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Environmental Pollution

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المرحله الثالثه - الدراستين الصباحية والمسائيه - الفصل الدراسي الثاني

تدريسي الماده

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Lecture 1: Introduction to pollution

1.Introduction

Although pollution had been known to exist for a very long time, it had taken global proportion only since the onset of the industrial revolution during the 19^{th} century. The industrial revolution brought with it technological progress such as the discovery of oil and it's virtually universal use throughout different industries. At the same time, of course, development of ecology led to the better understanding of negative effects produced by pollution on the environment.

2.Definition

We can define the term "**Environmental pollution**" as" the unfavorable alteration of our environment, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical composition and abundances of organisms". The agents which cause environmental pollution are called **pollutants**. A pollutants may be defined as a physical, chemical or biological substance which is directly or indirectly harmful to humans and other living organisms.

Generally, pollutants may be classified by various criteria:

1. By the origin: whether they are natural or man-made (synthetic)
2. By the effect: on an organ , or species or an entire ecosystem
3. By the properties: mobility or persistence or toxicity
4. By its nature: physical or chemical or biological pollutants

3.Important characteristics of pollutants

3.1: Natural and artificial pollutants

More than 70 million of different chemicals are known and registered in the Chemicals Abstract System, about 100.000 of chemicals are in daily use and ten thousands of chemicals are typically detected in environmental samples such as sediments, soil, water and biota.

However, most pollutants that concern humans occur in nature, while other considered artificial. Several examples of natural and artificial pollutants are listed below:

- *Almost completely artificial:*
  Such as pesticides and lead aerosol
- *Substantially artificial*
  Such as oil in the oceans or phosphates in running water
- *Real contributions from natural sources such as,*
  1.Hydrocarbons in the atmosphere
  2.Radiation
  3.Sulfur oxides in the atmosphere.

3.2. Persistence

Some pollutants remain dangerous indefinitely; beryllium and lead are examples. Others that are eventually broken down into harmless compounds may still persist in the environment for long periods. Estimates of pesticide persistence in soil, defined as the time needed for the pesticide level to be reduced to less than 25 percent of the original level applied, follow:

5 years for chlordane

4 years for DDT

1.5 years for picloram

1 month for 2,4-D

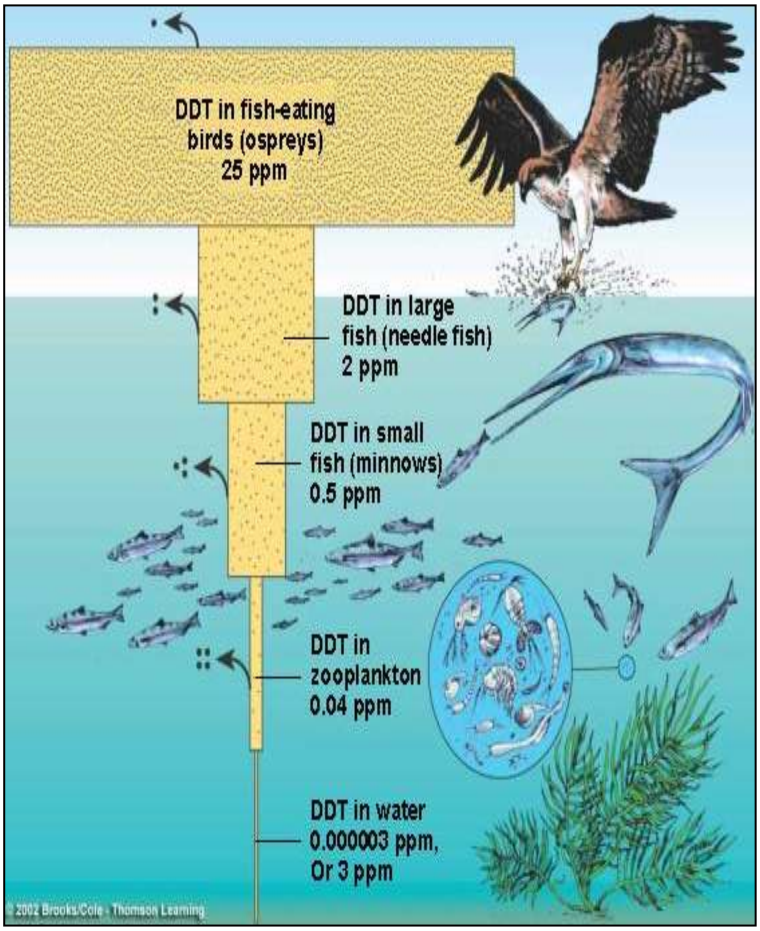
There is often a time lag between the release of pollutants and the onset of their effects. Sometimes the lag is due to long-term changes that occur before adverse effects appear. It has been estimated that 10-100 years are required for inorganic mercury compounds in bottom sediments of lakes and rivers to be converted into methylmercury, an organic from dangerous to animal life.

3.3:Long –Distance movement of pollutants

There is accumulating evidence that many types of pollutants can become distributed over the whole earth in relatively short periods. Radioactive fallout from atmospheric nuclear tests is detectable throughout the world within days or weeks. Another dramatic example is the worldwide distribution of chlorinated hydrocarbons such as DDT and its metabolites. These were first developed for pesticidal use in the late 1930s and were released for civilian use in 1945. Since that time they have been widely used throughout the world. For example, such hydrocarbons are now widely distributed throughout the marine ecosystems of Pacific Ocean. These pesticides had clearly been transported a great distance by means not fully understood.

3.4: Biological concentration and discrimination

Another important characteristic of pollutants is that they may be concentrated biologically so that levels in one part of an ecosystem are much larger than those in other parts. This typically occurs in food chains: Levels in an organism are higher than those in its food.



The study of one Michigan ecosystem found the following levels of DDT.

0.014 ppm in sediments on the bottom

0.41 ppm in bottom feeding crustacea

0.5-2 ppm in various fish

Varied between 25- 2400 ppm in the body fat of fish-eating birds.

Biological discrimination can also occur. It is common to find lower insecticide residues in plant tissues than in the soils in which the plants are growing. Potatoes and alfalfa growing in soil with 0.48 to 8.36 ppm of aldrin, while residues had only 0.009 to 0.32 ppm of aldrin.

3.5:Toxicity

Toxicity is the ability of a substance to cause harmful health effects. These effects can strike a single cell, a group of cells, an organ system, or the entire body.

All chemicals can cause harm at a certain level. When a small amount can be harmful, the chemical is considered toxic. The toxicity of pollutants depends on three factors:

1. its chemical structure,
2. the extent to which the substance is absorbed by the body,
3. and the body's ability to detoxify the substance (change it into less toxic substances) and eliminate it from the body.

3.6: Synergism and Antagonism

It is impossible to discuss properly the effects of pollution merely by discussing the effects of individual pollutants. In many cases the combined effects of two or more pollutants are more severe or even qualitatively different from individual effects of separate pollutants a phenomenon known **synergism**. Sometimes the combined effects of two pollutants are less sever rather than more sever, and this situation is referred to as **antagonism**. Cyanides in industrial wastes are quite poisonous to aquatic life, and in the presence of zinc or cadmium they are extremely poisonous (**a synergistic effect**), apparently due to the formation of complex, while in the presence of nickel, however, a nickel –cyanide complex that is not very toxic is formed (**antagonism)**. The occurrence of synergistic effects makes it difficult to study the effects of pollution, because there are so many different pollutants present in the environment.

4. Effects of pollution

4.1:Introduction

The scientists note that a very important aspect of the effect of pollution is its dose (or concentration) required to cause environmental damage. Therefore they define ***pollution response*** as "the change in the effect of a pollutant in response to a change in its concentration".

In this respect, we can identify 2 different types of response to different pollutants concentration;

1. Linear effect
2. Threshold effect

In *the linear effect*, environmental damage increases linearly with pollution concentrations. In other words, "the total damage or risk is directly proportional to the accumulated exposure".

This effect occurs with radioactive substances, most heavy metals and asbestos.

In *the threshold effect*, pollution produces no effect until a certain threshold in pollution concentrations is achieved. In other words, "so long as a given threshold is not exceeded, the damage from pollution would be completely repaired. This effect is found with biodegradable pollutants.

4.2: Sequential effect of pollutants

1.Effects upon the individual organism

A molecular interaction occurs between the pollutant and cellular structures within the organism. Critically, many toxic effects are due to specific interactions between these pollutants and their sites of action. Sites of action may bind hormones (e.g., estrogen receptors), bind neurotransmitters (e.g., acetylcholine), or be the enzymes such as acetylcholinsterase. Interactions of this kind will be termed biochemical effects. These localized biochemical effects often lead to physiological damage, e.g., of the brain or nervous system or the blood. Next, the localized damage can be distributed, leading to effects at the level of the whole organism. Effects at the whole organism level include sub-lethal ones on behavior or reproduction that have the potential to cause population declines, as will be explained later.

Generally, three major effects of pollutants on some organisms especially humans:

1. Carcinogenicity (induction of cancer)
2. Mutagenicity (induction of mutation)
3. Teratogenicity (induction of birth defects)

The World Health Organization states that 2.4 million people die each year from causes directly attributable to air pollution only, with 1.5 million of these deaths attributable to indoor air pollution.

1. Effects at the population level

A population is a group of individuals belonging to a single species. Effects at the population level may be characterized in two distinct ways:

(1) by changes in population numbers (population dynamics) and,

(2) by changes in the genetic composition (population genetics).

Taking population numbers first when studying population dynamics in the field. Migration in and out of an area during the course of an experiment can have a profound effect on the population numbers that are recorded. If the effect of a pollutant on a population is to be studied, it is desirable that there be as little migration as possible during the experimental period.

Regarding genetic aspect, pollutants of all kinds, can cause harm to free- living organisms. They have the potential to exert a selective pressure on these organisms. Pesticides, which are designed to control populations of pests, are a very clear example of this. Broadly speaking, the most important resistance mechanisms that have been developed by insects against insecticides are of two kinds:

(1) enhanced enzymic detoxication and

(2) insensitivity of the site of action.

3. Effects upon the structure and function of communities and ecosystems

An *ecosystem* has been defined as a collection of populations that occur in the same place and at the same time that can interact with each other and their physical and chemical surroundings; a *community*, more simply, is a collection of populations that occur in the same place and at the same time.

The effects of pollutants upon communities are of two different kinds. First, there can be effects upon structure (i.e., on composition); here the primary concern is about the species that are present. While , the *function* of a community refers to the operation of processes within it—for example, the operation of the carbon cycle or the nitrogen cycle. Studying these processes can provide measures of the health of a community or of an ecosystem as a whole. Effects of this kind can be measured by monitoring the levels of pollutants in natural processes.

Lecture 2: Air pollution

1.The atmosphere

Without our atmosphere, there would be no life on earth. Two gases (nitrogen 78%, and oxygen 21%) make up the bulk of the earth's atmosphere . Argon, carbon dioxide and various trace gases make up the remainder.

The typical composition of unpolluted dry air is given in this table.

Constitutes	Molecular formula	Volume fraction
Nitrogen	N_2	78%
Oxygen	O_2	21%
Argon	Ar	0.93%
Carbon dioxide	CO_2	0.032%
Neon	Ne	18ppm
Helium	He	5.2ppm
Methane	CH_4	1.3ppm
Krypton	Kr	1ppm
Hydrogen	H_2	0.5ppm
Nitrous oxide	N_2O	0.25ppm
Carbon monoxide	CO	0.1ppm
Ozone	O_3	0.02ppm
Sulfur dioxide	SO_2	0.001ppm
Nitrogen dioxide	NO_2	0.001ppm

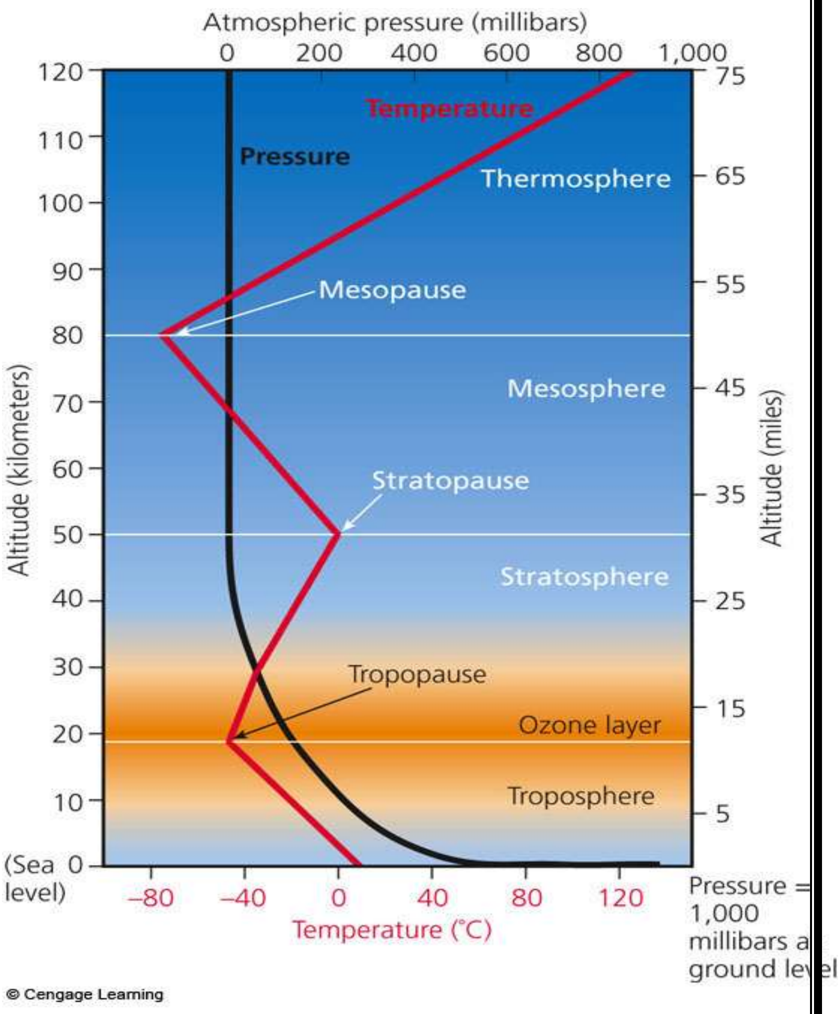
For purpose of dealing with air pollution, it is necessary to have a rough idea of the temperature distribution with atmospheric layers.

1.1:Troposphere

This is the layer of the atmosphere closest to the Earth's surface, extending up to about 10-15 km above the Earth's surface. It contains 75% of the atmosphere's mass, in which the temperature decrease fairly steadily from the ground temperature to a temperature of -50 °C. The air in the troposphere is well mixed by currents. This layer contains most of the atmospheric water, clouds and particulate matter. The temperature curve changes slop rather suddenly in a narrow transitional layer known as the *tropopause*.

1.2: Stratosphere

Above the tropopause is the stratosphere, typically 50km high, in which the temperature curve shows a warming trend with increasing height. This warming due to absorption of solar ultraviolet by ozone. The air in the stratosphere is very dry. The *stratopause* at the top of stratosphere.



1.3: Mesosphere

Mesosphere located directly above the stratosphere, extending from 50 to 80 km above the Earth's surface, in which the temperature again decreases with height with a very coldest temperature in the atmosphere, typically about -100 °C. The region of minimum temperature is the *mesopause.*

1.4: Thermosphere

The thermosphere extends from 80 km above the Earth's surface to outer space. This layer is very hot and may be reaching to thousands degrees.

2. Air pollutants

Air pollutants are generally defined as " **substances emitted into the atmosphere by both natural and anthropogenic (human-caused) sources, that are capable of causing harm to the environment in general, and living organisms in particular**".

The major five air pollutants are particulate matter, carbon monoxide, sulfur oxides, hydrocarbons and nitrogen oxides.

1.Particulate matter

They are tiny fragments of solid or liquid nature suspended in the air (aerosols). Particles may be *primary* – when emitted directly into the atmosphere by sources, or *secondary* – when particles are formed in the atmosphere through the interaction of primary emissions. Solid particles between 1 and 100 μm in diameter are called *dust* particles, while solid particles less than 1 μm in diameter are called *fumes*, or *smoke*.

- ✓ **The major sources**

Anthropogenic particles account for around 10% of the total amount of particles in the atmosphere. Fossil fuel combustion is one of the main processes which causes vast amounts of particles to be emitted into the atmosphere.

The major anthropogenic sources of airborne particles are; Road transport, Electrical power generating and other processes. While main natural sources of particles are;

- Erosion of soil by wind which generates *dust* particles that travel around the globe.
- Evaporation of droplets of sea water resulting in sea *salt crystals* being suspended in the air.
- Volcanoes
- Forest fires

✓ ***Effects of* particulate matter**

Particles less than 10 µm in diameter are of biggest concern to human and animal health as they can be easily inhaled and get trapped in the respiratory system. The most harmful particles are the small ones. The smaller particles reach the lung more easily, and a greater proportion of them remain in the lung. Unfortunately, toxic substance are more expected to be found in the smaller particles.

The four chief human illnesses resulting from particulate matter are listed below:

- Chronic bronchitis. The bronchial tubes are permanently damaged.
- Bronchial asthma : foreign matter leads to an allergic reaction which cause shortness of breath.
- Emphysema
- Lung cancer

2.Sulfur Dioxide (SO_2)

Sulfur dioxide is a colorless gas with acrid taste. The most important sulfur emitted by pollution sources is sulfur dioxide(SO2) and this form oxidized to SO_3 in the atmosphere by photochemical or catalytic processes, in the presence of humidity the SO_3 becomes sulfuric acid or sulfate salt, both of which dangerous to health. The SO_2 in the atmosphere lasts only a few days at most, and this reason that the SO_2 mass in the atmosphere is so small compared to annual emissions by humans.

✓ ***Sources of Sulfur Dioxide Emissions***

Sulfur is contained within all fossil fuels, and is released in the form of *sulfur dioxide* (SO_2) during fossil fuel combustion. Fossil fuel combustion accounts for almost all anthropogenic (human-caused) sulfur emissions.

Sulfur contents in fossil fuels range between 0.1% and 4% in oil, and up to 40% in natural gas . Also it is produced by volcanoes and in various industrial processes.

✓ ***Effects of Sulfur Dioxide***

Sulfur dioxide found in the air produces following effects ;

- Irritates eyes, nose, throat
- Damages lungs when inhaled
- As part of acid rain:
  - acidifies lakes and streams
  - destroys plant and fish life in lakes and streams
  - may cause reduction of forest and agricultural yields
  - corrodes metals
  - damages surfaces of buildings.

3. Carbon monoxide (CO)

Carbon monoxide is a colorless, odorless and tasteless gas which is highly toxic to humans. The combustion of carbon-based fuels produces carbon dioxide (CO_2). But not all such combustion is complete, and this leads to the production of carbon monoxide (CO).

- ***The sources***

Motor vehicles and industry are among the largest anthropogenic sources of carbon monoxide emissions.

- ***Effects of Carbon Monoxide Emissions***

Carbon monoxide is the most common type of fatal poisoning in many countries around the world.

The toxic effects of CO on human beings and animals arise from its reversible combination with hemoglobin (Hb) in the blood.

$HbO_2 + CO \Longleftrightarrow HbCO + O_2$

Hemoglobin has a much greater affinity for CO than it does for O_2 . The combination of hemoglobin with CO lessens the oxygen-carrying capacity of the blood so that less O_2 is available to the body cells. It also reduces the dissociation of oxyhemoglobin (HbO_2) in to hemoglobin and oxygen so that anoxia (Oxygen starvation) may result , although the blood is carrying several times as much O_2 as the body requires.

4.**Nitrogen Oxides**

Although many different oxides of nitrogen are known, only nitric oxide and nitrogen dioxide are emitted to the atmosphere in significant quantities by humans activities. Nitric oxide (NO) is a colorless gas. While nitrogen dioxide (NO_2) is a gas of reddish-brown color with a distinct sharp odor. Combustion of fuels always produces both NO_2 and NO.

- ***Anthropogenic Sources of Nitrogen Oxides Emissions***

Road transport (motor vehicles) is by far the largest contributor of nitrogen emissions. Other sources are energy production and industrial activities.

- ***Effects of Nitrogen Dioxide (NO_2) Emissions***

When inhaled, nitrogen dioxide becomes a serious air pollutant which may:

- Cause pulmonary edema (accumulation of excessive fluid in the lungs).
- Be part of acid rain (destroying fish and plant life in lakes, damaging surfaces of buildings etc).
- Contribute to photochemical smog.

5.Hydrocarbons

Hydrocarbons are chemical compounds containing only carbon and hydrogen. Open chain hydrocarbons contain noncyclic chains of carbon atoms to which hydrogen atoms are bounded; they may be saturated (paraffinic) such are methane and propane , or unsaturated (olefinic) such as ethylene. Cyclic hydrocarbons contain rings of carbon atoms; they may be saturated or an saturated .

The light hydrocarbons are gaseous at ordinary temperature , examples, methane, propane and ethylene. Heavier hydrocarbons , such as those which occur naturally as petroleum are liquids. Very heavy hydrocarbons may be solids at ordinary temperature. The gaseous of hydrocarbons are the ones of particular concern as air pollutants . Hydrocarbons with more than 12 carbon atoms are not present in the atmosphere in concentrations high enough to be of concern.

✓ ***The sources***

Natural sources of hydrocarbons are largely biological. Hydrocarbons emissions attributable to humans reaching to 90 million metric tons annually.

✓ ***The effects***

The only pure hydrocarbon known to be capable of harming plants at concentrations that occur in or near urban regions is ethylene, whose role in inhibiting plant growth. Open Chan hydrocarbons appear to have no effects on human beings at level below 500ppm.

Hydrocarbons are of particular concern because they are involved in the production of photochemical oxidants, which cause eye irritation and other effects.

Lecture 3: Classical and photochemical Smog and Ozone hole

1. Classical and photochemical Smog

Air pollution in urban regions is often referred to as smog. During foggy weather, when little wind was present the smoke produced by the coal would mix with the fog and form smog.

Smoke + Fog = Smog

The smog made it difficult for people to see and breathe. In 1952 the great London smog occurred, killing 4000 or more people.

Today , the London type smog is often referred to as classical smog, whereas the Los Angeles type smog, which is quit different, is referred to photochemical smog, because it is formed through chemical reactions involving sunlight.

Table below lists some of the characteristics of the two types of smog

Characteristics	**Classical smog**	**Photochemical smog**

1.First occurrence noted	London	Los Angeles
2.Major pollutants	Sulfur oxides and particulate matter	Ozone, nitrogen oxides, hydrocarbons, carbon monoxide and free radicals
3.Principal sources	Industrial and fuel combustion	Motor vehicle fuel combustion
4.Effects on humans	Lung and throat irritation	Eye irritation
5.Effects on compounds	Reducing	Oxidizing
6. Time of occurrence of worst episodes	Winter months (especially in early morning)	Around midday of summer months

2.Ozone hole

2.1:Introduction

Ozone is a triatomic form of oxygen (O3) found in Earth's upper and lower atmosphere. The basic equations determining ozone formation in the stratosphere are the "Chapman Reactions."

$O_2 + UVC \longrightarrow O + O$

$O + O_2 \longrightarrow O_3$

The ozone produced by the Chapman reactions will absorb UVB radiation and prevent this radiation from reaching the Earth's surface.

$O_3 + UVB \longrightarrow O_2 + O$

$O + O_3 \longrightarrow O_2 + O_2$

2.2:The ozone layer

The ozone layer, situated in the stratosphere about 15 to 30 km above the earth's surface. The stability of the ozone layer in the stratosphere is of particular interest because of its role in absorbing ultraviolet radiation from the sun and preventing much of it from reaching the earth surface.

2.3:What causes the ozone hole?

The ozone layer is being destroyed by nitrogen oxides resulting from supersonic flight. The chemical effect of the nitrogen oxides is very simple. The nitrogen oxides act as catalysis which destroy ozone but are regenerated to repeat the cycle. The cycle involves two reactions.

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$NO_2 + O \longrightarrow NO + O_2$$

Whose net reaction is

$$O_3 + O \longrightarrow O_2 + O_2$$

The cycle probably destroys about 70 percent of the ozone formed in the stratosphere. It is now realized that nuclear weapons tests in the atmosphere also introduced nitrogen oxides in to the stratosphere in sufficient quantities to have adverse effects.

In the mid-1970s anew threat to the stratosphere ozone layer suddenly appeared that the chlorofluorocarbons can also destroy the ozone layer. These compounds are so stable, they are chemically inert and do not react with other substances they come in contact with. As a result they float up through the atmosphere unchanged and eventually reach the stratosphere. There they absorb ultraviolet solar radiation and break down, liberating free atomic chlorine (Cl). The chlorine also can destroy ozone by the following reactions:

$$Cl + O_3 \longrightarrow CIO + O_2$$

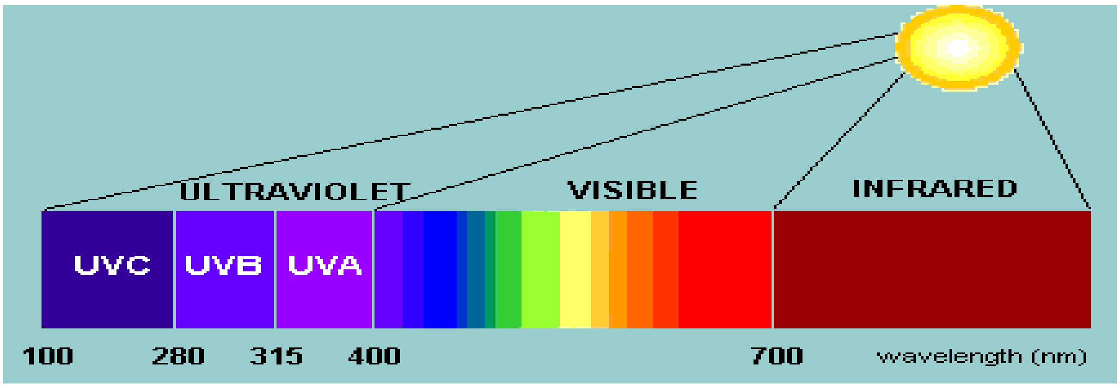
$$CIO + O \longrightarrow Cl + O_2$$

Cl is not consumed by this reaction. It can destroy thousands of ozone molecules.

Ozone depletion progressing globally except in the tropical zone. A combination of low temperatures and elevated chlorine and bromine concentrations are responsible for the destruction of ozone in the upper stratosphere thus forming a “hole”. In 1985, using satellites, balloons, and surface stations, a team of researchers had discovered a balding patch of ozone in the upper stratosphere. The size of the ozone hole reached to 24 million square meter over Antarctica.

2.4: Ultra-violet radiation (UVR)

High energy electromagnetic wave emitted from the sun. It is made up of wavelengths ranging from 100nm to 400nm.UV radiation includes UV-A, the least dangerous form of UV radiation, with a wavelength range between 315nm to 400nm, UV-B with a wavelength range between 280nm to 315nm, and UV-C which is the most dangerous between 100nm to 280nm. UV-C is unable to reach Earth’s surface due to stratospheric ozone’s ability to absorb it.



Increased ultraviolet radiation leads to the following

1.Skin cancer

2.Eye damage such as cataracts

3.Immune system damage

4.Reduction in phytoplankton

5.Damage to the DNA in various life-forms

6.Possibly other things too that we don't know about at the moment

Lecture 4: Global warming (Greenhouse Effect)

*T*he Greenhouse Effect is the capacity of certain gases in the atmosphere to trap heat emitted from the Earth's surface, thereby insulating and warming the Earth. Without the thermal blanketing of the natural greenhouse effect, heat leaving the planet with an inhospitable temperature close to –19°C , instead of the present average surface temperature close to 14°C . The greenhouse effect has warmed the Earth for over 4 billion years.

Now scientists are growing increasingly concerned that human activities may be modifying this natural process, with potentially dangerous consequences. Scientists call this unnatural heating effect, **global warming** and blame it for an increase in the Earth's surface temperature of about 0.6°C (about 1 Fahrenheit degree) over the last nearly 100 years. Without remedial processes, many scientists fear that global temperatures will rise 1.4 to 5.8°C.

1.1:How the greenhouse effects works

The greenhouse effect results from the interaction between sunlight and the layer of greenhouse gases in the Earth's atmosphere that extends up to 100 km above the Earth's surface.

Sunlight is composed of a range of radiant energies known as the solar spectrum, which includes visible light, infrared light, gamma rays, X-rays, and ultraviolet light. When the Sun’s radiation reaches the Earth’s atmosphere, some 25 percent of the energy is reflected back into space by clouds and other atmospheric particles. About 20 percent is absorbed in the atmosphere. For instance, gas molecules in the uppermost layers of the atmosphere absorb the Sun’s gamma rays and X rays.

The Sun’s ultraviolet radiation is absorbed by the ozone layer, located 19 to 48 km above the Earth’s surface. About 50 percent of the Sun’s energy, largely in the form of visible light, passes through the atmosphere to reach the Earth’s surface. Soils, plants, and oceans on the Earth’s surface absorb about 85 percent of this heat energy, while the rest is reflected back into the atmosphere—most effectively by reflective surfaces such as ice, and sandy deserts. In addition, some of the Sun’s radiation that is absorbed by the Earth’s surface becomes heat energy in the form of long-wave infrared radiation, and this energy is released back into the atmosphere.

Certain gases in the atmosphere, including water vapor, carbon dioxide, methane, and nitrous oxide, absorb this infrared radiant heat, preventing it from dispersing into space. As these atmospheric gases warm, they in turn emit infrared radiation in all directions. Some of this heat returns back to Earth to further warm the surface in what is known as the greenhouse effect.

1.2:Types of greenhouse gases and factors causes global warming

1. Water vapor **2**. Carbon dioxide **3**. Methane **4**. Nitrous oxide **5**. Fluorinated compounds **6**. Other factors such as volcanoes, evaporation and alterations in atmospheric and ocean circulation

1.3:Effects of global warming

The carbon dioxide, methane, soot, and other pollutants we release into the atmosphere act like a blanket, trapping the sun's heat and causing the planet to warm. Evidence shows that 2000 to 2009 was hotter than any other decade in at least the past 1,300 years. This warming is altering the earth's climate system, including its land, atmosphere and oceans**.** Global warming could also affect the following:-

1.More severe weather

Higher temperatures are worsening many types of disasters, including storms, heat waves, floods, and droughts. A warmer climate changing weather patterns in such a way that wet areas become wetter and dry areas drier.

According to the National Oceanic and Atmospheric Administration, in 2015 there were 10 weather and climate disaster events in the United States—including severe storms, floods, drought, and wildfires. Elsewhere around the world, lack of water is a leading cause of death and serious disease. At the opposite end, heavier rains cause streams, rivers, and lakes to overflow, which damages life and property, contaminates drinking water, creates hazardous-material spills.

2.Higher death rates

Today's scientists point to climate change as "the biggest global health threat of the 21st century." It's a threat that impacts all of us—especially children and the elderly. In the developed countries, hundreds of heat-related deaths occur each year due to direct impacts and the indirect effects of heat, life-threatening illnesses, such as heatstroke, and cardiovascular and kidney diseases. Indeed, extreme heat kills more Americans each year, on average, than hurricanes and floods.

3.Higher wildlife extinction rates

As land and sea undergo rapid changes, the animals that inhabit them are doomed to disappear if they don't adapt quickly enough. Some will make it, and some won't. According to the Climate Change's 2014 assessment, many land, freshwater, and ocean species are shifting their geographic ranges to cooler climes or higher altitudes, in an attempt to escape warming.

They're changing seasonal behaviors and traditional migration patterns, too. And yet many still face "increased extinction risk due to climate change." Indeed, a 2015 study showed that vertebrate species—animals with backbones, like fish, birds, mammals, amphibians, and reptiles—are disappearing 114 times faster than they should be, a phenomenon that has been linked to climate change, pollution, and deforestation.

4.More acidic oceans

The earth's marine ecosystems are under pressure as a result of climate change. Oceans are becoming more acidic, due in large part to their absorption of some of our excess emissions. As this acidification accelerates, it poses a serious threat to underwater life, particularly creatures with calcium carbonate shells or skeletons, including mollusks, crabs, and corals.

5. Higher sea levels

These warmer temperatures resulting from green house effect could melt parts of polar ice and most mountain glaciers. Average temperatures in the Arctic are rising twice as fast as they are elsewhere on earth, and the world's ice sheets are melting fast. By 2100, it's estimated our oceans will be one to four feet higher, threatening coastal systems and low-lying areas, including entire island nations and the world's largest cities, including New York, Los Angeles, and Miami as well as Mumbai, Sydney, and Rio de Janeiro.

Lecture 5: Radiation pollution

1. Introduction

In its broadest sense, radiation is energy being propagated from one place to another. The spontaneous emission of particles and rays by an unstable nucleus is called **radioactivity** and such substances are called Radioactive Substances e.g. Radium, Uranium and Thorium. Radioactive pollution can be defined *as the release of radioactive substances or high-energy particles into the air, water, or soil as a result of human activities*.

2. Radiation sources in the environment

There are two sources of radiation pollution, namely natural sources and anthropogenic sources. Radiation comes from outer space, another comes from radio- active materials like uranium, thorium, and potassium, which are found in the ground and the remainder comes from radioactive materials in our bodies, especially potassium, a substantial quantity of which is vital to life.

The most well-known artificial radiation (anthropogenic sources) results from nuclear-power generating centers. Other sources of radiation include by-products of mining operations, and experimental research laboratories. Increased exposure to medical X rays and to radiation emissions from microwave ovens and other household appliances.

3.Radioactive fallout

Radioactive pollution that is spread through the earth's atmosphere is termed *fallout*. Such pollution was most common in the two decades following World War II, when the United States, the Soviet Union, and Great Britain conducted hundreds of nuclear weapons tests in the atmosphere.

Three types of fallout result from nuclear detonations: local, tropospheric and stratospheric.

1. Local fallout is quite intense but short-lived.
2. Tropospheric fallout (in the lower atmosphere) is deposited at a later time and covers a larger area, depending on meteorological conditions.
3. Stratospheric fallout, which release extremely fine particles into the upper atmosphere, may continue for years after an explosion and reach a worldwide distribution.

4.Types of ionizing radiation

The radiation that of concern as pollution is ionizing pollution, or radiation have sufficiently great energy to ionize atoms and molecules. An atom is ionized when it gains sufficient energy for one or more of its electrons to be separated from the atom. Ionization of a molecule might split it into two charged fragments, such as

$$H_2O \longrightarrow H^+ + OH^-$$

The most important types of ionizing radiation from the standpoint of pollution are follow:

1. ***Alpha radiation***

An alpha particle is a ^{4}He nucleus, which consists of two protons and two neutrons. Alpha particles have a positive electro charge, and are capable of interacting strongly ordinary matter (including living tissues) by electromagnetic interactions. Because they lose all of their energy in a small volume, alpha particles can be very damaging when inside the human body. Inside the body, alpha particles can kill nearby cells. Examples of radioactive materials that give off alpha particles are polonium-210, radon-222, and radium-226.

2. ***Beta radiation***

Beta particles are electrons emitted from an atom. In air, beta particles can travel a few hundred times farther than alpha particles and can interact strongly with matter by the electromagnetic interactions. Examples of radioactive materials that give off beta particles are hydrogen-3 (tritium), carbon-14, phosphorus-32, and sulfur-35.

3. Gamma radiation

Gamma radiation consists of very energetic photons, that is very short wavelength electromagnetic radiation. Despite being uncharged, photons are capable of very strong electromagnetic interaction with matter. Examples of common radionuclides that emit gamma rays are iodine-125, iodine-131, cobalt-57, and cesium-137.

4. X rays

Waves of energy (photons) that travel at the speed of light. These waves can have considerable range in air and have greater penetrating power (can travel farther) than either alpha or beta particles. X rays and gamma rays differ from one another because they come from different locations in an atom. Gamma rays come from the nucleus of an atom while x rays come from the electron shells. Other types of ionizing radiation are encountered less frequently but they can also be dangerous to living systems such as protons and neutrons.

4.The effects of radiation on Human

Although radiation appears very dangerous, we should remember that individuals are struck by about a million particles of radiation every minute from natural sources. However, even a small amount of radiation exposure can have serious (and cumulative) biological consequences, since many radioactive wastes remain toxic for centuries.

When ionizing radiation passes through body tissue, it splits the molecules of the tissue into ions or free radicals, such as water molecules mentioned above. These fragments may be later combine to form new chemical compounds (Such as H_2O_2) or free radicals (such as HO_2). Ionizing radiation can thus split molecules in to useless or reactive fragments. Also, the effects of radiation can be classified in two groups:

1. Direct effects–fragmentation of biologically important molecules, such as DNA molecules.

2. Indirect effects- fragmentation of biologically less vital molecules, such as water with the formation of reactive ions or free radicals that can later effect more important molecules.

When radiation affects the DNA, RNA replication and chromosome. It causes the following effects,

1.Mutation 2. Chromosomal aberration 3. Chromosomal fragmentation 4. Inhibition of RNA and DNA synthesis

The biological damage caused by the radiation depends upon the following factors

(i) the time of exposure

(ii) the intensity of radiation

(iii) the type of ionizing radiation (i.e. its penetration power)

However, not all radiation has the same biological effect, even for the same amount of absorbed dose.

The environmental effects of exposure to high-level ionizing radiation have been extensively documented through postwar studies on individuals who were exposed to nuclear radiation in Japan. Some forms of cancer show up immediately, but latent maladies of radiation poisoning have been recorded from 10 to 30 years after exposure.

Effects of acute exposures in humans (*rad=radiation absorbed dose*)	
Dose	**effects**
Less than 25 rads	No observation effect
About 25 rads	Threshold level for detectable effect
About 50 rads	Slight blood changes
About 100 rads	Fatigue and vomiting
200 rads	Fatality possible, although recovery is more possible
About 500 rads	Perhaps one half the victims would die
About 1000 rads	All the victims would die in 30 days

The effects of exposure to low-level radiation are not yet known. A major concern about this type of exposure is the potential for genetic damage. The changes in genetic structure are not apparent in the individual. The effects are exhibited by offspring and in the subsequent generations.

5.Effects on Ecosystems

During the past decades man has had the capacity to increase levels of ionizing radiation in the environment. No other factor appears to have quite the same potential for producing both genetic and somatic effects in living systems. The concern with the potential effects on man has led to focus of research in environmental biology on the possibility of contamination of man's food chain with radioactive isotopes and to neglect of the potential effects of radioactivity on ecological systems.

The recent discovery that certain plants are damaged by total exposures in the same range as those which cause damage in mammals, and higher levels of ionizing radiation in the environment would be not only a direct hazard to man but also would cause changes in the ecological systems of which man is but a part.

Ionizing radiation is generally deleterious to living systems, and exposure can be expected to reduce physiological tolerances to environmental stress.

The effects of exposure of plants to ionizing radiation range from death, through varying degrees of growth inhibition, to effects on reproductive capacity and to even more subtle genetic effects recognizable only in subsequent generations.

A large variation in radio-sensitivity between species exists. Radio-sensitivity tends to increase with increasing biological complexity of the organism, as indicated by lethal doses, with birds, mammals and few trees species which considered the most radiosensitive. There is a positive correlation between radiosensitivity and increased DNA content of cells. Those organisms likely to experience the highest dose rates within an ecosystem tend to be less complex (e.g. bacteria) are representative of the least sensitive groups. Also, variation in sensitivity to damage during the life cycle of an organism may be extreme, the population as a whole thus being much more sensitive than the mature stages of single organisms. In general, reproductive processes are most sensitive to damage, while mature stages least sensitive.

Organism	Dose (Gy)	Type of experiment
Blue-green algae	4000-12000+	LD_{90}
Other algae	30-1200	LD_{90}
Protozoa	Up to 6000	LD_{90}
Mollusca	200-1090	LD_{50}
Crustacea	15-566	LD_{50}
Fish	11-56	LD_{50}

Lecture 6: Water pollution

We live on a planet that is dominated by water. More than 70% of the Earth's surface is covered with this simple molecule. Scientists estimate that the hydrosphere contains about 1.36 billion cubic kilometers of this substance mostly in the form of a **liquid** (water). The second most common form of the water molecule on our planet is **ice.** If all our planet's ice melted, sea-level would rise by about 70 meters.

Water is also essential for life. It is the major constituent of almost all life forms. Most animals and plants contain more than 60% water by volume.

1.Water quality

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. When water quality is poor, it affects not only aquatic life but the surrounding ecosystem as well. These sections detail all of the parameters that affect the quality of water in the environment. Physical properties of water quality include temperature and turbidity. Chemical characteristics involve parameters such as pH and dissolved oxygen. Biological indicators of water quality include algae and phytoplankton. These parameters are relevant not only to surface water studies of the ocean, lakes and rivers, but to groundwater and industrial processes as well.

1.1: Water temperature

The temperature of water is an important physical parameter affecting other water quality parameters. Water temperature affects the ability of water to hold oxygen, the rate of photosynthesis by aquatic plants and the metabolic rates of aquatic organisms. Living organisms differs in their ability to tolerant the temperature , the species have a wide range ability of tolerance called **Eurythermic , but called stenothermic organisms** when it be with low wide of tolerance.

1.2: Color

Water may become cloudy or discolored (green , yellow ,brown or red) as a result of pollutants , so it called polluted water ,while the pure - clean water appear to be colorless.

1.3: Turbidity

Turbidity in water is caused by suspended material such as clay, silt, finely divided organic and inorganic matter, soluble colored compounds and plankton and microscopic organisms. Turbidity is an expression of the optical properties that cause light to be scattered and absorbed rather than transmitted in a straight line through the water. Standard units for turbidity are "nephelometric turbidity units" **(NTU)** .

1.4: Electrical conductivity and total dissolved solids (TDS)

Conductivity is a measure of the capacity of an aqueous solution to carry an electrical current, and depends on the presence of ions. Conductivity is commonly used to determine salinity and is mostly reported in micro-Siemens per centimeter (µS/cm) at a standard reference temperature of 25 degrees Celsius. While**,** total dissolved solids (TDS) are a measure of all inorganic and organic constituents dissolved in water**.**

1.5: Salinity

The salinity is the quantity of dissolved salt content of the water. Salts are compounds like sodium chloride, magnesium sulfate, potassium nitrate, and sodium bicarbonate which dissolve into ions. The concentration of dissolved chloride ions is sometimes referred to as chlorinity.

Thus, water can be classified into the following depending on the content of salt

1- **Euhaline water** : salinity about 15-35% , EX: oceans , seas and gulfs.

2- **Brackish water** : it divided to ,

a- ***Polyhaline*** : salinity about 18-30 % , EX: Shatt Al-Arab near Fao region.

b- ***Mesohaline*** : salinity about 5-18 % , EX: the southern part of Shatt Al-Arab .

c- ***Oligohaline*** : salinity about 0.5-5% , EX: the upper part of Shatt Al-Arab .

3- **Fresh water** : salinity less than 0.5 % , EX: Tigris and Euphrates rivers.

1.6: Dissolved Oxygen (DO)

The most important measure of water quality is the dissolved oxygen (DO). Oxygen, although poorly soluble in water, is fundamental to aquatic life. Without free DO, streams and lakes become uninhabitable to gill-breathing aquatic organisms. Dissolved oxygen is inversely proportional to temperature, and the maximum oxygen that can be dissolved in water at most ambient temperatures is about 10 mg/L. In general, rapidly moving water contains more dissolved oxygen than slow or stagnant water . The decomposition of organic matter through microbial activity also consumes oxygen and can be evident at nutrient enriched sites.

1.7: pH

The pH of the aquatic systems is an important indicator of the water quality. Water (H_2O) contains both hydrogen (H^+) and hydroxyl (OH^-) ions. The pH of water is a measurement of the concentration of H^+ ions, using a scale that ranges from 0 to 14. A pH of 7 is considered "neutral", since concentrations of H^+ and OH^- ions are equal. Liquids or substances with pH measurements below 7 are considered "acidic", and contain more H+ ions than OH^- ions. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units". Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of five is ten times more acidic than water having a pH of six. Natural water usually has a pH between 6.5 and 8.5. The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.).

2:Water pollutants

Water pollution happens when toxic substances enter water bodies such as lakes, rivers, oceans and so on, getting dissolved in them, lying suspended in the water or depositing on the bed. This degrades the quality of water.

Water pollution can be defined as "***any biological, chemical, or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses.***

2.1: Sources of water pollution

Water pollution can come from a number of different sources. If the pollution comes from a single source, such as an oil spill, it is called point-source pollution. Water pollutants are categorized as ***point source*** if these pollutants enter watercourses through pipes or channels. **Point source** pollution comes mainly from industrial facilities and municipal wastewater treatment plants. **Nonpoint source (NPS** generally results from land runoff, precipitation, atmospheric deposition and drainage. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters.

2.2: **Types of water pollutants**

1. Organic pollutants

Organic pollutants can be further divided in to following categories:

a) Oxygen Demanding wastes: The wastewaters such as, domestic and municipal sewage, wastewater from food processing industries, canning industries, paper and pulp mills, tanneries, breweries, distilleries, etc. have considerable concentration of biodegradable organic compounds either in suspended, colloidal or dissolved form. These wastes undergo degradation and decomposition by bacterial activity**.** The dissolved oxygen available in the water body will be consumed for aerobic oxidation of organic matter present in the wastewater. Hence, depletion of the DO will be a serious problem adversely affecting aquatic life, if the DO falls below 4.0 mg/L. This decrease of DO is an index of pollution.

Biochemical oxygen demand (BOD) is a measure of demand for oxygen utilized by micro-organism, during oxidation of organic matter. It is defined as the amount of oxygen in milligram per liter or in ppm used by micro-organisms to degrade the organic matter. A high BOD value indicates more polluted water.

Water quality can classified according to BOD values

BOD values (mg\L)	Water quality
1	**Very clean**
2	**Clean**
3	**Rather clean**
5	**Doubt in cleanse**
10	**Bad**

Chemical Oxygen Demand or COD is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water. The method involves using a strong oxidizing chemical, potassium dichromate $Cr_2O_7^{2-}$, to oxidize the organic matter in solution to carbon dioxide and water under acidic conditions. COD is normally higher than BOD because more organic compounds can be chemically oxidised than biologically oxidised. TOC or Total Organic Carbon is the measurement of organic carbons.

b) Synthetic Organic Compounds

Synthetic organic compounds are also likely to enter the ecosystem through various manmade activities such as production of these compounds, spillage during transportation, and their uses in different applications. These include synthetic pesticides, synthetic detergents, food additives, insecticides, paints, synthetic fibers, plastics, solvents and volatile organic compounds (VOCs).

Most of these compounds are toxic and they are resistant to microbial degradation. Even concentration of some of these in traces may make water unfit for different uses. The detergents can form foams and volatile substances. Polychlorinated biphenyls (PCBs) are used in the industries since 1930s which are complex mixtures of chlorobiphenyls. Being a fat soluble they move readily through the environment and within the tissues or cells.

Lecture 7: Water treatments

2. Inorganic Pollutants

Apart from the organic matter discharged in the water body through sewage and industrial wastes, high concentration of heavy metals and other inorganic pollutants contaminate the water. These compounds are non-biodegradable and persist in the environment. These pollutants include mineral acids, inorganic salts, trace elements, metals, complexes of metals with organic compounds, cyanides, sulphates, etc. The accumulation of heavy metals may have adverse effect on aquatic flora and fauna and may constitute a public health problem where contaminated organisms are used for food. Metals in high concentration can be toxic to biota e.g. Hg, Cu, Cd, Pb, As, and Se.

3.Disease causing agents

Pathogens are another type of pollutants that prove very harmful. They can cause many illnesses that range from typhoid and dysentery to minor respiratory and skin diseases. Pathogens include such organisms as bacteria, viruses, and protozoan. These pollutants enter waterways through untreated sewage, storm drains, septic tanks, runoff from farms, and particularly boats that dump sewage. One of the biggest threats for the developing countries is the disease caused by polluted water such as cholera. Regular intake of polluted water may cause sclerosis, skin legions, and problems in blood circulation, mineral deposits in bones, certain cancers and disease of the nervous system. Diseases caused by water pollution are the major cause of human death across the world.

- ✓ **Bacterial indictors of water pollution:**

Bacteria are naturally present in water. However, fecal coliform bacteria in the water may indicate human or animal wastes because these bacteria inhabit the intestines of humans and other vertebrates. Coliform do not necessarily cause disease themselves. Rather they are an indicator of fecal material, which may contain pathogens. Coliform are used as an indicator because simple inexpensive methods are available to detect them. If coliform are found in the water, then it is tested further for the presence of organisms definitely known to be pathogens. Enteric viruses are pathogens which can cause gastrointestinal distress.

Legionella bacteria are responsible for the respiratory disease, Legionnaire's disease. *Giardia lamblia*, a protozoan, causes intestinal illness. Any of these diseases can be serious or, sometimes, deadly.

4.Thermal pollutants

Considerable thermal pollution results due to discharge of hot water from thermal power plants, nuclear power plants, and industries where water is used as coolant. As a result of hot water discharge, the temperature of water body increases, which reduces the DO content of the water adversely, affecting the aquatic life. This alters the spectrum of organisms, which can adopt to live at that temperature and DO level. When organic matter is also present, the bacterial action increases due to rise in temperature; hence, resulting in rapid decrease of DO. The discharge of hot water leads to the thermal stratification in the water body, where hot water will remain on the top.

5. **Plant nutrients**

The agriculture run-off, wastewater from fertilizer industry and sewage contains substantial concentration of nutrients like nitrogen and phosphorous. These waters supply nutrients to the plants and may stimulate the growth of algae and other aquatic weeds in receiving waters. However, these nutrients are responsible for what is known as the phenomenon eutrophication. In freshwater environments (e.g. lakes), **phosphorus** is usually the nutrient in the lowest concentration and therefore generally limits the growth of phytoplankton. In coastal environments (estuaries), nitrogen usually limits the growth of phytoplankton because it is generally the nutrient in the lowest concentration. **Nitrogen** is commonly found in aquatic environments as nitrate (NO_3^-), nitrite (NO_2^-), or ammonia (NH_4^+ or NH_3). Human factors affecting the concentration of nitrogen in aquatic environments are wastewater and septic system effluent, fertilizer runoff, animal waste, fossil fuel, and industrial discharge. **Phosphorus** is commonly found in aquatic environments as phosphate (PO_4^{-3}). The sources of phosphorus in aquatic environments are wastewater and septic system effluent, detergents, fertilizer runoff, animal waste, development/paved surfaces, industrial discharge, phosphate mining, drinking water treatment, forest fires, and synthetic material. Based on the amount of phytoplankton growth and the concentration of nutrients, the degree of eutrophication in aquatic environments can be classified: as **Oligotrophic, Mesotrophic, Eutrophic**, or **hypereutrophic.**

Oligotrophic : environments are characterized by clear waters, little suspended organic matter, and low primary production (phytoplankton growth).

Mesotrophic: environments have higher nutrient inputs and rates of primary production.

Eutrophic: environments have extremely high nutrient concentrations and biological productivity.

Hypereutrophic environments are characterized by murky, highly productive waters in which many clear water species cannot survive.

The algal blooms(eutrophication) lead to

1.Produce extremely dangerous toxins that can sicken or kill people and animals

2.Create dead zones in the water due to the depletion of oxygen and reduce the amount of light available to organisms and plants beneath the surface layer

3. Species diversity decreases and the dominant biota changes

4. Turbidity increases

5. Rate of sedimentation increases, shortening the lifespan of the lake

6.Raise treatment costs for drinking water

Also, Nitrate levels above 10 mg/L (10 ppm) in water can cause **blue baby syndrome** (**methemoglobinemia**), leading to **hypoxia** (which can lead to coma and death if not treated). It is widely believed to be caused by nitrate contamination in water resulting in decreased oxygen carrying capacity of haemoglobin in babies leading to death. The drinking water can be contaminated by leaching of nitrate generated from fertilizer and chemicals used in agricultural lands. Cases of blue baby syndrome have for example been reported in villages in Romania and Bulgaria where the groundwater has been polluted with nitrate leaching from pit latrines. However, the linkages between nitrates in drinking water and blue baby syndrome have been disputed in large number of studies.

6. Suspended solids and sediments

These comprise of silt, sand and minerals eroded from land. These appear in the water through the surface runoff during rainy season and through municipal sewers. This can lead to the siltation, reduces storage capacities of reservoirs. Presence of suspended solids can block the sunlight penetration in the water, which is required for the photosynthesis by bottom vegetation. Deposition of the solids in the quiescent stretches of the stream or ocean bottom can impair the normal aquatic life and affect the diversity of the aquatic ecosystem. If the deposited solids are organic in nature, they will undergo decomposition leading to development of anaerobic conditions. Finer suspended solids such as silt and coal dust may injure the gills of fishes and cause asphyxiation.

7. Radioactive Substances

Contamination of radioactive substances such as wastes of uranium and thorium can be carried into water from nuclear power plants, during their mining and refining processes. Scientific and medical institutions, which utilize radioactive materials can also contaminate water bodies. These substances may cause radioactivity in living organisms and produce harmful effects.

Testing of Nuclear capability for war or peaceful purposes in oceans damages marine eco systems. The use of oceans for nuclear testing has damaged much of marine life in these water zones and nuclear explosions in oceans are now banned under an international treaty.

8. Oil

Oil is a natural product which results from the plant remains fossilized over millions of years. It is a complex mixture of hydrocarbons and degradable under bacterial action, the biodegradation rate is different for different oils, tars being one of the slowest. Oil enters in to water through oil spills, leak from oil pipes, and wastewater from production and refineries. Every year, between 1 and 10 billion tons of oil are spilt in to different ecosystems. Cleanup efforts have been weak, as only about 10% of the oil is removed by the most successful efforts. Oil pollution is a growing problem, particularly devastating to coastal wildlife. An oil spill from a **tanker** is a severe problem because there is such a huge quantity of oil being spilt into one place. Oil cannot dissolve in water and forms a thick sludge in the water. This suffocates fish because the oil layer on the surface of water reduce the DO level in water as oxygen transfer from atmosphere is prevented , also gets caught in the feathers of marine birds stopping them from flying and blocks light from photosynthetic aquatic plants. Also ,they are toxic to most living organisms , carcinogenic to other and have the ability to transport through the food chain.

3. Water treatment

Water treatment is any process that makes water more acceptable for a specific end-use. The end use may be drinking, industrial water supply, irrigation, river flow maintenance, water recreation or many other uses, including being safely returned to the environment. Water treatment removes contaminants and undesirable components, or reduces their concentration so that the water becomes fit for its desired end-use.

3.1: Polluted water treatment

Wastewater treatment is the process that removes the majority of the contaminants from wastewater or sewage and produces both a liquid effluent suitable for disposal to the natural environment .

- ✓ **The treatment phases :**

1.The sewage first goes through a primary phase (primary treatment). This is where some of the suspended, solid particles and inorganic materials is removed by the use of filters.

2.The secondary treatment involves the reduction of organic, this is done with the use of biological filters and processes that naturally degrade the organic waste material.

3.Final treatment; The water at this stage is almost free from harmful substances and chemicals. The water is allowed to flow over a wall where it is filtered through a bed of sand to remove any additional particles. It can discharge water which treat with primary phase to sea, and to river (and other water source) if treated with secondary phase , and for drinking after treated with tertiary phase.

3.2: Treatment for drinking water production

Treatment for drinking water production involves the removal of contaminants from raw water to produce water that is pure enough for human consumption without any short term or long term risk of any adverse health effect. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, and minerals such as iron and manganese. The processes involved in removing the contaminants include physical processes such as settling and filtration, chemical processes such as disinfection and coagulation and biological processes such as slow sand filtration.

Treatment for drinking water production involves the following steps:

1. **Pre-chlorination** for algae control and arresting biological growth

2.Coagulation and flocculation

Alum is added in proportion to the river turbidity to form floc particles created from the suspended materials in the water.

3.Sedimentation

The water travels through Sedimentation Basins where the heavier material settles.

4. Filtration

Following sedimentation, the water travels through an extensive filtration process that removes sediment and other suspended materials.

5. Disinfection for killing bacteria viruses and other pathogens

After filtration, the finished water is disinfected, often with chlorine. Disinfection kills the remaining microorganisms in the water, some of which may be pathogenic. Chlorine gas from bottles or drums is fed in correct proportions to the water to obtain a desired level of chlorine in the finished water. When chlorine comes in contact with organic matter, including microorganisms, it oxidizes this material and is in turn itself reduced. Chlorine gas is rapidly hydrolyzed in water to form hypochlorous acid, by the reaction

$CI\ 2 + H2O \longrightarrow HOCI + H + CI^-$

The hypochlorous acid itself ionizes further to the hypochlorous ion:

$HOCI \longrightarrow OCI- + H$

At the temperatures usually found in water supply systems, the hydrolysis of chlorine is usually complete in a matter of seconds, while the ionization of HOCI is instantaneous. Both HOCI and OCI-are effective disinfectants and are called *free available chlorine* in water.

Free available chlorine kills pathogenic bacteria and thus disinfects the water. Many water plant operators prefer to maintain a *residual* of chlorine in the water; that is, have some available chlorine left over once the chlorine has reacted with the currently available organics. Then, if organic matter like bacteria enters the distribution system, there is sufficient chlorine present to eliminate this potential health hazard. Tasting chlorine in drinking water indicates that the water has maintained its chlorine residual. Chlorine may have adverse secondary effects. It is thought to combine with trace amounts of organic compounds in the water to produce chlorinated organic compounds that may be carcinogenic or have other adverse health effects. Some studies have shown an association between bladder and rectal cancer and consumption of chlorinated drinking water, indicating that there may be some risk of carcinogenesis. Disinfection by ozonation, the bubbling of ozone through the water, avoids the risk of side effects from chlorination, but ozone disinfection does not leave a residual in the water. A number of municipalities also add fluorine to drinking water because it has been shown to prevent tooth decay in children and young adults. The amount of fluorine added is so small that it does not participate in the disinfection process.

Lecture 8: Metals pollution

1. Introduction

Metals are solid material which is typically hard, shiny, malleable, fusible, and ductile, with good electrical and thermal conductivity (e.g. iron, gold, silver, and aluminum). Heavy metals are defined as metallic elements that have a relatively high density compared to water (more than 5 g/cm^3). Heavy metals are also considered as trace elements because of their presence in trace concentrations (ppb range to less than 10ppm) in various environmental matrices. With the assumption that heaviness and toxicity are inter-related, heavy metals also include metalloids, such as arsenic, that are able to induce toxicity at low level of exposure . In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals. It has been reported that metals such as cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn) are essential nutrients that are required for various biochemical and physiological functions . Inadequate supply of these micro-nutrients results in a variety of deficiency diseases or syndromes

2.Sources of metal pollution

Although metals are naturally occurring elements that are found throughout the earth's crust, most environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds . Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metal ions and leaching of heavy metals, sediment re-suspension and metal evaporation from water resources to soil and ground water . Natural phenomena such as weathering and volcanic eruptions have also been reported to significantly contribute to heavy metal pollution. Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high tension lines, plastics, textiles, microelectronics, wood preservation and paper processing plants.

3. Where can metal pollution present concerns?

_ Fresh water. Even quite small levels of metal pollutants can pose problems to freshwater bodies, with their low amounts of metals. Fresh-water organisms evolved with low metal levels, so higher concentrations can cause adverse effects. Moreover, many lakes have small volumes or few outlets to dilute or displace polluting metals.

_ Marine waters. Metals in marine waters are naturally higher than in freshwaters. Nonetheless, ever-growing coastal populations have led to increasing marine pollution coming from runoff from developed land, and rivers carrying pollutants.

_ Cities. Older cities had more metal-processing facilities than did rural areas. These left some city soils highly polluted.

_ Agricultural soils. Above that rate, the soil is not fit to grow crops. Some agricultural villages in Eastern Europe are deserted due to metal contamination. In Japan, metal contamination has made nearly 10% of rice-paddy land unusable . The cost to remediate metal-contaminated soil is high. Large areas may be impossible to clean up.

_ Hazardous-waste sites. Lead, cadmium, mercury and arsenic are four of the ten most common pollutants found at US hazardous-waste sites.

_ Connection to acid rain. Acid can worsen the risks. Bacteria convert more elemental mercury to the highly toxic methylmercury in acidified lakes. Metals -- aluminum is a prominent example – become more soluble in acid soils. Subsequently washed out by rain, metals run off into nearby water bodies and may damage aquatic life.

4.Effects of Heavy Metals

The heavy metals are dangerous because they are stable and persistent environmental contaminants, since they cannot be degraded or destroyed, so they tend to accumulate in the soil, fresh water, sea water and sediment.

4.1:Effects on ecosystems

Toxic heavy metals are among the most harmful pollutants and are of particular concern because of their toxicity to human, which have the ability to accumulate in the organisms through the transition to different levels of the food chain and reach to human or other organisms at the top of food chains and threaten the life of organisms and sometime causes death. Aquatic invertebrates show special and high susceptibility to collect element from the plankton by filtering during feeding, also the aquatic crustaceans absorb heavy metals through permeable body surface.

Freshwater and seawater algae can absorb metals from the media and gather it in their body cells. The metals become more concentrated from water through the food chain . The presence of heavy metals in rivers, lakes or any aquatic environment can change both aquatic species diversity and ecosystems due to their toxicity and accumulative behavior. The slightly elevated metal levels in natural water may cause the following sub-lethal effects in aquatic organisms:

1- Histological or morphological change in tissues.

2-Changes in physiology, such as suppression of growth and development and poor swimming performance

3- Change in biochemistry, such as enzyme activity and blood chemistry.

4- Change in behavior.

5- Changes in reproduction.

4.2: The effects on human health

In biological systems, heavy metals have been reported to affect cellular organelles and components such as cell membrane, mitochondrial, lysosome, endoplasmic reticulum, nuclei, and some enzymes involved in metabolism, detoxification, and damage repair. Metal ions have been found to interact with cell components such as DNA and nuclear proteins, causing DNA damage and conformational changes that may lead to cell cycle modulation, carcinogenesis or apoptosis. Heavy metal-induced toxicity and carcinogenicity involves many mechanistic aspects, some of which are not clearly elucidated or understood. However, each metal is known to have unique features and physic-chemical properties that confer to its specific toxicological mechanisms of action. This review provides an analysis of the environmental occurrence, potential for human exposure, and molecular mechanisms of toxicity of lead, mercury and cadmium.

4.2.1:Lead’s adverse effects

Thousands of years ago ancients knew lead was toxic, and forced slaves to do the mining. It continued to be used for thousands of years. In the late twentieth century, childhood lead poisoning was described as the most consequential environmental health problem in the United States. Lead’s effect on the nervous system of the developing fetus and small child is of most concern. The potential for damage starts long before pregnancy. The mother may have been exposed as a child and, because the body treats lead much as it does calcium, ingested lead accumulated in her bones. About 90% of a person’s lead intake is eventually stored in the skeleton. Lead levels in modern human skeletons and teeth are hundreds of times greater than those found in pre-industrial-age skeletons. During pregnancy, as the mother’s bones release calcium to the blood to meet the needs of her fetus, lead is released too. Lead passes with calcium into the placenta, thus exposing the fetus. Very-low doses of lead may not obviously harm the fetus or small child. In addition to lead’s toxicity to the developing nervous system, lead may cause kidney cancer. Mice exposed to lead developed kidney cancer later in their lives. Although adults are not as sensitive as children, they too suffer adverse effects from lead exposure. Chronic workplace exposure increases the likelihood of high blood pressure, can damage the nervous system and kidneys, and sometimes leads to anemia and infertility. Disturbing results recently emerged: long after worker exposure to lead ceased, damage to brain function continued to worsen.

4.2.2 Exposure and adverse effects of Mercury

About 95% of the average person’s mercury exposure comes from eating contaminated fish. As with lead, the greatest concern about mercury is its toxicity to the nervous system. Again, as with lead, the fetus and small child bear the greatest risk. The developing embryo is five to ten times more sensitive to mercury than adults. In 2000, the US National Research Council reported that 60 000 US babies born each year are at risk of slowed development, such as delayed walking and talking, because of prenatal methylmercury exposure. Most maternal exposure results from eating contaminated fish.

_ Workplace exposure. With the exception of some dental workers, workplace exposures are generally well controlled in developed countries. Unfortunately, facilities making most mercury measuring devices are now located in countries where workers often lack basic protection. Chronic inhalation of elemental mercury fumes over weeks, months, or years leads to poor coordination and strange sensations in fingers, toes, and lips. Severe poisoning can lead to blindness, deafness, kidney damage, irreversible brain damage, even death.

4.2.3: Exposure and adverse effects of Cadmium

Whereas lead has been mined for at least 4000 years, cadmium was not even discovered until 1817, and has only been heavily mined since the mid-1940s. Environmental cadmium levels are lower than those of lead, and people ordinarily have lower exposure. Nonetheless, cadmium levels in the environment have been increasing, and exposure is hundreds of times greater than in pre-industrial times.

Cadmium bioaccumulates in the kidney. The amount stored increases with age. Kidney damage is the most common chronic effect among those who have suffered high occupational exposure. In some middle aged or older individuals *not* occupationally exposed, cadmium has concentrated to levels almost as high as those known to affect kidney function. Cadmium may also contribute to kidney stones. It affects calcium metabolism too and exposure can accentuate osteoporosis. A cadmium poisoning occurred some years ago among poor, elderly Japanese women, who were eating rice grown in cadmium contaminated paddies. They experienced *itai itai* (‘‘pain, pain”) disease, characterized by kidney damage and brittle, painful bones. In rodent studies, cadmium showed many dose-dependent effects, including birth defects; it is also a carcinogen. More than 90% of the average non-smoker’s exposure to cadmium is from food.

Lecture 9: Soil pollution

1. Introduction

Soil is the thin layer of organic and inorganic materials that covers the Earth's rocky surface. The organic portion, which is derived from the decayed remains of plants and animals, is concentrated in the dark uppermost topsoil.

Soil pollution definition *is the presence of toxic chemicals (pollutants or contaminants) in soil in high enough concentrations to be of risk to human health and/or ecosystem.* Additionally, even when the levels of contaminants in soil are not of risk, soil pollution may occur simply due to the fact that the levels of the contaminants in soil exceed the levels that are naturally present in soil (in the case of contaminants which occur naturally in soil).

2. The sources of soil pollution

Mining, agriculture, and deforestation are important energy intensive activities that impact economies and at the same time directly and indirectly cause soil and land pollution. **Soil pollutants** include a large variety of contaminants or chemicals (organic and inorganic), which could be both naturally-occurring in soil and man-made. In both cases, the main soil pollution causes are the human activities (i.e., the accumulation of those chemicals in soil at levels of health risk is due to human activities such as accidental leaks and spills, dumping, manufacturing processes, etc.). Accumulation due to natural processes is also possible. Natural processes, however, may have an influence of the human released toxic chemicals (pollutants) in the soil, overall decreasing or increasing the pollutant toxicity and/or the level of contaminated soil.

3.Soil erosion and deforestation

The amount of soil **erosion** occurring in the world today may be two or three times it was before human intervention in nature. Eroded materials can also be contributed by urban, industrial, and highway construction sites . These materials when they reach rivers and lakes lead to settle on fish spawning beds and suffocate the eggs. It can clog gills of adult fish, and can interferes with domestic and industrial uses of water and adds to the expenses of water purification .

Deforestation is simply the conversion of forested tracts to barren lands. This is usually done by clear-cutting trees and removing the wood. Forested areas are typically cleared to make area for agricultural operations or to harvest wood as a fuel source or for lumber products. Much of the deforestation occurring globally is due to slash-and burn operations that make space for agricultural operations. The process of deforestation results in many undesirable environmental impacts at multiple scales. Local impacts include decreasing soil stability, increasing erosion and sediment transport into streams, reduction in biodiversity through loss of habitat, and alterations to microclimates that typically increase local temperatures because of loss of vegetation and increased numbers of heat islands. Removal of forest vegetation increases the potential of soils to become eroded by wind and/or rainfall. Runoff during precipitation events can promote both the erosion of soils and the transport of sediments into river systems. These sediments will degrade water quality by increasing turbidity and levels of dissolved nutrients (*e.g.*, phosphorus and nitrates) .

4. Soil pollutants

Soil is a very sensitive and vulnerable pollution receptor. Contaminants can damage not only terrestrial ecosystems but can also be transferred from the soil to air, water or food.

According to estimates by the European Environment Agency (EEA), in 1999 there were between 300,000 and 1,500,000 contaminated sites in Western Europe. In general, soil may be polluted by the following

(1) Industrial wastes: Industries are the major causes for soil pollution Textiles, steel, paper, Cement, oil, dyeing and other industries are responsible for soil pollution. Toxic organic compounds and phenol destroy the fertility of the soil.

(2) Biological agents – Fungi, protozoa, bacteria are important Biological agents for soil pollution. The human and animal wastes, garbage, waste water generates heavy soil pollution.

(3) Radio-active pollutants: Atomic reactor, nuclear radio active devices releases radio active pollutants. These pollutants enter the land and accumulate there by causing soil pollution

(4) Agricultural pollution : It is important to know that the modern agriculture practices pollute the soil to a large extent. Since agricultural practices are the most important factor in the pollution of the soil so it will take a special interest in this lecture. Today huge quantities of fertilizers, pesticides, weedicides are added to increase the crop field. Apart from these farm wastes, manure debris, soil erosion containing inorganic chemicals are causing soil pollution. The excessive use of these products can affect soils and water quality. The chemicals can also be absorbed by plants which are then consumed by animals and humans, terribly harmful to animal and human health. Below are some pollutants that are mainly agricultural pollutants

1.**Animal wastes**

Over the centuries, farm animal waste have been regarded by all peoples as an important soil fertilizer. Fields fertilized with manure generally show higher yields than these without manure. Animal wastes contain several types of land pollutants that are of increasing concern both to the public and regulators. Besides traditional pollutants, increasing evidence suggests that excessive use of animals waste on land releases measurable amounts of antibiotics, growth hormones, and pesticides containing toxic metals like arsenic. Animal waste have two principal measurable effects on surface water quality:

(1) increased turbidity through the movement of soil particles into streams, rivers, and lakes; and

(2) farm animal waste problems, including serious water pollution and unpleasant smell and the transfer of bacterial and viral diseases, parasitic and others.

Current interest in animal waste control centers on the use of aerobic and anaerobic biologically active systems and the spreading of waste on the land. Anaerobic digestion system have proved successful in the laboratory and in field under some conditions. Aaerobic lagoons are used to remove and destroy much of the organic matter, and aerobic units are generally shallow oxidation ponds or lagoons with actually anaerobic conditions.

2. **Plant residues**

Plant residues from crops and orchard constitute environmental pollution when they harbor plant diseases and pests or when they are burned and emit smoke and hydrocarbons . Agricultural burning is a fairly important source of air pollution .

On method controlling the plant residue of plant debris can be used as a mulch, for example, it can be spread over the ground under orchard trees . Mulching on a large scale can be affected on crop land by leaving residue from the previous crop on the soil surface .

Mulching reduces wind and water erosion and usually (but not always) leads to improved crop yields . Plant residues are also used to some extent for other purposes, such as bedding for poultry and livestock or in the manufacture of corrugated cartons .

Lecture 10: Agricultural chemicals

3.Agricultural chemicals

Agrochemical or **agrichemical**, a contraction of *agricultural chemical*, is a generic term for the various chemical products used in agriculture. In most cases, *agrichemical* refers to the broad range of pesticides, including insecticides, herbicides, fungicides and nematicides. It may also include synthetic fertilizers, hormones and other chemical growth agents,

3.1:Fertilizers

Plants need numerous chemicals in order to complete their life cycles. There are at least 16 essential elements required for the growth of all plants: C, H, O, N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo, B, and Cl in various ionic forms. Interestingly, soil microbes require these same elements. In undisturbed ecosystems, plants obtain these nutrients from the soil solution via mineral weathering, atmospheric inputs, inputs from stream deposition, and nutrient recycling due to death and decomposition of vegetation. The availability of the nutrients depends on a biotic soil factors and chemical and biological properties. Agricultural crop production has always relied on soil components for nutrient sources. However, excessive cropping and in particular dense monoculture practices deplete soil plant nutrients, especially N, P, K, and Ca. Thus, over years of continuous crop production, large amounts of nutrients are removed, with a concomitant decline in productivity. Therefore, N, P, K, and other plan nutrients must be periodically augmented by the use of fertilizers, including animal or human wastes. Fertilizers may contain any of the essential nutrients, but the majority of fertilizers applied to agricultural soils contain nitrogen (N), phosphorus (P), potassium (K), or some combination thereof.

These are the so-called **macronutrients** because plants take them up in larger amounts than the other essential nutrients. Fertilizer use dramatically increased around the time of World War II, as improved crop varieties and management practices, together with increased mechanization, made fertilizer use both practicable and profitable. In the 1980s, however, fertilizer use began to level off, reflecting both lower agricultural profitability and increased environmental concerns related to fertilizer use.

3.2.Pesticides

3.2.1:What are pesticides?

Pesticides are agents used to destroy pests. Under certain circumstances almost any living creature can be a pest. The purposes of pesticide use are to increase the production of food and to promote public health; in practice they are also used for aesthetic reasons.

A pesticide that kills insects is an *insecticide*. One killing plants is a *herbicide*. Among the pests attacking agricultural crops are insects, weeds, rodents, birds, and disease-causing organisms including fungi and bacteria. Weeds are undesired plants of any kind that, if left uncontrolled, crowd out the desired crop plant.

3.2.2: Important classes of pesticides

Pesticide can be classified in a number of different ways :

First: by their target

1.Insecticides

2.Fungicides.

3.Herbicides.

4.Rodenticide.

5.Acaricides or Miticides.

6.Nematocides.

7.Bactericides.

8.Algicides.

9.Avicides.

10.Piscicides.

11. Gastropodcides or Molluscicides.

Second: by their chemical nature

1.Inorganic Compounds:

The source of these compounds is natural environment, they doesn't contain any carbon atoms . These compounds are **non-volatile**, and have **high solubility** in water, and the most important the ones that contains **arsenic** , **cyanide** and **mercury** and they have the ability to accumulate in organism tissues. Examples of some of inorganic chemical pesticides are:

Boric Acid, Sodium Amino Fluorides, Sodium Fluoride, Copper Oxide, and Silica Aerogel.

2.Organic Compounds:

These compounds are extracted from natural sources such as plants, or man-made, and contains carbon and hydrogen and some other elements such as chlorine , Oxygen, Sulfur, Phosphor and Nitrogen, the most important groups are:

1.Botanicals (Plant-derived pesticides): They are natural pesticides such as: **Neem Extract, Nicotine, Pyerthrum, and Rotenone pesticides.**

2.Organochlorine pesticides: They contain chlorine , hydrogen and oxygen in their structure . They can be named as chlorinated hydrocarbon compounds, such as: **DDT**.

3.**Organophosphorous**: are the most toxic insecticides and the mode of action is inhibition the (Acetylcholinestrease enzyme), such as: **Dursban, and Sumithion** pesticides.

4.Organosulfur Compounds: They contain sulfur and the most common of them **Tedion** and **Omite** pesticides.

5.Carbamate Compounds: They are similar to the **Organophosphorous** as they inhibition the enzyme of (Acetyl chloriestrase enzyme). Low persistence in environment Ex. **Baygon and Oxamyl** pesticides.

6.Pyrethroids: is an organic compound similar to the natural pyrethrins produced by the flowers of pyrethrums. Pyrethroids now constitute the majority of commercial household insecticides. Ex. Cypermethrin, Alphacypermethrin, Sumsdin pesticides.

Third: According to their mode of action:

1.Stomach Poisons: the most important ones are **Arsenites** and **Mercury** compounds.

2.Contact Poisons: the most important ones are **Organochlorine pesticides** and **Organophosphorous** and **Carbamate**.

Fourth: **By their physical state :** dusts (Powder) , dissolved solutions , suspended solution, and volatile solids.

3.2.3: The effects of pesticides

1.On non target species

Extensive use of synthetic pesticides began in the 1940s with DDT used to control mosquitoes. This was quickly followed by the adoption of pesticides in large-scale agricultural production. Initially pesticide use was credited with significant increases in food production. Once there, they can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds, and other wildlife**.** In 1962, Rachel Carson's book *Silent Spring* brought public attention to the fact that chlorinated pesticides were very persistent in the environment. These chemicals can accumulate in animal fatty tissue and produce fish kills when released into waterways. DDT, associated with the rapid decline of some birds of pray, was banned for agricultural use in the United States in 1973. Other chlorinated pesticides were also banned, but have been replaced by much less persistent, but more acutely toxic, pesticides. Less persistent pesticides are usually much more soluble in water than chlorinated hydrocarbons. Unfortunately, these new pesticides are more like to leach to groundwater or be found in the agricultural runoff if they are not degraded fast enough in the soil environment. Today, pesticides continue to be used extensively in modern farming, urban lawns, parks, and golf courses primarily to control weeds, fungi, and insect infestations. Unfortunately, even less persistent pesticides have their problems. In 2003, the U.S. EPA concluded that atrazine, the second most widely used pesticide (herbicide) in the U.S., could cause sexual abnormalities in frogs. In addition, atrazines, the most common family of herbicide chemicals found in groundwater are also potential endocrine disruptors.

2. On human health

Pesticide exposure can cause a variety of adverse health effects. These effects can range from simple irritation of the skin and eyes to more severe effects such as affecting the nervous system, mimicking hormones causing reproductive problems, and also causing cancer. A 2007 systematic review found that "most studies on non-Hodgkin lymphoma and leukemia showed positive associations with pesticide exposure" and thus concluded that cosmetic use of pesticides should be decreased. Strong evidence also exists for other negative outcomes from pesticide exposure including neurological, birth defects, fetal death, and neurodevelopmental disorder. The World Health Organization estimate that each year, 3 million workers in agriculture in the developing world experience severe poisoning from pesticides, about 18,000 of whom die. According to one study, as many as 25 million workers in developing countries may suffer mild pesticide poisoning yearly.

One study found pesticide self-poisoning the method of choice in one third of suicides worldwide, and recommended, among other things, more restrictions on the types of pesticides that are most harmful to humans.

3.2.4. Pest resistance

Pests may evolve to become resistant to pesticides. Many pests will initially be very susceptible to pesticides, but some with slight variations in their genetic makeup are resistant and therefore survive to reproduce. Through natural selection, the pests may eventually become very resistant to the pesticide. Pest resistance to a pesticide is commonly managed through pesticide rotation, which involves alternating among pesticide classes with different modes of action to delay the onset of or mitigate existing pest resistance.

3.2.5:Alternative methods for pest control :

A number of alternative pest control method have been developed or are being developed that may involve less environmental pollution than the chemical pesticides presently in use since the early 1950 . The alternative include the following

1- Autocide .
2- Chemosterilization .
3- Sex attractants .
4- Juvenile hormones .
5- Resistant crop varieties .
6- Integrated pest management programs ,
7- Trap crops, which attract pests away from the valuable crops.
8- Reduced use of chemical pesticides.
9- Biological pest control, such as:
   a. Pheromones.
   b. Fungi , Bacteria and viruses.