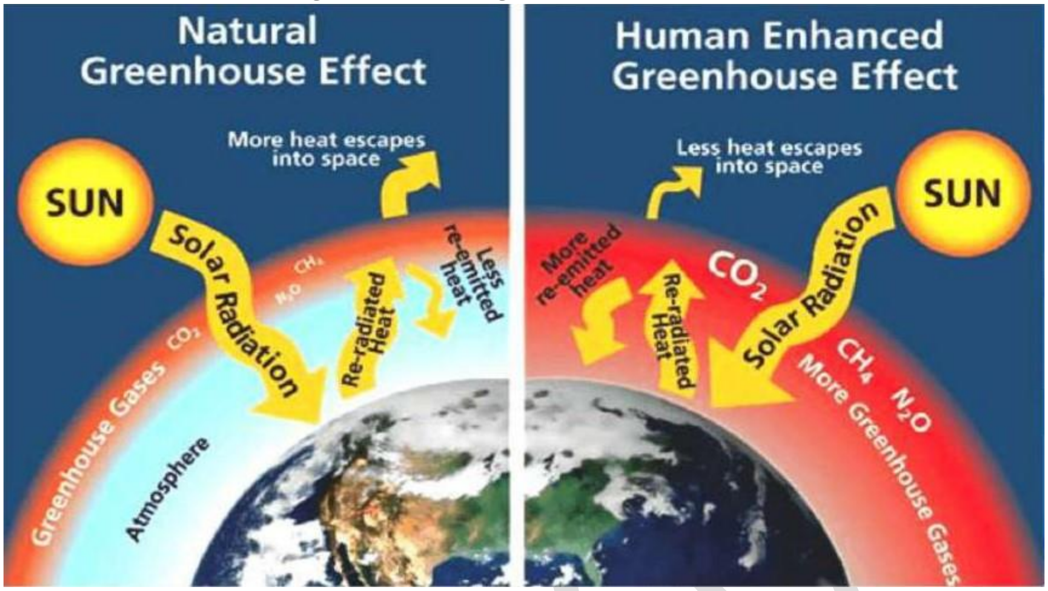
Global warming is the slow increase in the average temperature of the earth's atmosphere because an increased amount of the energy (heat) striking the earth from the sun is being trapped in the atmosphere and not radiated out into space. The earth's atmosphere has always acted like a greenhouse to capture the sun's heat, ensuring that the earth has enjoyed temperatures that permitted the emergence of life forms as we know them, including humans. Without our atmospheric greenhouse the earth would be very cold. Global warming, however, is the equivalent of a greenhouse with high efficiency reflective glass installed the wrong way around. Global warming is just one aspect of climate change. It's a term used to describe the recent rise in the global average temperature near Earth's surface, which is caused mostly by increasing concentrations of greenhouse gases (such as carbon dioxide and methane) in the atmosphere. The terms "global warming" and "climate change" are sometimes used interchangeably, but warming is only one of the ways in which climate is affected by rising concentrations of greenhouse gases. The average surface temperature is about 15°C. This is about 33°C higher than it would be in the absence of the greenhouse effect. Without such gases most of the Earth's surface would be frozen with a mean air temperature of -18°C. Human activities during the last few decades of industrialisation and population growth have polluted the atmosphere to the extent that it has begun to seriously affect the climate. Carbon dioxide in the atmosphere has increased by 31% since pre-industrial times, causing more heat to be trapped in the lower atmosphere. Global warming influences climate change.

Climate Connections

Changes in temperature change the great patterns of wind that bring the monsoons in Asia and rain and snow around the world, making drought and unpredictable weather more common. This is why scientists have stopped focusing just on global warming and now focus on the larger topic of climate change.

Causes for Global Warming

Global warming and climate change result from human activity (are "anthropogenic"), scientists attribute current atmospheric warming to human activities that have increased the amount of carbon containing gases in the upper atmosphere and to increased amounts of tiny particles in the lower atmosphere. Specifically, gases released primarily by the burning of fossil fuels and the tiny particles produced by incomplete burning trap the sun's energy in the atmosphere. Scientists call these gases "greenhouse gases" (GHGs) because they act like the wrong way reflective glass in our global greenhouse. Scientists call the tiny particles 'black carbon' (you call it soot or smoke) and attribute their warming effect to the fact that the resulting layer of black particles in the lower atmosphere absorbs heat like a black blanket. Scientists date the beginning of the current warming trend to the end of the 18th or beginning of the 19th century when coal first came into common use. This warming trend has accelerated as we have increased our use of fossil fuels to include gasoline, diesel, kerosene and natural gas, as well as the petrochemicals (plastics, pharmaceuticals, fertilizers) we now make from oil. Scientists attribute the current warming trend to the use of fossil fuels because using them releases into the atmosphere stores of carbon that were sequestered (buried) millions of years ago. The addition of this "old" carbon to the world's current stock of carbon, scientists have concluded, is what is heating our earth which causes global warming.



Most important greenhouse gases(GHGs)

The most common and most talked about greenhouse gases is $C0_2$ or carbon dioxide. In fact, because it is so common, scientists use it as the benchmark or measure of things that warm the atmosphere. Methane, another important GHG, for example, is 28-36 times as warming as $C0_2$ when in the upper atmosphere. 1 ton of methane = 28-36 tons $eC0_2$ or $C0_2$ equivalents.

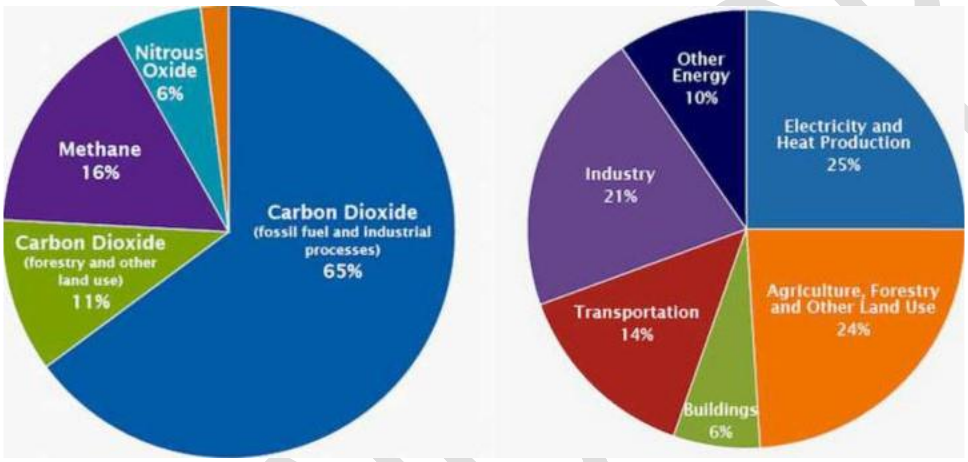
The most commonly discussed GHGs are:

- *$C0_2$ or carbon dioxide* is produced any time something is burned. It is the most common GHG, constituting by some measures almost 55% of total long-term GHGs. It is used as a marker by the United States Environmental Protection Agency, for example, because of its ubiquity. Carbon dioxide is assigned Global Warming Potential (GWP) of I .
- *Methane or CH_4* is produced in many combustion processes and also by anaerobic decomposition, for example, in flooded rice paddies, pig and cow stomachs, and pig manure ponds. Methane breaks down in approximately 10 years, but is a precursor of ozone, itself an important GHG. CH_4 has a GWP of 28-36.
- *Nitrous oxide in parean (laughing gas), NO/N_20 or simply N_0X* is a byproduct of fertilizer production and use, other industrial processes and the combustion of certain materials. Nitrous oxide lasts a very long time in the atmosphere, but at the 100 year point of comparison to $C0_2$, its GWP is 265-298.
- *Fluorinated gases* were created as replacements for ozone depleting refrigerants, but have proved to be both extremely long lasting and extremely warming GHGs. They have no natural sources, but are entirely man-made. At the 100 year point of comparison, their GWPs range from 1 ,800 to 8,000 and some variants top 10,000.
- *Sulphur hexafluoride or SF_6* is used for specialized medical procedures, but primarily in what are called dielectric materials, especially dielectric liquids. These are used as insulators in high voltage applications such as transformers and

grid switching gear. SF6 will last thousands of years in the upper atmosphere and has a GWP of 22,800.

- *Black carbon (BC)* is tiny particles of carbon released as a result of the incomplete combustion of fossil fuels, biofuels and biomass.
- *Particulate matter* These particles are extremely small ,ranging from 10 um (micrometers, PM_{10}), the size of a single bacterium to less than 2.5 pm ($PM_{2.5}$), one thirtieth the width of a human hair and small enough to pass through the walls of the human lung and into the bloodstream.

Fossil fuel and related uses of coal and petroleum are the most important sources of GHGs and black carbon (power generation, industry, transportation, buildings). Agriculture is the second most important source (animals - cows and pigs), feed production, chemical intensive food production, and flooded paddy rice production, as well as deforestation driven by the desire to expand cultivated areas. Natural sources of GHGs and black carbon include forest fires, savanna fires and volcanos.



Climate change impact

Because the global climate is a connected system climate change impacts are felt everywhere. Among the most important climate change impacts are:

1) Rising Sea Levels: Climate change impacts rising sea levels. Average sea level around the world rose about 8 inches (20 cm) in the past 100 years; climate scientists expect it to rise more and more rapidly in the next 100 years as part of climate change impacts.
2) Melting Ice: Projections suggest climate change impacts within the next 100 years, if not sooner, the world's glaciers will have disappeared, as will the Polar ice cap, and the huge Antarctic ice shelf, Greenland may be green again, and snow will have become a rare phenomenon at what are now the world's most popular ski resorts.
3) Torrential downpours and more powerful storms: While the specific conditions that produce rainfall will not change, climate change impacts the amount of water in the atmosphere and will increase producing violent downpours instead of steady showers when it does rain. Hurricanes and typhoons will increase in power, and flooding will become more common. Anyone in the United States who has tried to

buy storm and flood insurance in the past few years knows that the insurance industry is completely convinced that climate change is raising sea levels and increasing the number of major storms and floods.

4) Heat-waves and droughts: Despite downpours in some places, droughts and prolonged heat-waves will become common. Rising temperatures are hardly surprising, although they do not mean that some parts of the world will not "enjoy" record cold temperatures and terrible winter storms. (Heating disturbs the entire global weather system and can shift cold upper air currents as well as hot dry ones. Single snowballs and snowstorms do not make climate change refutations). Increasingly, however, hot, dry places will get hotter and drier, and places that were once temperate and had regular rainfall will become much hotter and much drier. The string of record high temperature years and the record number of global droughts of the past decade will become the norm, not the surprise that they have seemed.

5) Changing ecosystems: As the world warms, entire ecosystems will move. Already rising temperatures at the equator have pushed such staple crops as rice north into once cooler areas, many fish species have migrated long distances to stay in waters that are the proper temperature for them. Farmers in temperate zones are finding drier conditions difficult for crops such as corn and wheat, and once prime growing zones are now threatened. Some areas may see complete ecological change. In Ln California and on the East Coast, for example, climate change impacts and warming will soon fundamentally change the forests; in Europe, hundreds of plants species will disappear and hundreds more will move thousands of miles.

6) Changing Fisheries: In once colder waters, this may increase fishermen's catches; in warmer waters, it may eliminate fishing; in many places, such as on the East Coast of the US, it will require fishermen to go further to reach fishing grounds.

7) Shift in Forest Types: Tree species will shift northward.

8) California Tree Species Changes: This is evidenced based observation.

9) European Species Changes: This is again evidenced based observation.

10) Impact on agriculture: There are different views regarding the effect of global warming on agriculture. It may show positive or negative effects on various types of crops in different regions of the world. Tropical and subtropical regions will be more affected since the average temperature in these regions is already on the higher side. Even a rise of 2^0 c may be quite harmful to crops. Soil moisture will decrease and evapo-transpiration will increase, which may drastically affect wheat and maize production. Increase in temperature and humidity will increase pest growth like the growth of vectors for various diseases. Pests will adapt to such changes better than the crops. To cope up with the changing situation drought resistant, heat resistant and pest resistant varieties of crops have to be developed.

11) Reduced food security: One of the most striking impacts of rising temperatures is felt in global agriculture, although these impacts are felt very differently in the largely temperate developed world and in the more tropical developing world. Different crops grow best at quite specific temperatures and when those temperatures change, their productivity changes significantly. In North America, for example, rising temperatures may reduce corn and wheat productivity in the

US mid-west, but expand production and productivity north of the border in Canada.

12) Climate Change and Food Security: For example, the productivity of rice, the staple food of more than one third of the world's population, declines 10% with every 1 ^{0}C increase in temperature. Climate Change shall have Impacts on food Production because temperatures play important role in Food Production.

13) Pests and Disease: Rising temperatures favor agricultural pests, diseases and disease vectors. Pest populations are on the rise and illnesses once found only in limited, tropical areas are now becoming endemic in much wider zones. In Southeast Asia, for example, where malaria had been reduced to a wet season only disease in most areas, it is again endemic almost everywhere year around. Likewise, dengue fever, once largely confined to tropical areas, has become endemic to the entire region. Increased temperatures also increase the reproduction rates of microbes and insects, speeding up the rate at which they develop resistance to control measures and drugs (a problem already observed with malaria in Southeast Asia).

14) Impact on public health: Global warming will directly affect human health by increasing cases of heat-related mortality, dehydration, and spread of infectious diseases, malnutrition, and damage to public health infrastructure. Areas which are presently free from diseases like malaria may become the breeding grounds for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya, India, Bangladesh and Indonesia. Warmer temperature and more water stagnation would favour breeding of mosquitoes, snails and some insects, which are the vectors of such diseases. Higher temperature and humidity will increase/aggravate respiratory and skin diseases.

Measures to check/ mitigation/ control global warming: To slow down enhanced global warming the following steps will be important:

1. Cut down the current rate of use of CFCs and fossil fuel;
2. Use energy more efficiently;
3. Shift to renewable energy resources;
4. Increase in nuclear power plants for electricity production;
5. Shift from coal to natural gas;
6. Trap and use methane as a fuel;
7. Reduce beef production;
8. Adopt sustainable agriculture;
9. Stabilize population growth;
10. Efficiently remove carbon dioxide from smoke stacks;
11. Plant more trees;
12. Remove atmospheric carbon dioxide by utilizing photosynthetic algae.

Thus, "Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in Washington, London or Beijing. Consequently, action by one country to reduce emissions will do little to slow global warming unless other countries act as well. Ultimately, an effective strategy will require commitments and action by all the major emitting countries." The global effort to manage climate change has been organized through what is called the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was launched at the 1992 Rio Earth Summit to achieve GHG concentrations "at a level that would prevent dangerous anthropogenic interference with the climate system". It also set voluntary GHG emissions reductions that countries did not meet. With the failure of the Rio initiatives, the then 191 signatories to the UNFCCC agreed to meet in Kyoto in 1997 to establish a more stringent regime. The resulting Kyoto Protocol created a global trading system for carbon credits and binding GHG reductions for ratifying countries. (The US did not sign; China and India were exempt as developing countries.) So-called Conferences of the Parties (COPs) were held almost annually thereafter in places such as The Hague, Cancun and Doha without progress being made.

OZONE LAYER DEPLETION

Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in Earth's stratosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone over Earth's polar regions. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar tropospheric ozone. Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in Earth's stratosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone over Earth's polar regions. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar tropospheric ozone depletion events. The details of polar ozone hole formation differ from that of mid-latitude thinning, but the most important process in both is catalytic destruction of ozone by atomic halogens. The main source of these halogen atoms in the stratosphere is photo-dissociation of man-made halocarbon refrigerants (CFCs, freons, halons). These compounds are transported into the stratosphere after being emitted at the surface. Both types of ozone depletion were observed to increase as emissions of halo-carbons increased. CFCs and other contributory substances are referred to as ozone-depleting substances (ODS). Since the ozone layer prevents most harmful UVB wavelengths (280— 315 nm) of ultraviolet light (UV light) from passing through the Earth's atmosphere, observed and projected decreases in ozone have generated worldwide concern leading to adoption of the Montreal Protocol that bans the production of CFCs, halons, and other ozone-depleting chemicals such as carbon tetrachloride and trichloroethane. It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts, damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.

Three forms (or allotropes) of oxygen are involved in the ozone-oxygen cycle: oxygen atoms (O or atomic oxygen), oxygen gas (O_2 or diatomic oxygen), and ozone gas (O_3 or triatomic oxygen). Ozone is formed in the stratosphere when oxygen molecules photo-dissociate/ photolytic decomposition after absorbing an ultraviolet photon whose wavelength is shorter than 240 nm. This converts a single O_2 into two atomic oxygen radicals. The atomic oxygen radicals then combine with separate O_2 molecules to create two O_3 molecules. These ozone molecules absorb

UV light between 310 and 200 nm, following which ozone splits into a molecule of O_2 and an oxygen atom. The oxygen atom then joins up with an oxygen molecule to regenerate ozone. This is a continuing process which terminates when an oxygen atom "recombines" with an ozone co-molecule to make two 0_2 molecules. The overall amount of ozone in the stratosphere is determined by a balance between photochemical production and recombination.

$$O2 + hv \rightarrow O + O$$

$$O + O2 + M \rightarrow O3 + M$$

$$O3 + hv \rightarrow O2 + O$$

(M is a third body necessary to carry away the energy released in the reaction).

Ozone can be destroyed by a number of free radical catalysts, the most important of which are the hydroxyl radical (OH•), the nitric oxide radical (NO•), atomic chlorine ion (Cl•) and atomic bromine ion (Br•). The dot is a common notation to indicate that all of these species have an unpaired electron and are thus extremely reactive. All of these have both natural and man-made sources; at the present time, most of the OH• and NO in the stratosphere is of natural origin, but human activity has dramatically increased the levels of chlorine and bromine. These elements are found in certain stable organic compounds, especially chlorofluorocarbons (CFCs), which may find their way to the stratosphere without being destroyed in the troposphere due to their low reactivity. Once in the stratosphere, the Cl and Br atoms are liberated from the parent compounds by the action of ultraviolet light, e.g.

$CFC1_3$ + electromagnetic radiation —+ $CFC1_2$ + Cl

The Cl and Br atoms can then destroy ozone molecules through a variety of catalytic cycles. In the simplest example of such a cycle, a chlorine atom reacts with an ozone molecule, taking an oxygen atom with it (forming CIO) and leaving a normal oxygen molecule. The chlorine monoxide (i.e., the CIO) can react with a second molecule of ozone (i.e., 03) to yield another chlorine atom and two molecules of oxygen. The chemical shorthand for these gas-phase reactions is:

- Cl + O_3 —+ CIO + 0_2 - The chlorine atom changes an ozone molecule to ordinary oxygen
- CIO + O_3 —+ Cl + 2 O_2 - The CIO from the previous reaction destroys a second ozone molecule and recreates the original chlorine atom, which can repeat the first reaction and continue to destroy ozone.

The overall effect is a decrease in the amount of ozone, though the rate of these processes can be decreased by the effects of null cycles. A single chlorine atom would keep on destroying ozone (thus a catalyst) for up to two years (the time scale for transport back down to the troposphere) were it not for reactions that remove them from this cycle by forming reservoir species such as hydrogen chloride (HCI) and chlorine nitrate ($CIONO_2$). On a per atom basis, bromine is even more efficient than chlorine at destroying ozone, but there is much less bromine in the atmosphere at present. As a result, both chlorine and bromine contribute significantly to the overall ozone depletion. Laboratory studies have shown that fluorine and iodine atoms participate in analogous catalytic cycles. However, in the Earth's stratosphere, fluorine atoms react rapidly with water and methane to form strongly bound HF, while organic molecules which contain iodine react so rapidly in the lower atmosphere that they do not reach the stratosphere in significant quantities.

Furthermore, a single chlorine atom is able to react with 100,000 ozone molecules. This fact plus the amount of chlorine released into the atmosphere by chlorofluorocarbons (CFCs) yearly demonstrates how dangerous CFCs are to the environment. Observations on ozone layer depletion using instruments such as the Total Ozone Mapping Spectrometer (TOMS) is possible. Atmospheric ozone is measured by Dobson spectrometer and is expressed in Dobson unit (DU); 1 DU= 0.01mm thickness of pure ozone at density it would possess if it were brought to ground level (1 atm) pressure. Normally over temperate latitude its concentration is about 350 DU, over tropics it is 250 DU whereas at sub polar regions (except when ozone thinning occurs) it is on an average 450 DU. It is because of the stratospheric winds which transport ozone from tropical towards polar regions.

Thinning of Ozone Layer; This phenomenon is now being detected in other places as well including Australia. Although the use of CFCs has been reduced and now banned in most countries, other chemicals and industrial compounds such as bromine, halocarbons and nitrous oxides from fertilizers may also attack the ozone layer.

Effects of Ozone depletion

- Ozone depletion in the stratosphere will result in more UV radiation reaching the earth especially UV-B (290–320 nm). The UV-B radiations affect DNA and the photosynthetic chemicals. Any change in DNA can result in mutation and cancer. Cases of skin cancer (basal and squamous cell carcinoma) which do not cause death but cause disfigurement will increase.
- Easy absorption of UV rays by the lens and cornea of eye will result in increase in incidents of cataract.
- Melanin producing cells of the epidermis (important for human immune system) will be destroyed by UV-rays resulting in immuno-suppression. Fair people (who cannot produce enough melanin) will be at a greater risk of UV exposure.
- Phytoplanktons are sensitive to UV exposure. Ozone depletion will result in decrease in their population thereby affecting the population of zooplankton, fish, marine animals, in fact the whole aquatic food chain.

- Yield of vital crops like corn, rice, soybean, cotton, bean, pea, sorghum and wheat will decrease.
- Degradation of paints, plastics and other polymer material will result in economic loss due to effects of UV radiation resulting from ozone depletion.

ACID RAIN

When fossil fuels such as coal, oil and natural gas are burned, chemicals like sulfur dioxide and nitrogen oxides are produced. These chemicals react with water and other chemicals in the air to form sulfuric acid, nitric acid and other harmful pollutants like sulfates and nitrates. These acid pollutants spread upwards into the atmosphere, and are carried by air currents, to finally return to the ground in the form of acid rain, fog or snow. The corrosive nature of acid rain causes many forms of environmental damage. Acid pollutants also occur as dry particles and gases, which when washed from the ground by rain, add to the acids in the rain to form a more corrosive solution. This is called acid deposition. Damage from acid rain is widespread in North America, Europe, Japan, China and Southeast Asia. In the US coal burning power plants contribute to about 70% of sulfur dioxide. In Canada oil refining, metal smelting and other industrial activities account for 61% of sulphur dioxide pollution. Motor vehicle exhaust fumes are the main source of nitrogen oxides. The acids in acid rain chemically react with any object they come in contact with. Acids react with other chemicals by giving up hydrogen atoms.

$$2SO_2+O_2+2H_2O \rightleftharpoons 2H_2SO_4$$
$$4NO_2+O_2+2H_2O \rightleftharpoons 4HNO_3$$

Pure rainwater is already acidic due to carbon dioxide (CO_2) in the air dissolving in the rainwater and reacting according to the following equation.

$$H_2O+CO_2 \rightleftharpoons H_2CO_3$$

Acid rain is caused additionally by having large amounts of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) from the atmosphere dissolve into the rainwater.

Sulfur dioxide is produced primarily from burning of fossil fuels that contains sulfur. It gets oxidized by molecular oxygen present in air to produce sulfur trioxide (SO_3), according to the following reaction.

$$2SO_2+O_2 \rightarrow 2SO_3$$

The sulfur trioxide produced then dissolves in the rainwater.

$$SO_3+H_2O \rightleftharpoons H_2SO_4$$

The overall reaction is given by combining the two steps.

$$2SO_2+O_2+2H_2O \rightleftharpoons 2H_2SO_4$$

Nitrogen dioxide results from combustion using air (which 99% is made up of N_2 and O_2) as oxidants. It reacts in water to form a equimolar nitrous (HNO_2) and nitric acid (HNO_3) solution.

$$2NO_2+H_2O \rightleftharpoons HNO_2+HNO_3$$

However, nitrous acid decomposes rapidly to regenerate nitrogen dioxide and water, while at the same time producing nitric oxide (NO).

$$2HNO_2 \rightarrow NO+NO_2+H_2O$$

The nitric oxide produced can be oxidized by atmospheric oxygen back into nitrogen dioxide, although this happens at a relatively slower rate.

$$2NO+O_2 \rightarrow 2NO_2$$

So when we combine the 3 reactions, the overall equation is

$$4NO_2+O_2+2H_2O \rightleftharpoons 4HNO_3$$

All the acids produced in the above reaction will dissociate in water to give H_3O^+, which is why the pH decreases.

$$H_2CO_3+H_2O \rightleftharpoons HCO_3^-+H_3O^+$$
$$HNO_3+H_2O \rightarrow NO_3^-+H_3O^+$$
$$H_2SO_4+H_2O \rightarrow HSO_4^-+H_3O^+$$

Effects: Acid rain is known to cause widespread environmental damage.

1. Acid rain dissolves and washes away nutrients in the soil which are needed by plants. It can also dissolve naturally occurring toxic substances like aluminium and mercury, freeing them to pollute water or poison plants.

2. Acid rain indirectly affects plants by removing nutrients from the soil in which they grow. It affects trees more directly by creating holes in the waxy coating of leaves, causing brown dead spots which affect the plant’s photosynthesis. Such trees are also more vulnerable to insect infestations, drought and cold. Spruce and fir forests at higher elevations seem to be most at risk. Farm crops are less affected by acid rain than forests.

3. Acid rain that falls or flows as ground water to reach rivers, lakes and wetlands, causes the water in them to become acidic. This affects plant and animal life in aquatic ecosystems.

4. Acid rain also has far reaching effects on wildlife. By adversely affecting one species, the entire food chain is disrupted, ultimately endangering the entire ecosystem. Different aquatic species can tolerate different levels of acidity. For instance, clams and mayflies have a high mortality when water has a pH of 6.0, while frogs can tolerate more acidic water, although with the decline in supply of mayflies, frog populations may also decline. Land animals that are de- pendent on aquatic organisms are also affected.

5. Acid rain and dry acid deposition damages buildings, automobiles, and other structures made of stone or metal. The acid corrodes the materials causing extensive damage and ruins historic buildings. For instance, the Parthenon in Greece and the Taj Mahal in India have been affected by acid rain.

6. Although surface water polluted by acid rain does not directly harm people, the toxic substances leached from soil can pollute water supply. Fish caught in these waters may be harmful for human consumption. Acid, along with other chemicals in the air, produces urban smog, which causes respiratory problems.

Solutions: The best way to stop the formation of acid rain is to reduce the emissions of sulphur dioxide and nitrogen oxides into the atmosphere. This can be achieved by using less energy from fossil fuels in power plants, vehicles and industry. Switching to cleaner burning fuels is also a way out. For instance, using natural gas which is cleaner than coal, using coal with lower sulphur content, and developing more efficient vehicles. If the pollutants have already been formed by burning fossil fuels, they can be prevented from entering the atmosphere by using scrubbers in smokestacks in industry. These spray a mixture of water and limestone into the polluting gases, recapturing the sulphur.
In catalytic converters, the gases are passed over metal coated beads that convert harmful chemicals into less harmful ones. These are used in cars to reduce the effects of exhaust fumes on the atmosphere. Once acid rain has affected soil, powdered limestone can be added to the soil by a process known as liming to neutralize the acidity of the soil.