UC21EV111A/B - Environmental studies and Life sciences

Unit 1: Environment and Disaster management

Basics of Ecosystem

An ecosystem is a geographic area where plants, animals, and other organisms, as well as weather and landscape, work together to form a bubble of life. Ecosystems contain biotic or living, as well as abiotic factors, or nonliving parts. It is a community or group of living organisms that live in and interact with each other in a specific environment.

The four ecosystem types are classifications known as artificial, terrestrial, lentic and lotic. Ecosystems are parts of biomes, which are climatic systems of life and organisms. In the biome's ecosystems, there are living and nonliving environmental factors known as biotic and abiotic. Examples of ecosystems are: agroecosystem, aquatic ecosystem, coral reef, desert, forest, human ecosystem, littoral zone, marine ecosystem, prairie, rainforest, savanna, steppe, taiga, tundra, urban ecosystem and others. As a society, we depend on healthy ecosystems to do many things; to purify the air so we can breathe properly, sequester carbon for climate regulation, cycle nutrients so we have access to clean drinking water without costly infrastructure, and pollinate our crops so we don't go hungry.

Classification of Ecosystem

Based on study area

1. **Autecology**: It deals with the study of an individual species of organisms and its population. It is also called the Species ecology.
2. **Synecology**: It deals with the study of communities, their composition, their behavior and relation with the environment. It is also called the Ecology of communities. It is further divided into 3 types:
    a. Population Ecology
    b. Community Ecology and
    c. Ecosystem Ecology

Types of Ecosystem

An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystem: **Terrestrial Ecosystem** and **Aquatic Ecosystem**

Terrestrial Ecosystems: are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. They are as follows:

1. Forest Ecosystems
2. Grassland Ecosystems
3. Tundra Ecosystems
4. Desert Ecosystem

1. **Forest Ecosystem**: A forest ecosystem consists of several plants, animals and microorganisms that live in coordination with the abiotic factors of the environment. Forests help in maintaining the temperature of the earth and are the major carbon sink.
2. **Grassland Ecosystem**: In a grassland ecosystem, the vegetation is dominated by grasses and herbs. Temperate grasslands, savanna grasslands are some of the examples of grassland ecosystems.
3. **Tundra Ecosystem**: Tundra ecosystems are devoid of trees and are found in cold climates or where rainfall is scarce. These are covered with snow for most of the year. The ecosystem in the Arctic or mountain tops is tundra type.
4. **Desert Ecosystem**: Deserts are found throughout the world. These are regions with very little rainfall. The days are hot and the nights are cold.

Aquatic Ecosystem: Aquatic ecosystems are ecosystems present in a body of water. These can be further divided into two types, namely:

1. Freshwater Ecosystem
2. Marine Ecosystem

1. **Freshwater Ecosystem**: The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands. These have no salt content in contrast with the marine ecosystem.
2. **Marine Ecosystem**: The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem.

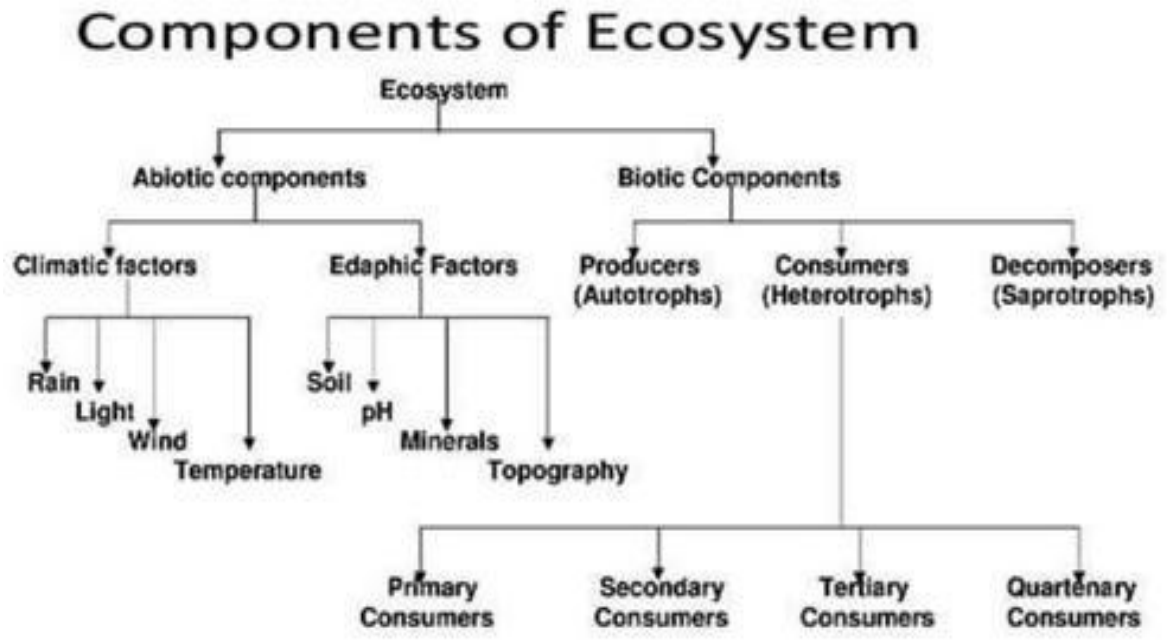
Structure of the Ecosystem

The structure of an ecosystem is characterized by the organization of both biotic and abiotic components. This includes the distribution of energy in our environment. It also includes the climatic conditions prevailing in that particular environment.The structure of an ecosystem can be split into two main components, namely:

Biotic Components

Abiotic Components

The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.



Structure of Ecosystem highlighting the biotic and abiotic factors

Biotic Components: Biotic components refer to all life in an ecosystem. Based on nutrition, biotic components can be categorized into ***autotrophs, heterotrophs*** and ***saprotrophs*** (or decomposers).

- ***Producers*** include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- ***Consumers*** or ***heterotrophs*** are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
  - ***Primary consumer***s are always herbivores that rely on producers for food.

- ***Secondary consumers*** depend on primary consumers for energy. They can either be a carnivore or an omnivore.
- ***Tertiary consumers*** are organisms that depend on secondary consumers for food. Tertiary consumers can also be an omnivore.
- ***Quaternary consumers*** are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.

- ***Decomposers*** include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

Abiotic Components: Are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

Functions of Ecosystem

The functions of the ecosystem are as follows:

1. It regulates the essential ecological processes, supports life systems and renders stability.
2. It is also responsible for the cycling of nutrients between biotic and abiotic components.
3. It maintains a balance among the various trophic levels in the ecosystem.
4. It cycles the minerals through the biosphere.
5. The abiotic components help in the synthesis of organic components that involves the exchange of energy.

Important Ecological Concepts

Food Chain

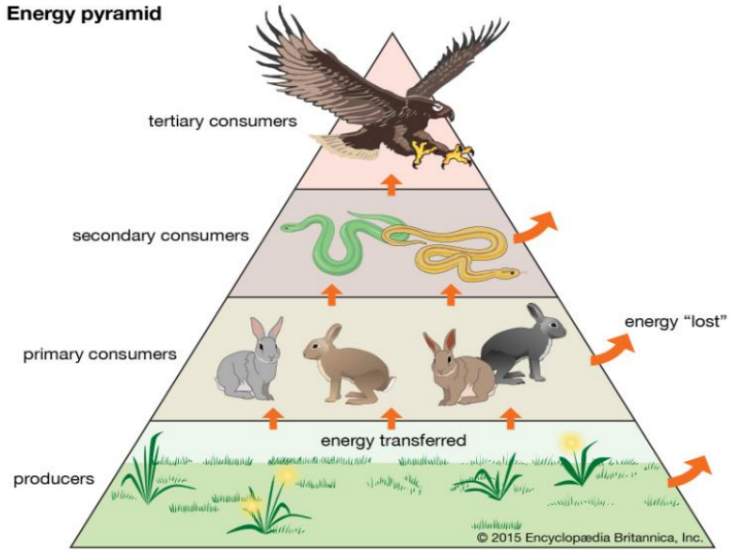
The sun is the ultimate source of energy on earth. It provides the energy required for all plant life. The plants utilize this energy for the process of photosynthesis, which is used to synthesize their food. During this biological process, light energy is converted into chemical energy and is passed on through successive levels.

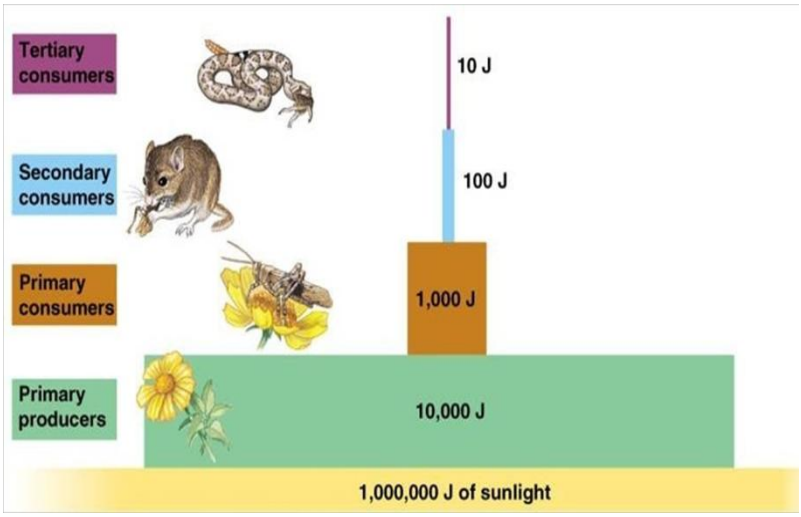
The flow of energy from a producer, to a consumer and eventually, to an apex predator or a detritivore is called the food chain. Dead and decaying matter, along with organic debris, is broken down into its constituents by scavengers. The reducers then absorb these constituents. After gaining the energy, the reducers liberate molecules to the environment, which can be utilized again by the producers.

Ecological Pyramids

An ecological pyramid is the graphical representation of the number, energy, and biomass of the successive trophic levels of an ecosystem. Charles Elton was the first ecologist to describe the ecological pyramid and its principals in 1927.

The biomass, number, and energy of organisms ranging from the producer level to the consumer level are represented in the form of a pyramid; hence, it is known as the ecological pyramid. The base of the ecological pyramid comprises the producers, followed by primary and secondary consumers. The tertiary consumers hold the apex. In some food chains, the quaternary consumers are at the very apex of the food chain.





Food Web: Food web is a network of interconnected food chains. It comprises all the food chains within a single ecosystem. It helps in understanding that plants lay the foundation of all the food chains. In a marine environment, phytoplankton forms the primary producer. A good ecosystem consists of native plants and animal species interacting with each other and the

environment. A healthy ecosystem has an energy source and the decomposers that break down dead plants and animal matter, returning essential nutrients to the soil.

Direct Values:

- Consumptive Use Value - Non-market value of fruit, fodder, firewood, etc., that are used by people who collect them from their surroundings.
- Productive Use Value – Commercial value of timber, fish, medicinal plants, etc., that people collect for sale.

Indirect Values:

- Non-consumptive use value – scientific research, bird-watching, ecotourism, etc.,
- Option value - maintaining options for the future, so that by preserving them one could reap economic benefits in the future.
- Existence value - ethical and emotional aspects of the existence of wildlife and nature.

ENERGY RESOURCES

An energy resource is something that can produce heat, power life, move objects, or produce electricity. Matter that stores energy is called a fuel. Human energy consumption has grown steadily. Energy sources can be classified into two types: non-renewable and renewable.

Non-renewable Energy Resources: Resources, such as fossil fuels and nuclear material, are removed from the earth and can be depleted. These resources have been the most used type of energy in the modern era. Energy resources are all forms of fuels used in the modern world, either for heating,generation of electrical energy, or for other forms of energy conversion processes. Until recently fossil fuels have provided for the majority of humanity's energy demands. These resources mainly include coal, oil, and natural gas.

Energy is an important and essential to continuing the economic growth and generates the wealth of the country. Natural resources are one of the resources that humans consume to generate energy. But the most important issue is how technology can contribute to generating the solution maintaining sustainability. The most popular renewable energy sources currently are:

- Solar energy
- Wind energy
- Hydro energy
- Tidal energy
- Geothermal energy
- Biomass energy

- **Biomass** – Organic matter that contains stored energy or energy produced by heat within the Earth's crust. Eg.: Plants, wood, and waste – Non-industrialized countries rely heavily on biomass for energy.
- Gasohol- Plant material that is changed into liquid fuel. Eg.: Plants containing sugar or starch can be made into alcohol. The alcohol is burned as a fuel or mixed with gasoline to form the gasohol.
- **Geothermal energy** – Harness heat from the Earth – Groundwater that seeps into hot spots near the surface of the Earth can form geysers. (Natural vents in which steam and water escape). Eg.: Old Faithful in Yellowstone National Park. The steam is used in power plants to generate electricity.
- **Hydroelectric energy** – Electricity produced by falling water – Recycled through the water cycle. Eg.: Dams.
- **Solar energy** – Energy from the sun can be obtained by two common ways (indirectly or directly):
    - Sunlight can be changed into electricity by the use of solar cells. – Ex: solar calculator, solar panels (large panels made up of many solar cells wired together).
    - Solar collectors - dark-colored boxes with glass or plastic tops used to directly heat.
    - Solar mirrors-mirrors that use sunlight to produce electricity for large-scale solar power.
- **Wind energy** – The energy in wind is exploited for different purposes. Uses wind turbines to convert kinetic energy into electrical energy by rotating a generator

Nonrenewable Resources

The energy resources that cannot be replaced after they are used or can be replaced only over thousands or millions of years – Fossil fuels and nuclear energy.

Coal is obtained either by mining deep beneath the Earth's surface or by strip mining. Strip mining- a process in which rock and soil are stripped from the Earth's surface to expose the underlying materials to be mined.

Petroleum and natural gas are removed from the Earth by drilling wells into rock that contain these resources. – Oil wells exist on land and in the ocean.

The energy resources that formed from the buried remains of plants and animals that lived in swamps millions of years ago – Coal, petroleum, and natural gas. Originally received their energy from the sun. The United States' primary source of electrical energy is generated by burning fossil fuels.

Solid Fossil Fuels: Eg.: Coal - A solid fossil fuel formed underground from buried, decomposed plant material. Most coal used in the U.S. is burned by power plants to run electric generators. Creates the most fuel emissions

Liquid Fossil Fuels: Eg. Petroleum - Can be called crude oil. It is an oily mixture of flammable organic compounds from which liquid fossil fuels and other products, such as asphalt, are separated – Gasoline, plastics, and petrochemicals (which are used to make synthetic fibers such as rayon) are some of the products.

Gaseous Fossil Fuels: Natural Gas - Used the most to heat businesses and homes as well as generating electricity, stoves, ovens, and in vehicles as an alternative to gasoline. It is the cleanest burning fossil fuel

Nuclear Energy

An alternative source of energy that comes from the use of nuclear reactions. A nuclear power plant generates thermal energy that boils water to produce steam. Fossil fuel and nuclear power plants use steam to turn a turbine, which rotates a generator that converts kinetic energy into electrical energy. Nuclear power plants provide alternative sources of energy without the problems that come with fossil fuels, but produce dangerous, radioactive wastes. Nuclear power can be obtained from ***nuclear fission***, nuclear decay and ***nuclear fusion*** reactions.

Nuclear fission reaction: A process when the nucleus of a uranium atom is split into two smaller nuclei, releasing nuclear energy.

Nuclear fusion reaction: the joining of nuclei of small atoms to form larger atoms.

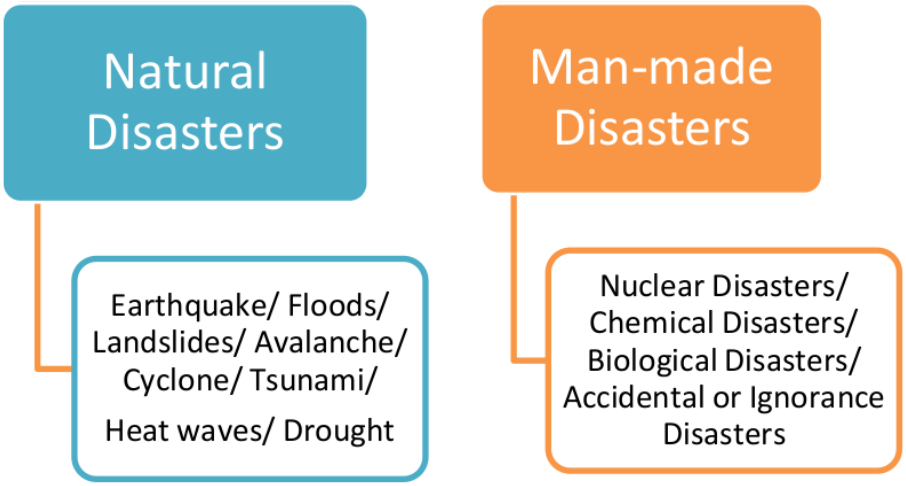
Nuclear fission and fusion reactions can produce few dangerous wastes (radioactive waste), very high temperatures are required for the reaction to take place.

Benefits

- Nuclear fights climate change- Provides large amounts of 24/7 carbon-free electricity now, which is irreplaceable in protecting the environment
- Nuclear protects our air- No trace elements like Nitrogen oxide, sulfur dioxide, particulate matter and mercury
- Nuclear boosts international development- Nuclear energy helps developing nations meet sustainable development goals.
- Nuclear powers electric vehicles- Electrified transportation promises to reduce carbon emissions

NATURAL DISASTERS

A Disaster is a serious disruption of the functioning of a society involving widespread human, material, economic or environmental losses & impacts which exceeds the ability of the affected community or society to cope using its own resources.



A Natural Disaster is a major adverse event resulting from natural processes of the Earth such as floods, volcanic-eruptions, earthquakes, tsunamis & other geologic processes; such events lead to loss of life & property. The severity of such events depends on the affected population's ability to recover.

Earthquakes

- An earthquake is the result of a sudden release of energy in Earth's crust that creates seismic waves. At the Earth's surface, earthquakes manifest themselves by shaking & sometimes displacement of the ground.
- **Seismic activity** of an area refers to the frequency, type & size of earthquakes experienced over a period of time & are measured using seismometers.
- Earthquakes are measured using observations from **seismometers** and moment magnitude is expressed in terms of Richter scale.
- When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently and cause tsunami.

Floods

- A flood is an overflow of water that submerges land, may occur as an overflow of water from water bodies, such as a river or lake, in which the water overtops, resulting in some

of that water escaping it's usual boundaries or it may occur due to accumulation of rainwater on saturated ground in an areal flood.

- Floods often cause damage to livelihood & structures. Floods cause damage to homes and businesses if they are placed in natural floodplains or rivers.
- The most common classifications are a **10-year flood**, a **50-year flood**, and a **100-year flood**. What "100-year flood" actually means is that there is a 1 percent chance that such a flood could happen in any given year.
- Flash floods can develop within hours of heavy rainfall. Deserts are vulnerable to flash floods. Wadis and arroyos are dry river beds that only flow during heavy rains.

Landslide

- A landslide is a geological phenomenon that includes a wide range of ground movements, such as rock falls, deep failure of slopes & shallow debris flows.
- Landslides can occur in offshore, coastal & onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, a landslide often requires a trigger before being initiated.
- Landslides are caused by rain, earthquakes, volcanoes, or other factors that make the slope unstable.
- There are several ways of describing how a landslide moves. These include falls, topples, translational slides, lateral spreads, and flows.
- Falls & topples-heavy blocks of material fall after separating from a very steep slope or cliff.
- In translational slides, surface material is separated from the more stable underlying layer of a slope.
- A lateral spread or flow is the movement of material sideways, or laterally.

Avalanche

An avalanche is a rapid flow of snow down a sloping surface. Avalanche is typically triggered in a starting zone from a mechanical failure in the snowpack(slab avalanche) after initiation, avalanches usually accelerate rapidly & grow in mass & volume as they collect more snow. During an avalanche, a mass of snow, rock, ice, soil, and other material slides swiftly down a mountainside. There are two main types of snow avalanches—**sluffs** and **slabs**.

- **Sluff avalanches** occur when the weak layer of a snowpack is on the top. A sluff is a small slide of dry, powdery snow that moves as a formless mass
- A **slab avalanche** occurs when the weak layer lies lower down in a snowpack. This layer is covered with other layers of compressed snow. When the avalanche is triggered, the weak layer breaks off, pulling all the layers on top of it down the slope. These layers tumble and fall in a giant block, or slab.

Cyclone

- A ***cyclone*** is an area of closed, circular fluid motion rotating in the same direction as the Earth. This is usually characterized by inward circular winds that rotate anti-clockwise in the Northern Hemisphere & clockwise in the Southern Hemisphere of the Earth.
- An ***anticyclone*** is the opposite of a cyclone. An anticyclone's winds rotate clockwise in the Northern Hemisphere around a center of high pressure. Air comes in from above and sinks to the ground. High pressure centers generally have fair weather.

Tsunami

- In Japanese, tsunami means "**harbor wave**". A Tsunami also known as a seismic sea wave, is a series of water waves caused by displacement of a large volume of a body of water, generally an ocean or a large lake.
- Tsunami waves do not resemble normal sea waves as their wavelength is longer. Rather than appearing as a breaking wave. A tsunami may initially resemble a rapidly rising tide & for this reason tsunamis are often referred to as tidal waves.
- Tsunamis race across the sea at up to 500 miles (805 kilometers) an hour—about as fast as a jet airplane. At that pace, they can cross the entire expanse of the Pacific Ocean in less than a day.

Drought

- Drought is an extended period when a region receives a deficiency in its water supply, whether atmospheric, surface or groundwater.
- A drought can last for months or years, or may be declared after as few as 15 days, this occurs when a region receives consistently below average precipitation.
- A Drought can have a substantial impact on the ecosystem & agriculture of the affected region.

Heat Wave

- A heat wave is a prolonged period of excessively hot weather accompanied by high humidity, especially in oceanic climate countries. It occurs during the summer season in the North-Western parts of India.
- The extreme temperatures and resultant atmospheric conditions adversely affect people living in these regions as they cause physiological stress, sometimes resulting in death.
- The health impacts of Heat Waves typically involve dehydration, heat cramps, heat exhaustion and/or heat stroke. The signs and symptoms are as follows:
    - **Heat Cramps**: Ederna (swelling) and Syncope (Fainting) generally accompanied by fever below 39*C i.e.102*F.

- **Heat Exhaustion**: Fatigue, weakness, dizziness, headache, nausea, vomiting, muscle cramps and sweating.
- **Heat Stroke**: Body temperatures of 40*C i.e. 104*F or more along with delirium, seizures or coma. This is a potential fatal condition.

Man made disaster

- Disasters having elements of human intent, negligence, error, failure of human-made systems. Such events result in huge losses of life & property along with damage to people's mental, physical & social well-being.
- The man-made disasters are Nuclear disaster, biological / chemical threat, accidental, terrorism, etc.
- The causes of man made disasters are:
  - Ignorance 52%
  - Unawreness 20%
  - Illiteracy 40%
  - Carelessness 42%

Nuclear Disaster

The growth in the application of nuclear science and technology in the fields of power generation, medicine, industry, agriculture, research and defense has led to an increase in the risk of occurrence of Nuclear and Radiological emergencies.

Nuclear and Radiological Emergency/Disaster Scenarios:

1. An accident taking place in any nuclear facility of the nuclear fuel cycle including the nuclear reactor, or in a facility using radioactive sources, leading to a large-scale release of radioactivity in the environment.
2. A 'criticality' accident in a nuclear fuel cycle facility where an uncontrolled nuclear chain reaction takes place inadvertently leading to bursts of neutrons and gamma radiation (as had happened at Tokaimura, Japan).
3. An accident during the transportation of radioactive material.
4. The malevolent use of radioactive material as Radiological Dispersal Device (RDD) by terrorists for dispersing radioactive material in the environment.
5. A large-scale nuclear disaster resulting from a nuclear weapon attack (as had happened at Hiroshima and Nagasaki in Japan) which would lead to mass casualties and destruction of large areas and properties.

Biological Disaster - Natural or Human-made

- The devastating effects caused by an enormous spread of a certain kind of living organism that may spread disease, viruses or infestation of plant, animal or insect life on an epidemic or pandemic level.
- Charles Baldwin developed the symbol for biohazard in 1966.
- Biological disasters are natural scenarios involving disease, disability, or death on a large scale among humans, animals, and plants due to microorganisms like bacteria, or viruses, or toxins.
- ***SARS-COV2*** is an example of Biological Disaster.

The US Center for Disease Control classifies biohazards into four biosafety levels as follows:

- ***BSL-1***: Bacteria and Viruses including Bacillus subtilis, some cell cultures, canine hepatitis, and non-infectious bacteria. Protection is only facial protection and gloves.
- ***BSL-2***: Bacteria and viruses that cause only mild disease to humans, or are difficult to contract via aerosol in a lab setting such as hepatitis A, B, C, mumps, measles, HIV, etc. Protection – use of autoclaves for sterilizing and biological safety cabinets.
- ***BSL-3***: Bacteria and viruses causing severe to fatal disease in humans. Example: West Nile virus, anthrax, MERS coronavirus. Protection – Stringent safety protocols such as the use of respirators to prevent airborne infection.
- **BSL-4**: Potentially fatal (to human beings) viruses like Ebola virus, Marburg virus, Lassa fever virus, etc. Protection – use of a positive pressure personnel suit, with a segregated air supply.

Chemical disaster

- Chemical, being at the core of modern industrial systems, has attained a very serious concern for disaster management.
- Chemical disasters may be traumatic in their impacts on human beings and have resulted in the casualties and also damages nature and property.
- The elements which are at highest risk due to chemical disaster primarily include the industrial plant, its employees & workers, hazardous chemicals vehicles, the residents of nearby settlements, adjacent buildings, occupants and surrounding community.

Chemical disasters may arise in number of ways, such as:-

1. Process and safety systems failures
    a. Human errors
    b. Technical errors
    c. Management errors
2. Induced effect of natural calamities
3. Accidents during the transportation

4. Hazardous waste processing/ disposal
5. Terrorist attack/ unrest leading to sabotage

India has witnessed the world's worst chemical (industrial) disaster "Bhopal Gas Tragedy" in the year 1984. 3. The Bhopal Gas tragedy was most devastating chemical accident in history, where over 2500 people died due to accidental release of toxic gas **Methyl IsoCyanate (MIC)**.

India continued to witness a series of chemical accidents even after Bhopal had demonstrated the vulnerability of the country. Only in the last decade, 130 significant chemical accidents were reported in India, which resulted in 259 deaths and 563 number of major injuries. There are about 1861 Major Accident Hazard (MAH) units, spread across 298 districts and 25 states & 3 Union Territories, in all zones of the country. Besides, there are thousands of registered and hazardous factories (below MAH criteria) and unorganized sectors dealing with numerous ranges of hazardous material posing serious and complex levels of disaster risks.

Bioterrorism

- Bioterrorism is the use of bacteria , viruses, or germs to purposely harm large quantities of people or communities. These "weapons" are spread through air, water, or food sources.
- Bioterrorism is rare and is used to threaten people, governments, and countries. Attacks with biological weapons are indeed a real threat and the responsible government agencies need to be aware of this
- The use of biological weapons has been reported as early as the sixth century B.C. when contamination of water supply with the fungus Claviceps purpurea (rye ergot) by the Assyrians.
- The hurling of the dead bodies of plague victims over the walls of the city of Kaffa by the Tartar army in 1346 and the spreading of smallpox via contaminated blankets by the British to the Native American population loyal to the French in 1767 are the most frequently cited episodes of poisoning.
- In the recent past, mycotoxins (fungal toxins) were reported to have been used in Afghanistan. The most significant biological attack in the United States (US) was the intentional contamination of restaurant salad bars with Salmonella by a religious cult in Oregon in 1984
- In September 2001, the American public was exposed to anthrax spores as a bioweapon delivered through the US postal system. (Ref: Das, S., & Kataria, V. K. (2010). Bioterrorism : A Public Health Perspective. Medical journal, Armed Forces India, 66(3), 255–260).