1.3 GLOBAL VIEW of DISASTERS

It has often been pointed out that most of the world's worst disasters tend to occur between the Tropic of Cancer and the Tropic of Capricorn i.e., in the tropical areas. Coincidentally, this is the area which contains the poorer countries of the world. A major significance of this is, of course, that such countries find themselves facing repeated setbacks to progress. Indeed, some countries seem destined to remain in the category of developing nation's primarily because of the severity and magnitude of their disasters. Seen in this light, therefore, disaster can be a strong aggravating factor in the differences between wealthy nations and poor nations. On the other hand, the simple fact is that the more nations develop and the more assets they build up, the more they stand to lose. It follows that any action that can be taken to reduce disaster-related loss must be seen as logical and desirable in cost-benefit terms. This applies to all countries, rich or poor, and it underlines the need for all countries to try to develop and maintain an effective disaster maintenance capability appropriate to their needs. It also underlines the necessity for cooperative and coordinated international action in order to strengthen all aspects of disaster management, wherever this is possible. Unless disaster can be mitigated and managed to the optimum extent possible, it will continue to have a debilitating effect in the future. The world is already facing a range of environmental and subsistence crises. Disaster mitigation should be regarded as an important tool in successfully coping with these crises. Also, the political, economic and. social stability of the world depends significantly on bridging the gap between developing and developed nations. The mitigation and containment of disaster effects on the developing nations, now and in the future, is an important step towards bridging this gap.

In the global context, it is significant to note that among the major disasters, the floods account for the largest number of deaths, persons affected and damage inflicted. In fact, nearly 30% of all deaths, damage and affected population can be traced to flood disasters. On the other hand, droughts do not result in too I 'many deaths and most of the persons also escape the serious effects by migrating but the damage is nevertheless significant, that is, around 20% of all the disaster related damages.

The study of the global statistics of disasters over the last few decades reveals that there is a significant and steady rise in the impacts of disasters (deaths, damage, persons affected). This appears for two reasons. viz .• (i) increased incidence of man-made disasters' due to industrialisation and ecological degradation: and (ii) increased technological capability to detect and monitor natural disasters.

The South Asian region faces various kinds of natural hazards. The countries in this region are dense,populated and are low-income economics 'l1lakin sustained efforts for economic growth. Recurrent natural disasters offer setbacks to their efforts at development and aggravate poverty conditions in the region.The South Asian countries have diverse agroclimatic regions, each subject to particular natural disasters, Long coastal regions are prone to cyclones. arid and semi-arid regions persistent droughts. the Himalayan mountain terrain and parts of the continental crust to earthquakes and landslides and the near-perennial rivers of the region to periodic floods. The coastal regions of India, Bangladesh, Myanunar and Sri Lanka are severely affected by cyclones arising in the Bay of Bengal. In the recent past Bangladash and India particularly have been ravaged by severe cyclones that have killed lakhs of people and damaged/destroyed property worth thousands of crores or rupees. The super

cyclone that hit Orissa in 1999 resulted in unprecedented destruction and loss of lives. Earlier in 1970 the then East Pakistan (New Bangladesh) was hit by a very severe cyclone. Floods are almost an annual feature of the region and cause heavy losses. The major rivers of the region like the Ganga, the Brahrmaputra and the Indus are all prone to flooding either due to heavy rains or due to fast melting of snow ill the Himalayas. Floods occur with unfailing regularity in Pakistan, India, Sri Lanka. Bangladesh and Nepal. while there are occasional flash floods in Bhutan. In India, more than 40 million hectares of land is flood prone. Seismic disturbances are common all over the region. Nepal alone has experienced 23 major earthquakes between 1890 and 1975. Earthquake of lesser magnitude also strike every year. Pakistan too has a long history of earthquakes. In 1935 an earthquake at Quetta killed 35,0OO people. Around 56% of India's total area is susceptible to seismic disturbances. India suffered from two major earthquakes recently in Maharashtra (1993) and in Gujarat (2001) that have taken a massive toll of human lives and property. Bangladesh is also susceptible to occassional seismic disturbances though the magnitude of the disturbances here is of a considerably lower scale than the rest of the region.

The inherently variable nature of tropical rain such as the monsoon is responsible for the frequent occurrence of droughts. In fact. it is not uncommon for onc pan of a large country like India to be experiencing droughts while a different part of the same country is reeling under the impact of floods. Two-thirds of India comes under arid and semiarid regions and dry subhumid conditions. These areas are all prone to droughts. 'The Western part of the country suffered from major drought in 1987. The Pakistani states of Sind and Punjab are the country's drought-prone areas. Sri Lanka's northern and eastern parts also suffer from droughts occasionally.

Landslides are an increasingly common occurrence ill the hilly areas of the region. Landslides cause extensive damage to roads, bridges. human dwellings. agricultural lands. orchards, forests resulting in loss or properly

1. INTRODUCTION Disasters are sudden and intense events which result in considerable destruction, injuries & deaths, disrupting normal life as well as the process of development. Increasing population and various other socio-economic factors have forced people to live in vulnerable areas. Disasters are perceived to be on the increase in terms of their magnitude, frequency, and economic impact. Unique geo-climatic conditions make the Indian region particularly vulnerable to disasters. Floods and high winds account for around 60 percent of all disasters. About 54 percent of the sub-continent's landmass is vulnerable to earthquakes, while about 4 crore hectares, that is, about 12 percent of the country is vulnerable to periodic floods. New disaster threats have also developed, such as the tsunami disaster of December 2004 which was an unprecedented natural disaster. The total expenditure on relief and reconstruction in Gujarat alone after the severe earthquake of January 2001 has been about Rs. 11,500 crore in that year. Thus it is evident from the facts and figures that for the national development and citizen's welfare, development process needs to be sensitive towards disaster prevention and mitigation aspects. There is an urgent need to look at the disasters from a development perspective. In this context, certain five year plans have been framed to plan for disaster preparedness and mitigation, in order that periodic shocks to our development efforts are minimized. In order to implement these plans, India has integral administrative machinery at national, State, District and sub-district levels. The basic responsibility of undertaking rescue, relief and rehabilitation measures in the event of disasters is that of the concerned state Government. In this situation, the Central Government supplements the efforts of the states by providing necessary financial and logistic support. The ministry of Home Affairs is the Nodal Ministry for coordination of relief & response, and overall disaster management of natural disasters. In addition, the department of Agriculture & Cooperation is the Nodal Ministry especially for drought management, and the Geological Survey of India is the Nodal agency for landslide management. For an effective disaster management and capacity building, joint efforts and active participation of political leaders, administrators and citizens is imperative. Important function of the non-governmental organisations and community based organisations is that of linkage between Government & the community. It is important that this link is maintained effectively at all the three stages of disaster management viz. pre-disaster, during disaster and post-disaster stage. This function is rendered through different mechanisms as per the requirements of a situation, such as distribution of relief material, ensuring sanitation & hygiene, and damage assessment. Media plays equally important role in disaster management as it can reach millions of people in short time.

2. NATURE OF NATURAL DISASTERS A natural disaster could occur due to an immediate extreme event or it could be the result of a long duration process, which disrupts normal human life in its established social, traditional and economic system to a considerable extent. The United Nations define it as "the occurrence of a sudden or major misfortune which disrupts the basic fabric and normal functioning of a society (or community)." The termDisaster‟ is commonly used to denote any extreme event, be it natural man-made, which brings about loss of life, property, infrastructure, essential service and means of livelihood to an extent that it becomes difficult to cope with the situation due to being beyond the normal capacity of the affected communities to deal with unaided. A hazardous situation turns into a disaster event when the affected community (or district or state or country) needs immediate and prolonged assistance and support to deal with the situation and its aftereffects. Disaster is the culmination of a hazard in a situation where the impact is accentuated by the vulnerability of the

community. To be more specific, a hazard may be regarded as a pre-disaster situation, in which some risk of disaster exists. In fact, hazards can be posed both by natural phenomena and by man-made events. Therefore, disasters can be natural or man-made. The severity of a disaster is assessed on the basis of disruption to normal pattern of life, impacts like loss of life and property, injury, hardship and adverse effects on health; community needs; specially shelter, food, clothing, medical assistance and social care; damage to infrastructure, buildings, communications; and the requirements of rehabilitation.

3. NATURAL DISASTERS IN INDIA India's unique geo-climatic position makes India particularly vulnerable to natural disasters. India is a vast peninsula of sub-continental size and surrounded by sea on three sides and has the Himalayas range on the fourth side, which has some of the tallest mountains of the world. That is why India has to face a very large variety of disastrous events of geological, oceanic or climatic origin. There is a broad classification of natural disasters in India. Brief description is mentioned below as per the geological origin of these disasters.

3.1. EARTHQUAKE A sudden geological event below the surface of the earth results in generation of waves that travel far and wide and cause vertical and horizontal vibrations. The consequential motion causes destruction. The severity of the impact depends on the magnitude of earthquake, which in turn depends on the amount of energy released at the spot where the geological event took place below the surface of the earth. Earthquakes occur suddenly, and thus there is no dependable technique for prediction of earthquakes as yet. India is highly vulnerable to earthquakes and severe earthquakes have occurred here.

3.2. VOLCANIC ERUPTION Volcano can be described as a vent or chimney, to the earth's surface, from a reservoir of molten rock, called magma, deep in the crust of the earth. It is not that volcanoes are always emitting lava, steam, or smoke. Many volcanoes have been "sleeping" for decades or even longer. In the context of forecasting of volcanic eruptions, it can be stated that short-term forecasts within hours or days may be made through volcano monitoring techniques. There are only two volcanoes in the Indian Territory i.e. Narcondam and Barren Islands-both in Andamans. Both the volcanoes are "sleeping" volcanoes‟ although the Barren Island volcano emits some heat and smoke occasionally and goes to sleep again. India is not much affected due to the volcanoes compared to the other countries like Italy, Mexico, Indonesia and Iceland.

3.3. LANDSLIDES Landslides are defined as the mass movement of rock debris or mud down a slope and have come to include a broad range of motions, whereby falling, sliding and flowing under the influence of gravity dislodged earth material. They also occur as secondary effects of heavy rainstorms, earthquakes and volcanic eruptions. Landslides occur as a consequence of changes, either sudden or gradual, in the composition and structure of rocks or vibrations in the earth's surface. Landslide can be caused by poor ground conditions, geomorphic phenomena, heavy rainfall, earthquakes or undercutting of the base of slopes by rivers and quite often due to heavy spells of rainfall coupled with impeded drainage. They are common in mountainous areas, such as Himalayas and the Western Ghats where they frequently destroy the infrastructure, agriculture and dwellings, resulting in considerable loss of life and property besides blocking vital needs in the inaccessible areas.

3.4. SNOW AVALANCHE An avalanche is defined as the event in which a large mass of snow, ice, rock or other material moves swiftly down a mountain side or over a precipice and crushes everything in its path. An avalanche starts when the large mass of snow, ice and rock overcomes the frictional resistance of the sloping surface, either due to rain, melting of ice base or vibrations of any kind. It will be seen that landslides and avalanche are events of mountain regions and are rather similar in nature and impact. The basic difference is that landslide involves movement of rock, soil and mud whereas avalanche comprises, snow, ice and rock. Landslides can occur in smaller hills or rocky slopes but avalanches occur in high mountains with snow in abundance.

3.5. TSUNAMI Tsunami is a Japanese term for sea waves generated by undersea earthquakes. These waves may originate from undersea or coastal seismic activity, or volcanic eruption. Sea water is displaced into a violent and sudden motion ultimately breaking over land even at very long distances with great destructive power. It is to be noted that while the coasts are hit by very high waves of water, there is hardly any appreciable wave on the high seas. Therefore, ships on the high seas are not affected. In most cases, tsunami could be the after-effect of undersea earthquake due to which the abrupt vertical movement of ocean floor generates waves, which travel at high speed in the ocean. As they approach land, their speed decreases while their height increases. It can be highly destructive to coastal areas as was witnessed during then catastrophic tsunami event in December 2004.

3.6. CYCLONE Tropical cyclones are characterized by destructive winds and copious rainfall, which causes flooding. In such storms, winds can exceed speeds of over 120 kmph. Due to such strong wind forcing, sea-water accumulates ahead of the cyclone as it moves towards the coast. When a cyclone hits the coast, the accumulated enormous mass of sea-water strikes the coast as a giant sea wave called storm surge which can have heights of the order of tens of metres. The storm surge with torrential rains and very strong winds brings widespread devastation to coastlines and islands lying in their paths. Cyclones pose a major threat to life and property. These storms are called cyclones in India. In other parts of the world they have different nomenclature, like hurricanes in America and typhoons in Japan. In India, there are two cyclone seasons viz. Pre-monsoon (April & may) and Post-monsoon (October &November). More cyclones form in the Bay of Bengal than in the Arabian Sea.

3.7. FLOOD Flood denotes inundation or accumulation of water. In other words, it results from an imbalance between inflow and outflow of water. Floods can occur through heavy rains, dam failure, rapid snow melts, river blockages or even bursting of water rains. Floods result in damage, deaths and injuries, and create problems in drinking water supply and food shortage. There are three types of floods i.e. flash floods, river floods, and coastal floods. Flash floods are generally events of hill areas where sudden very heavy rain over a limited area can cause string flow. River floods occur due to heavy inflow of water from heavy rainfall, snowmelt, and short intense storms. Flooding in rivers is also caused by inadequate capacity within the banks of the river to contain high flows, river banks erosion and silting of riverbeds, synchronization of flood in main and tributary rivers, and flow retardation due to tidal and backwater effects. Coastal floods are caused due to tsunami or heavy rainfall from cyclones and the storm surge associated with a cyclone.

3.8. DROUGHT Drought is a temporary reduction in water availability on an area for unusually long period. Depending on the resulting water scarcity, a drought has disastrous and long-term socio-economic impacts, which may last for months and in some cases years. It is a slow phenomenon. It is generally caused by adverse water balance, or scarcity of water to satisfy the normal needs of agriculture, livestock or human population. There are three types of droughts i.e. meteorological drought, hydrological drought, agricultural drought. Meteorological drought occurs when the monthly or seasonal rainfall over an area is appreciably below normal. Hydrological drought occurs when the water scarcity over an area results in reduction in the available water in surface water bodies and the water table also recedes. Agricultural drought occurs when the water scarcity results in partial or total loss of crops and affects agricultural activity adversely.

3.9. HEAT WAVE AND COLD WAVE These are spells of extreme surface air temperature over a region for rather prolonged periods of several days for few weeks. When the maximum temperature in the day over an area overshoots in the hot weather months (March to June), it leads to heat wave. Similarly, when the minimum temperature falls appreciably below normal in the winter months, it is called cold wave.

3.10. GLOBAL WARMING Increase in greenhouse gases (carbon dioxide, methane, nitrous oxide and others) retards cooling of the earth‟s surface at nights and this tends to increase the minimum temperature i.e. morning temperature, almost all over the globe resulting in the phenomenon called Global Warming. There would not only be less cooling of the earth’s surface at night but the atmosphere will also get warmer due to trapping of the heat on account of green house effect.

3.11. SEA LEVEL RISE Any increase in the average temperature of the earth is bound to have two impacts. Firstly, the glaciers, permafrost, ice caps on the poles and mountain peaks will witness increased melting and consequent increase in the waters in rivers and oceans. Secondly, the large body of water in the seas will expand in volume due to increased temperature. Both these factors will create a rise in the level of water in the seas and oceans, which eventually poses serious problems to the inhabitants of coastal and island areas and affects their socio-economic wellbeing.

3.12. OZONE DEPLETION Ozone is an isotope of oxygen which is created in the lower stratosphere where under conditions of low atmospheric pressure, the ultraviolet radiation in the sun’s rays breaks the oxygen molecule into atomic oxygen, which combines with oxygen molecule to form ozone. The ultraviolet radiation breaks up the ozone molecule into a normal oxygen molecule and atomic oxygen. Thus the process goes on and creates a layer of ozone in the upper atmosphere with maximum density of ozone around 20 km or so above the earth. This process consumes a large part of harmful ultraviolet radiation in the sun’s rays and thus saves human, animal and plant life on the earth from the harmful effects of ultraviolet radiations. Certain chemicals in use on earth send chlorine up in the upper atmosphere where under certain conditions of low temperature and darkness, chlorine consumes atomic oxygen in a chemical reaction with the result that ozone formation is reduced thus lowering the ozone density in the ozone layer in upper atmosphere. This process of ozone depletion ensures that less amount of ultraviolet radiation in the sun’s rays gets consumed in the ozone layer and more ultraviolet radiation reaches the earth's surface to create harm.

4. REGIONAL DISASTER PROFILE OF INDIA North India comprising the Himalayan mountainous region and the Indo-Gangetic plains ahs highly variable topography with some of the tallest mountains and perennial rivers. Its northern most boundary also happens to be the zone of collision of two major tectonic plates, viz. the Indian plate and the Asian plate. The area also has many geological faults. North India is also characterized by spells of hot, cold and rainy weather and attributes can vary within wide limits creating unusual situations. As a result of these characteristics geographical, climatic, and geological features, North Indian states (J&K, HP, Punjab, Haryana, Uttaranchal, Delhi, UP, Bihar) are visited by natural disasters in the form of earthquakes, landslides, avalanches, floods, droughts, heat and cold waves. The location and climate of East and North East India (WB, Sikkim, Assam, Arunachal Pradesh, Nagal and Manipur, Meghalaya, Tripura, Mizoram) are such that these states are visited by earthquakes, landslides, floods, and droughts. West Bengal can be affected by cyclones also. The central parts of the country (Orissa, Chhattisgarh, Jharkhand, M.P, Rajasthan, Gujarat, Maharashtra and Goa) have a highly variable rainfall regime, both in time and space. Therefore, floods and droughts are major disasters in the area. Orissa and Gujarat suffer heavily from cyclones. Goa and Maharashtra suffer from very heavy rain fury. Orissa has also suffered from heat waves in recent years. The peninsular India (Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala) suffer mainly from cyclones, floods and droughts. While Kerala escapes the fury of cyclones, it suffers from earthquakes and landslides in addition to floods and droughts. The Telangana and Rayalaseema area of Andhra Pradesh are highly rain-deficient areas and therefore suffer drought conditions often. Among the Island groups, Andaman & Nicobar Islands are vulnerable to earthquakes, heavy rains and occasionally cyclones. Andaman Islands also have two sleeping volcanoes i.e. Narcondam and Barren Island (as already discussed in this paper). The Lakshadweep Islands are coral islands and therefore are only a few centimeters above the sea level. They could be threatened in case of significant sea level rise due to the global warming. This could threaten some of the India‟s biggest cities like Kolkata, Chennai and Mumbai, which are commercial hubs.

5. SEASONAL DISASTER PROFILE OF INDIA India experiences four distinct seasons form climatic point of view. These are: Winter season (December, January• & February) Pre-monsoon or Hot weather season (March, April and May)• Monsoon season (June to September)• Post-monsoon season (October, November)•

5.1. Winter season (December, January & February) During these months, Himalayan range receive copious amounts of rain and snow and the weather phenomenon known as “western disturbances” also brings in strong winds with rain, which at time can be heavy. Hence, the mountainous areas of north India are prone to snow avalanches and landslides. In the aftermath of rainy spells in this cold season, one or two spells of cold waves occur usually. Heavy fog creates aviation hazard, and hail damages crops and orchards in the plains of north India.

5.2. Pre-monsoon or Hot weather season (March, April and May) Cyclones take shape over the Bay of Bengal and the Arabian Sea and move westward or northwestward. Thus the eastern coast is more vulnerable to cyclones and accompanying storm surges. The cyclones that generate in the Arabian Sea move west or northwestwards, thus sparing the west coast but pose serious risk to the oil exploration

outfits in the Arabian Sea. If a cyclone recurves, it affects Gujarat adversely and gives considerable rains in Rajasthan as well and creates floods sometimes.

5.3. Monsoon season (June to September) T his is the flood season for the entire country and floods occur wherever monsoon becomes more active. Conversely, the areas where the monsoon remains weak, suffer from drought in this season. Landslides are a common feature in the hilly areas of Himalayas from J&K to the northeastern States. Landslides also occur in the Western Ghats and in the hilly areas of Kerala in this season. 5.4. Post-monsoon season (October, November) This is again a cyclone season when cyclones generate in the Bay of Bengal and Arabian Sea and move west or northeastwards in the same general fashion as in the pre-monsoon season. But the cyclonic activity is usually more pronounced in this post monsoon season as compared to that in the pre-monsoon season. This is also the season when the southern states of Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala receive considerable rainfall from the northeast monsoon, and are therefore vulnerable to the threat of floods.

CONCLUSION Disasters are sudden and intense events which result in considerable destruction, injuries & deaths, disrupting normal life as well as the process of development. Disasters are perceived to be on the increase in terms of their magnitude, frequency, and economic impact in India. It has been emphasized that a disaster retards the development process in the affected area and extends to the neighbouring regions also. Various types of natural disasters that occur in India like Earthquakes, Volcanic eruption, Landslides, Snow Avalanches, Tsunami, Cyclone, Floods, Drought, heat & cold Waves, sea Level Rise, Gl0bal warming, Ozone depletion have been described very briefly and the regional and seasonal profile of their occurrence have been outlined. Seasonal profile briefly describes four different seasons of India like Winter season covering December, January & February; Pre-monsoon or Hot weather season which include March, April and May; Monsoon season that lasts from June to September; and finally Postmonsoon season covering October & November.

UNIT 3 BIOLOGICAL HAZARDS

Structure

3.0 INTRODUCTION

You have studied about different kinds of natural hazards in the previous units. You have also studied about the harmful effects of these hazards. In this unit, we will study about biological hazards. There is very less public awareness about these hazards. Biological hazards, also known as biohazards, refer to biological substances that pose a threat to the health of living organisms, particularly to human beings. As the name indicates, these hazards are mostly organic in nature. They include pathogenic micro-organisms, viruses, and toxins from biological sources, spores, fungi and bio-active substances. Bacteria, viruses, insects, plants, birds, animals, and even human beings are the sources of these hazards. These sources can cause a variety of health effects ranging from skin irritation and allergies and infections. Let us study more about biological hazards.

3.1 OBJECTIVES

After reading this unit, you will be able to;

- define biological hazards;
- identify the types of biological hazards;
- explain the threats of various biological hazards and
- explain the meaning of biological warfare.

3.2 WHAT ARE BIOLOGICAL HAZARDS?

As the name indicates, biological hazards are hazards caused due to living organisms. Simply speaking, biological hazards are organisms, or by-products of an organism, that are harmful or potentially harmful to human beings. It may be defined as "processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation." These hazards occur naturally in the environment but cause harmful effect only when favourable conditions are met. They enter the human body through inhalation, ingestion or absorption. Once inside the body, these infectious agents multiply quickly and are passed on from one person to another. Even some of them are able to survive outside the host body if suitable breeding ground and optimum conditions are met. However, the extent of the damage caused by these hazards is determined by the toxicity of a particular substance.

You will be surprised to know that unlike other hazards, biological hazards have no threshold level of exposure, i.e., dose and response relationship. That means there is no limit to the dose concentration on the effect. They are omnipresent in the environment and there is no specification of "permissible exposure limits". Biological hazards are affected by the presence of other biological agents and do not necessarily behave in a synergistic manner. These hazards interact with the host and ambient environment to produce adverse effects.

3.2.1 Sources of Biological Hazards

Biological hazards come in various forms, types and have varied places of occurrence. They can be found at home, hospitals, farms or any other place.

The major sources of biological hazards are:

- Contaminated soil and water
- Contaminated food products
- Faecal matter from animals
- Untreated manure
- Wastes from hospitals and other sectors.

3.3 TYPES OF BIOLOGICAL HAZARDS

Biological hazards range from plants, animals, allergens to microorganisms. They mainly include the following:

- Microorganisms including bacteria, viruses, fungi, parasites,
- Microorganisms in human or non-human primate body fluids, tissues, or wastes (e.g. blood borne pathogens), including non-human cell culture (primary or continuous)
- Microorganisms in animals (e.g. zoonotic diseases)
- Microorganisms in human body fluids, tissues, or wastes

- Plant and animal toxins
- Plant and animal allergens
- Genetically engineered organisms and products

Let us now discuss some of the biological hazards in detail.

3.3.1 Bacteria, Viruses and Fungi

Bacteria are simple unicellular organisms and are capable of reproducing. They exist everywhere in air, water, soil and even inside our bodies. Most bacteria come in any of the three basic shapes: coccus, rod or bacillus, and spiral. Bacteria are often thought to be the causative agent of many diseases. You must have come across various diseases which are caused by bacteria. But you must know that most of them are completely harmless and some of them are very useful. For example, bacteria such as actinomycetes produce antibodies. Similarly bacteria like rhizobium found in the root nodules of leguminous plants helps in nitrogen fixation. Bacteria in the large intestine help in the process of digestion. You must know that curd contains bacteria. It is acidophilus bacteria which is very good for the health. Hence, we may classify bacteria into pathogenic (capable of causing illness) or non-pathogenic (not likely to cause illness) bacteria.

Pathogenic bacteria invade in our body and increase in number to the extent that they cause various diseases. Such instances cause bacterial infections and make people very ill. Examples of some of the bacteria causing hazards are *Bacillus cereus, Clostridium botulinum* and *Staphylococcus aureus.* The range of infections may vary from a mild effect such as a sore throat to a life threatening hazard as in necrotising fasciitis which is a severe disease caused due to bacterial infection. Similarly, most strains of *E. coli* do not cause us harm, but the strain known as E. coli O157:H7 can cause food poisoning if ingested. Bacteria are the most common cause of food poisoning. The symptoms and severity of food poisoning vary, depending on which bacteria has contaminated the food.

Bacteria tend to be vulnerable to an antibiotic, which is why people who have a bacterial infection are often prescribed antibiotics. You must know that sometimes the bacteria become resistant to antibiotics. It is so because of the following reasons:

- Pathogenic bacteria mutate and eventually become resistant to specific antibiotics.
- Antibiotics may destroy harmless bacteria and in such case the harmful bacteria multiply and take their place.
- Over-use of antibiotics in recent years has resulted in the rise of superbugs such as methicillin-resistant *Staphylococcus aureus* (MRSA).

It is necessary to take precautionary measures and maintain proper hygiene to avoid hazards caused by bacteria. Let us now study about the Viruses.

Viruses

Viruses are much smaller than bacteria, and are more complex inspite of being the smallest known organisms. They lie on the borderline of living and non

living. Viruses are not affected by antibiotics, which is why antibiotics are not prescribed for viral infections. There are, however, antiviral drugs available to treat some infections. Viruses are obligate parasites and cannot survive without living cells. Hence to multiply they have to invade a 'host' cell and take over its machinery in order to be able to make more virus particles. They do this by invading into the human cells and getting inside them. Viruses consist of genetic materials (DNA or RNA) surrounded by a protective coat of protein. The cells of the mucous membranes, such as those lining the respiratory passages we breathe through, are particularly open to virus attacks because they are not covered by protective skin. As well as all cold and flu infections and most coughs and sore throats, viruses are also the cause of many serious infectious diseases. Viruses exist in foods without growing, so they need no food, water or air to survive. They do not cause spoilage. Viruses cause illness by infection. In order to get rid of a virus, the cell which has been invaded by the virus must be killed, which results in damage to the cells themselves. For this reason doctors can only control the symptoms of a viral infection, but to date medical research has found no cures. When a virus invades the body, the immune system releases white blood cells. These cells produce antibodies, which cover the virus's protein coat and prevent it from attaching itself to the cell. White blood cells also destroy infected cells and thus kill the virus before it can reproduce. Unfortunately, some viruses such as measles, influenza and mononucleosis (glandular fever) weaken the immune system for a period of time. Viruses can be found in people who were previously infected but are no longer ill. Viruses can also be present in people who show no outward signs of illness (carriers). Transmission of viruses to foods is usually related to poor hygienic practices.

Viral food borne infection has recently been recognized as a major contributor to the food borne diseases. While there are many viruses known to inhabit the intestines, only a few have been proven to cause food borne illness. Unlike bacteria, viruses cannot grow in or on foods. Food borne illnesses are associated with viruses due to contamination of the fresh produce or processed food by virus-containing faecal material. All food-borne viruses originate from the human intestine and contamination of food occurs either by contamination from an infected person during preparation or by contact with sewage or contaminated water.

The leading cause of gastroenteritis, food-borne viral infections are primarily due to two types of virus, norovirus which causes gastroenteritis and Hepatitis A virus which causes hepatitis. However, little is known about viral food infection due to variety of factors, including the range of symptoms caused by viruses, the difficulty of detecting viruses in food and the difficulty of categorically diagnosing viral food borne illness through stool samples. Among all illnesses caused by food-borne pathogens, recent estimates of as high as 67% have been attributed to viruses alone, and an upward trend in the of transmission of viruses by food and water has been recently acknowledged. Due to the highly infectious nature of these viruses and their survival under drastic conditions such as high acidic pH and low temperatures, it has long been recognized that immunization against such pathogens is the ideal solution to provide protection against the illness and disease outbreaks associated with these viruses.

Fungi have the broadest spectrum among the biological agents. They are plant like organisms but unlike plants they cannot make food on their own. They are either parasitic or saprophytic. Some species of fungi get their nutrition by breaking down the remains of dead plants or animals. Fungi can be either single celled like yeasts (single-celled), or multi celled like mushrooms and moulds. Examples of fungal infections include athlete's foot, thrush and ringworm. Fungi are composed of molds and yeasts, some species exhibit dimorphic properties, depending on the substrate and temperature. Out of thousands of fungal species are found in nature, many are responsible for all human and animal infections and few are responsible for human mycotic infections. Fungal diseases are classified as mycoses, mycotoxicoses and allergies. The mycoses can be localized or systemic.

3.3.2 Plant and Plant Products

Many plants contain latex, gum or resin (saps), or bristles, have a corrosive or irritant action on the skin. Such plants or plant products also fall in the category of biological hazards as they cause mild to severe infections and diseases in human beings.

Some examples include:

- Gardeners, landscapers and nursery workers are typically exposed to plants, which may initiate allergic skin responses. The spikes in cactus plant are extremely irritant and can have a tumour-promoting effect on the skin.
- Carpenters, polishers and painters are exposed to fine dusts from woods. Common trees which cause irritation to the skin are western red cedar, acacia, ash, birch, maple, mahogany, pine and spruce.

Contact with certain plants, plant materials or fungi may cause non-infectious poisoning, stinging, allergic reactions (e.g. anaphylaxis, mushroom workers 'lung, and bagassosis in the sugar cane industry), and irritant- contact or allergic –contact dermatitis.

3.3.3 Animals and Animal Products

Some animals and animal products are also considered as biological hazards as they can cause allergies and other ailments. Diseases which are transmitted from animals to human beings are known as zoonosis. These are infectious diseases that can be vector-borne or transmitted directly from wild or domestic animals (e.g. plague, anthrax, salmonella, etc.). Other forms of transmission of zoonoses include those due to exposure to bacteria (e.g. leptospirosis, brucellosis and anthrax) or viruses (e.g. bat lyssavirus). Also, a wide range of workers, especially outdoor workers, are potentially at risk of toxic exposure by venomous terrestrial animals (e.g. snakes, spiders and scorpions) or aquatic animals (e.g. stinging fish, and sea snakes). Practising good personal hygiene, wearing protective clothing, undertaking preventative measures and vaccinations can minimise the risk of some animal-borne diseases infecting people.

On average, one new infectious disease emerges in humans every four months. Although several originate in wildlife, livestock often serve as an epidemiological bridge between wildlife and human infections. This is

especially the case for intensively reared livestock which are often genetically similar within a herd or flock and therefore lack the genetic diversity that provides resilience: the result of being bred for production characteristics rather than disease resistance. An example of livestock acting as a "disease bridge" is the case of bird flu or avian influenza pathogens, which first circulated in wild birds, then infected domestic poultry and from them passed on to humans.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Define biological hazards giving suitable examples.

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2. Some plant and plant products act as biological hazards. Throw some light on the statement.

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3.4 THREATS OF BIOLOGICAL HAZARDS

Biological hazards pose health risk, cause ailments and impair the normal functioning of human body. The threats are severe for the individuals who are engaged in such kind of occupations where the risk is more. People who work with animals or plants or in health and child care are most at risk for biological hazards. For example, workers in health care professions are exposed to biological hazards such as blood, tissues, saliva, mucous, urine and faeces. These substances have a high risk of containing viral or bacterial diseases. Likewise, people who work with living animals or animal products (blood, tissue, milk, eggs) are exposed to animal diseases and infections, some of which (zoonoses) have the potential to infect humans (for example, Q-fever, avian flu or Hendra virus) or cause serious allergy via sensitisation. Exposure to biological hazards in the work environment can also occur when people are in contact with laboratory cell cultures, soil, clay and plant materials, organic dusts, food, as well as rubbish, wastewater and sewerage. Exposure to moulds and yeasts is common in some industrial processes, in workplaces with air conditioning systems and high humidity, and in the construction industry. Therefore, it can be interpreted that biological hazards are also occupation specific. For example, construction and maintenance workers at sewage treatment plants are at increased risk of bacterial infections. While some infections are contracted during the course of work especially when living in, or travelling to or from, areas where there is an increased incidence of infectious or other diseases.

Exposure to biological hazards is therefore widespread and so are the effects. Biological agents that are capable of causing disease are known as pathogens.

Common diseases caused by biological agents include:

- Bacterial diseases, such as tuberculosis, tetanus, food poisoning and blood poisoning.
- Fungal diseases, such as ringworm and thrush.
- Viral diseases, such as mumps, hepatitis, German measles, West Nile Virus.
- Parasitic worms that enter the body when their eggs are ingested.

You must also understand that the threats of biological hazards are not only limited to human health but our surroundings are also affected by the presence and growth of these harmful organisms. For example, you must have heard about the foot and mouth disease. Foot-and-mouth disease (FMD) is an acute infectious disease caused by a virus. Due to contagious nature of the disease large number of animals is affected. The poor who are entirely dependent on the livestock are severely affected. Hence we must understand that there are socio economic impacts also of biological hazards that we must consider. Human and animal well being, ecosystem integrity and economic development all are linked with each other.

3.5 BIOLOGICAL WARFARE/ BIOTERRORISM

You must have heard and read a lot about terrorism. In this section we will study about bioterrorism. It means a kind of violence or intimidation caused by organisms. Biological warfare or bioterrorism may be defined as "the intentional use of any microorganism, virus, infectious substance, or biological product that may be engineered as a result of biotechnology, or any naturally occurring or bioengineered component of any such microorganism, virus, infectious substance, or biological product, to cause death, disease, or other biological malfunction in a human, an animal, a plant, or another living organism in order to influence the conduct of government or to intimidate or coerce a civilian population."

Biological warfare and bioterrorism are often used interchangeably, but bioterrorism usually refers to acts committed by a sub-national entity, rather than a country. It is said that if the 20th century was the century of physics, the 21st century will be the century of biology. Thus, Bioterrorism is posed to be the next possible threat the civilized world faces. It also differs from various other forms of terrorism because biological agents are relatively easy and inexpensive to obtain, can be easily disseminated and often cause widespread fear and panic beyond the actual physical damage they can cause. Risk of massive destruction in the form of life is too high. It also happens that exposure to minute quantities of a biological agent does unnoticed and ultimately it results in death.

Biological warfare agents may be more potent than conventional and chemical weapons. During the past century, the progress made in biotechnology and biochemistry has cut down the development and production of conventional weapons. Use of genetic engineering to develop biological weapons holds dangerous option. Ease of production and the broad availability of biological agents and technical knowhow have led to the further spread of biological weapons and an increased desire among developing countries to have them.

Infectious diseases were recognized for their potential impact on people and armies as early as 600 BC. The *first disease used as a tool for bioterrorism was Bubonic Plague in 14th century.* Likewise, biological warfare has been known to show its impact in 19th and 20th century as well. It implies that biological weapons are not just a 21st century concern but humans have used infectious agents in conflicts for hundreds of years. Below are a few examples.

- In a 1336 attempt to infect besieged city dwellers, Mongol attackers in Ukraine used catapults to hurl the bodies of bubonic plague victims over the city walls of Caffa.
- Tunisian forces used plague-tainted clothing as a weapon in the 1785 siege of La Calle.
- British officers discussed plans to intentionally transmit smallpox to Native Americans during Pontiac's Rebellion near Pennsylvania in 1763. It is not clear whether they actually carried out these plans. But, whatever its source, smallpox did spread among Natives Americans in the area during and after that rebellion.
- The Japanese used plague as a biological weapon during the Sino-Japanese War in the late 1930s and 1940s. They filled bombs with plague-infected fleas and dropped them from airplanes onto two Chinese cities; they also used cholera and shigella as weapons in other attacks. An estimated 580,000 Chinese people died as a result of the Japanese bioweapons program (Martin et al., 2007).

So far, Biological weapons have been used to create mass panic only but it may pose dangers in the years to come. We must realize that the threat of bioterrorism is real and significant and is beyond the boundaries of our country. Therefore it is necessary to evaluate the historical account of the development and use of biological agents.

In this regard, there is a need to develop a system to prioritize biological agents according to their risk to national security. Basically, there are three kinds of agents that are classified on the basis of the extent of damage caused. Category A agents are the highest priority, and these are disease agents that pose a risk to national security because they can be transmitted from person to person and/or result in high mortality, and/or have high potential to cause social disruption. These are anthrax, botulism, plague, smallpox, etc. Category B agents are moderately easy to disseminate and result in low mortality. These include brucellosis, glanders, Q fever, typhus fever, and other agents. Category C agents include emerging disease agents that could be engineered for mass dissemination in the future, such as Nipah virus.

There had been several sporadic incidents bioterrorism in past but the October 2001 use of anthrax letters in United States was one incident that killed five people and triggered a worldwide alarm. There are no confirmed incidents of bioterrorism attack in India yet, in 2001, the office of the Deputy Chief Minister of Maharashtra had received an envelope having anthrax culture. It wakes up Indian security agencies and consequently several incidents were suspected to be acts of bioterrorism.

Source: http://www.gktoday.in/indias-bioterrorism-preparedness/

The government must form strategies to fight against the bioterrorism. Some measures that can be taken up are:

- Prevention of an attack
- Detecting bio weapons
- Availability of drugs and medicines
- Spread of awareness
- Providing quick relief in case of an attack.

The use of proper vaccines is necessary to protect lives and limit disease spread in case of any emergency. Licensed vaccines are currently available for some threats such as anthrax and smallpox, and research is underway to develop and produce vaccines for other threats, such as tularaemia and Ebola virus. Many disease threats, however, lack a corresponding vaccine, and for those that do, significant challenges exist to their successful use in an emergency situation. Thus, making a strong public health system is precondition to effectively handle the threat. For this, the various components of the Public Health System such as surveillance, assessment, medical management, information and education, etc. needs to be made stronger and efficient.

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Define biological warfare?

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2. Explain the threats of biological hazards in detail.

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3.6 LET US SUM UP

Biological hazards are as harmful as the physical and chemical hazards. The microorganism like bacteria and viruses along with plants and animals cause mild to severe diseases in human beings. Unlike physical and chemical hazards, biological hazards are less paid attention and often cause socio economic problems also. Effects of bio-hazardous agents are slight and slow initially but risk increases when the causative agents are left unattended. Biological terrorism is the deliberate introduction of a biological hazard into a region with the intention of causing mass scale damage to crops, animals or epidemics in human beings. We must treat the biological hazards with extraordinary caution.

3.7 KEY WORDS

Biohazard : Organisms or products of organisms that present a risk to humans.

Pathogen : A bacterium, virus, or other microorganism that can cause disease.

Disease : A disorder in the functioning of a plant, an animal or a human body system.

Infection : Infection is the invasion of an organism's body tissues by disease-causing agents, their multiplication, and the reaction of host tissues to these organisms and the toxins they produce.

3.8 REFERENCES AND SUGGESTED FURTHER READINGS

http://www.gktoday.in/indias-bioterrorism-preparedness/

Biological and Environmental Hazards, Risks, and Disasters edited by Ramesh Sivanpillai, Elsevier, 2015.

Biological Weapons and Terrorism (2 Vols.) 01 Edition (English, Hardcover, G. C. Satpathy), Kalpaz Publications, ISBN: 9788178351681, 8178351684

Christopher, L. G. W., Cieslak, L. T. J., Pavlin, J. A., & Eitzen, E. M. (1997). Biological warfare: a historical perspective. *Jama*, *278*(5), 412-417.

3.9 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

1. Your answer must include the following points:
   - Risks and dangers associated with biological organisms.
   - Plant and plant products
   - Animal and animal products
   - Microorganisms
2. Your answer must include the following points:
   - Latex, gum or resin (saps), or bristles in plants.
   - Corrosive or irritant action on the skin.
   - Most susceptible are Gardeners, nursery workers Carpenters, painters, etc.

Answers to Check Your Progress 2

1. Your answer must include the following points:

   - The intentional use of any microorganism, virus or biological product.
   - Leading to death or any other ailment in the entire population.

2. Your answer must include the following points:

   - Adverse effect on human health
   - Effect on animal population
   - Effect on ecosystem balance and economic development

UNIT 2 EARTHQUAKES AND VOLCANOES

Structure

2.0 INTRODUCTION

Natural geological phenomenon such as earthquakes, tsunamis, floods, landslides, avalanches, and volcanic eruptions have haunted mankind from time immemorial. ***Earthquake*** literally means shaking of the earth. The occurrences of earthquakes have been mentioned in the ancient european, greek, chinese and Indian scripts. They attributed the shaking of earth to the movement giant creatures dwelling underneath the ground such as serpents, turtles, etc. The philosophers before the medieval period have mentioned about the devastation caused by the earthquakes. It is important to mention Greek philosopher Aristotle attempted to explain earthquake with the concept of winds blowing in the underground caves within the earth in 330 BCE and his view was widely accepted till the 15th century! (Agnew, 2002).

The great Lisbon earthquake of 1755 and the destruction it brought along set the impetus for scholars in the 18th century to give serious scientific reasoning for the cause of earthquakes. The devastation caused by seismic waves was always felt, but it was in 19th century that the branch of **seismology** evolved and a systematic study of earthquakes started. Prediction of an earthquake startled the geoscientists and seismologists until 1960's. The Plate Tectonic theory was a big respite to the seismologists. Seismographs were devised which could accurately measure the seismic waves and their intensities and large number of seismic observatories with seismographs were setup to locate the earthquakes. The seismology also helped in identification of seismic zones around the globe. Based on plate movements with respect to each other and the mammoth data collected from seismic observatories throughout the world. This helped the seismologists in identifying locations vulnerable to earthquakes. Accordingly, scientists and local governments have devised measures to reduce the destruction caused by earthquakes and made people aware of how to cope up with this natural calamity in sensitive areas prone to earthquakes.

2.1 OBJECTIVES

After reading this unit on earthquakes, you should be able to:

- understand the causes of earthquakes;
- list the vulnerable locations on earth prone to earthquakes;
- appreciate the significance of plate tectonics in understanding the shallow and deep foci earthquakes;
- learn the concept of epicentre, focus and magnitude of earthquake; and
- recognise the nature of destruction earthquake brings along and how its effects are enhanced if tsunami, landslides, fire etc are triggered by it.
- define volcano and associated volcanic features;
- classify volcanoes based on their varied characteristics;
- explain the causes of volcanism;
- show spatial distribution of volcanoes on world map;
- understand evaluate the natural hazards caused by volcanism;

- describe role of volcanism in climate change; and
- recognize the effects of volcanism on environment and occupation.

2.2 CAUSES OF EARTHQUAKES

The myths about the causes of earthquakes were put to rest with scientific quest, reasoning and understanding of the makeup of the internal structure of the planet 'Earth'. The ***Plate Tectonic*** theory was propounded by **John Tuzo Wilson (**a Canadian geophysicist and geologist) in the year 1965. This theory advocates the idea that the rigid lithosphere (crust and upper part of mantle) is broken into thirteen major plates and numerous smaller plates which are continuously in motion over the weaker ductile asthenosphere. The plate tectonic theory gained momentum by the end of 1970's and was widely accepted by seismologists to explain earthquakes vis-a-vis plate boundaries.

2.2.1 Types of Plate Boundaries

Let us examine the types of plate boundaries and plate motions in order to quickly recapitulate theory of plate tectonics,. These plate boundaries are associated with large scale geologic features such as volcanic and island arcs and mid ocean ridges. Thus the plate boundaries are the locations where earthquakes, volcanoes, rifts, fault occur. Three types of plate boundaries have been documented on account of movement of plates with respect to each other:

1. D**ivergent Plate Boundary: O**pening of new oceanic crust when two plates diverge from each other (e.g. Mid Atlantic ridge).
2. **Convergent Plate Boundary:** Plates collide with each other as a result lighter plate overrides and the denser plate gets subducted into the mantle (Volcanic and island arcs; e.g. Andes mountain, Indonesian arc).
3. **Transform Faults: P**lates slide past each other (San Andreas fault, US; transform faults offsetting the mid oceanic ridges)

2.2.2 Concept of Stress, Strain and Rock Failure

The plate motion is responsible for the above three types of plate boundaries. These boundaries are the sites of enormous stresses operational in between the plates. The stress is defined as force exerted per unit area and is responsible for strain which causes the brittle rocks to deform. The brittle rocks can withhold stress up to a critical limit beyond which they fail and results in faulting/breaking of rocks. The faulting results in displacement (slip) of rocks on both sides of the fault, and cause an **earthquake**. Most earthquakes have been attributed to geologic faults and when there is sudden displacement along the faults (slip) energy in form seismic waves is released. Many faults active in the past and are still active eg. San Andreas Fault, USA. The faults can also be hidden beneath the surface of the earth and have not been exposed on the surface of the earth are called blind faults. The active faults are concentrated mostly along plate boundaries where stress and strain are operational on a large scale by plate movements.

2.2.3 Focus and Epicenter

Focus is the point inside the earth where an earthquake initiates and the point directly above the focus on the surface of the earth is defined as an ***epicentre***.

The rupturing of the fault starts from the focus and travels along the fault surface up to the surface, i.e. epicentre and at times the rupturing dose not reach the surface in case of blind faults. The intensity of the stresses and nature of the rocks define the extent of faulting. The faulting ceases where the stresses become mellow or the where the rocks are more competent to be affected by stresses and also where material becomes ductile. Minor earthquakes which occur on everyday basis along the plate boundaries are low magnitude earthquakes so they fail to rupture the ground surface. The large earthquakes with high magnitude have the potential to rupture faults for 1000's of km and can cause displacement of rock blocks on either side of the fault on scale of 10's of meter. San Andreas fault in 1906 is a classic example of transform fault, where the Pacific and American plate moved past each other and the earthquake developed a slip of almost 10 m. Everyday earthquakes in the San Andreas fault zone varying in magnitude as low as less than 1 are recorded.

2.2.4 Sesmic Waves (P, S and Surface Waves)

The energy released during an earthquake is in form of ***seismic waves***. The seismic waves trigger outwards from the focus of the earthquake where the rupture initiates. The seismic waves are of three types viz.:

P waves or the ***Primary waves;***

S waves or the ***Secondary waves***; and

Surface waves.

P waves are compressional waves and propagate like sound waves. The P waves are the fastest of all the three types of seismic waves and can travel through solid, liquid and gaseous materials. These waves travel at a speed of 6 km/sec through the solid rock of Earth's crust. Both P waves and S waves travel through Earth's interior. The S waves are transverse waves and are slower than the P waves. Unlike P waves, S waves can only travel through solid materials (they cannot pass through liquids, molten materials or gases). The S waves travel at a speed approximately half that of P waves through earth's crustal rocks. Surface waves are of two types: Love and Rayleigh waves and are the most destructive waves.

Table 1.1 Three types of seismic waves

Source:http://web.ics.purdue.edu/~braile/edumod/waves/WaveDemo.htm

Type	Particle motion	Typical velocity	Other characteristics
P waves (Compressional / Primary/ Longitudinal)	Compressional waves move in the same direction as the wave is propagating	V_P ~ 5 – 7 km/s in typical Earth's crust : >~ 8 km/s in Earth's mantle and core	Pmotion travels fastest in materials, so the P-wave is the first-arriving energy on a seismogram.
S waves (Shear/ Secondary/ Transverse)	Transverse waves moves perpendicular to the direction of propagation.	V_S ~ 3 – 4 km/s in typical Earth's crust : >~ 4.5 km/s in Earth's mantle; ~ 2.5-3.0 km/s in (solid) inner core	S-waves do not travel through fluids, so do not exist in Earth's liquid outer core or molten rock (magma). S-waves travel slower than P-waves in a solid and, therefore, arrive after the P-wave.

L Love Surface waves	Transverse horizontal motion, perpendicular to the direction of propagation and generally parallel to the Earth's surface	V_L ~ 2.0 - 4.5 km/s in the Earth depending on frequency of the propagating wave	Love waves exist because of the Earth's surface. They are largest at the surface and decrease in amplitude with depth.
R Rayleigh Surface waves	Motion is both in the direction of propagation and perpendicular (in a vertical plane)	V_R ~ 2.0 - 4.5 km/s in the Earth depending on frequency of the propagating wave	Rayleigh wave's amplitudes generally decrease with depth in the Earth. Appearance and particle motion are similar to water waves.

2.2.5 Shallow and Deep Focus Earthquakes

Shallow earthquakes with focus < 50 km have been recorded all along the mid ocean ridges which are prominent feature of divergent pate boundaries on ocean floor. The transform-fault boundaries which displace mid-oceanic ridges horizontally on ocean floors record high incidence of earthquake activity compared to mid ocean ridges. The largest (in terms of magnitude) and deep (>600 km deep focus) earthquakes rock the convergent plate boundaries (e.g. Sumatra earthquake of 2004; Chile earthquake of 1960). Most of the earthquakes occurring at convergent plate margins are also responsible for ***Tsunamis*** that cause havoc at the coastlines**.** Tsunamis are large sea waves which can be generated by displacement of seafloor initiated by large earthquakes affecting seafloor. Tsunamis are also triggered by large scale landslides and volcanic eruptions. The deepest earthquakes (> 700 km focus) have known to occur where the old, cold plate gets subducted e.g. west coast of South America and Ring of Fire (Circum - Pacific Belt). All the earthquakes do not originate at plate boundaries, some earthquakes also are recorded within plates (intraplate). The intraplate earthquakes are shallow focus (< 30 km) and mostly occur on continents. Bhuj earthquake of India in 2001 is an example of intraplate earthquake.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. What were the earlier notions on the causes of earthquakes?

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2. Which theory was a big respite for earth scientists to explain the location of earthquakes?

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3. What is the difference between the epicentre and focus of an earthquake? Draw a sketch to illustrate your answer.

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4. Have you ever experienced an earthquake? If yes, describe your observations during an earthquake.

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5. How many types of plate boundaries are there? Describe them in details and how are they related to earthquakes?

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2.3 LOCATION OF AN EARTHQUAKE EPICENTRE AND FOCUS

Seismic waves emanate as a result of sudden faulting move out from the focus. They are recorded by an instrument called ***Seismograph***. Seismograph record all the three types of seismic waves and are extremely helpful in delineating the location of epicentre and focus of an earthquake. The velocity relationship between the three types of seismic waves is used to calculate the distance of an epicentre from the seismic observatory where a seismograph is housed. We know that P waves are the fastest and are recorded first by the seismograph followed by S and Surface waves. A seismologist uses the time difference in the arrival of the three types of seismic waves with respect to the velocity to calculate the distance of epicentre from a seismic observatory. More the difference in the arrival time of P, S and Surface waves greater the distance between the seismic observatory and the epicentre. Using the recorded time interval at a seismic station with the known travel-time curves it is possible to delineate the distance between a seismic observatory and the earthquake epicentre. To locate the focus and epicentre of an earthquake the seismic data from three or more seismographs is collected. The distances calculated from individual seismographs from at least three seismographic observatories can locate the focus. Using the above information it is also possible to detect the time at which the earthquake occurred in an investigated area. Data pertaining to the earthquake, is collected from these seismic observatories helps us in knowing its epicenter, depth of focus and time of origin. The seismic observatories are well equipped with sophisticated instruments with state of the art sensors and large quantity of data.

2.4 MEASURING THE SIZE OF AN EARTHQUAKE

Magnitude of an earthquake is very important to measure besides detecting the epicentre, depth of focus and time of origin of an earthquake. **Magnitude** of an earthquake depends on the intensity of the P, S and Surface waves which cause shaking of the ground. The magnitude of an earthquake also speaks of the volume of destruction an earthquake can cause. For example earthquakes of magnitude 2/3 causing no devastation are happening all the time in seismically active zones but an earthquake with magnitude > 6 can be destructive. ***Richter magnitude*** was devised by an American seismologist Charles Richter in 1935. It is a scale for measuring the ground movement of an earthquake He assigned a numerical size (1 to 10) to each earthquake on a logarithmic scale based on the amplitude of ground movement caused by the seismic waves and recorded by a seismograph. For example earthquakes of magnitude 2 and 3 differ in terms of ground movement by a factor of 10, i.e. the earthquake of magnitude 3 will cause ground movement 10 times more compared to magnitude 2 earthquakes. Thus earthquake with magnitude 3 will be more destructive than magnitude 2. Likewise if we compare earthquakes of magnitude 6 and 8; magnitude 8 earthquake will cause 100 times more ground movement compared to earthquake of magnitude 6. Thus earthquake of magnitude 8 is more destructive. Every year approximately 1 million earthquakes with magnitude >2 and < 3 are recorded all over the world over. The number of earthquakes with magnitude >3 and <4 drop by the factor of 10 on logarithmic scale which implies approximately 0.1 million earthquakes of magnitude >3 and <4. ***Moment magnitude*** is preferred over Richter magnitude by seismologists to measure the severity of an earthquake. Moment magnitude defines the size of an earthquake based on the physical properties of a fault that caused the earthquake. The calculation of moment magnitude is based on the average slip caused at the site of the faulting, area of faulting and the nature or strength of the rock undergoing faulting whereas the Richter magnitude is based on the ground shaking.

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. What is a seismograph?

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2. Which is the most destructive seismic wave during an earthquake?

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3. What is basis of devising magnitude scale for an earthquake? Differentiate between Richter magnitude and moment magnitude.

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4. What are seismic waves? Discuss their nature and how they behave with respect to earth.

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2.5 NATURE OF DESTRUCTION

We know that the earthquakes are the most dreaded natural disaster faced by mankind and earthquakes alone have killed over 2 million people around the globe in the last century (Grotzinger and Jordan, 2014). During the last 15 years some of the deadliest earthquakes that have occurred are Sumatra earthquake, Indonesia in 2004; Tohuku earthquake, Japan in 2011; Bhuj earthquake, India in 2001; Nepal Earthquake, Nepal in 2015, which have caused grave loss of life and property. The loss of life is indeed a great casualty but a high magnitude earthquake also disrupts the economy of the affected country. The ground shaking during earthquakes cause tsunamis, landslides, avalanches, fires, which aggravate the quantum of destruction of life and property. In 2011 Tohuku earthquake of Japan, with magnitude 9 created tsunamis (large oceanic waves) that were as high as approximately 40 m. They inundated land up to 10 kms inwards in the low lying city of Sendai. There was enormous loss of life and approximately 0.23 million people became homeless. The destruction was multiplied by knocking down of Fukushima- Daiichi power plant (nuclear power plant) which suffered a level 7 nuclear meltdown causing deadly radioactive leaks from the nuclear power plant. People in Japan have still not fully recovered from this shock. The earthquake damaged approximately 1 million buildings and caused severe damage to road and railways infrastructure. The earthquake and the tsunami rendered millions of people in northern Japan without electricity and water. Japanese Premier Naoto Kan admitted that after World War II, this is the most difficult time for Japan. The Tohoku earthquake, till now has been the most destructive and economy draining natural disaster!

2.6 EFFECTS OF EARTHQUAKES

The shaking and trembling of earth during earthquake can lead to tsunamis, landslides, avalanches, depending on its intensity. The direct impact of ground shaking is collapsing of manmade structures, such as buildings, dams, nuclear power plants to name a few. The collapsing of structures can cause a great loss of life and monetary loss to a nation. In densely populated areas maximum destruction is caused by collapsing of buildings since people get buried under the rubble. Loss of life is accelerated during high magnitude earthquakes in countries where building codes are not followed and seismicity resistant structures are not built in seismically prone areas.

The earthquakes commonly generate landslides. When water saturated soils are acted upon by seismic waves, they behave like a liquid (***liquefaction***). The ground starts to flow like liquids and carry along buildings, bridges, etc along with it. In the multiple earthquakes in 2010–2011 in Christchurch, New Zealand, liquefaction destroyed the infrastructure of the city. Peru earthquake of 1970, triggered an avalanche which devastated the towns of Yungay and Ranrahirca and killed approximately18,000 people. Tsunamis are the most common and the most destructive natural hazard triggered by an earthquake. . Their impact is most noticeable around the subduction zones and near the arc systems, e.g. in Circum-Pacific region. The oceanic waves created by earthquakes travel with a speed of up to 800 km/hour. The impact of a tsunami is most dramatic when it reaches shallow coastal waters. The destruction caused by tsunami was at its peak during the Tohoku earthquake which rocked Japan on 11th March, 2011. The city of Miyako saw water mass rising up to 40 m above sea level and causing enormous destruction of life and property. Another example of a destructive tsunami was during 9.2 magnitude Sumatra earthquake of 26th September, 2004. The tsunamis devastated the coasts of Indonesia, Thailand, Sri Lanka, India, and even the far off east coast of Africa. More than .15 million people residing in the coastal areas lost their lives. Besides, the natural hazards triggered by earthquakes, some secondary hazards like fires, leak of nuclear material, etc may also cause destruction of life and property. The gas lines, electric poles, petrol pumps get ruptured leading to fires which causes havoc in thickly populated regions. Example of Kanto earthquake of Japan in 1923 led to loss of 0.14 million lives due to fire in the cities of Tokyo and Yokohama triggered by an earthquake.

Check Your Progress 3

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. What is liquefaction?

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2. Give example of an earthquake which gave rise to a tsunami.

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3. Discuss in detail the destruction caused by a tsunami triggered during Tohoku earthquake of Japan.

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4. Write your views on the destruction caused due to earthquakes in the Himalayas. Give examples to support your answer.

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2.7 VOLCANOES

Volcanoes make an amazing sight and are one of the most dynamic geological feature present on the Earth. The word **volcano** comes from the Greek word *'Vulcan'* which means 'God of fire'. In simplest words, a volcano is an opening on Earth's surface through which hot molten material escapes from its deep interior. Volcanism includes all those processes by which molten rock/ magma and gases rise and discharge into the Earth's surface/ crust and atmosphere. It is one of the most spectacular geologic phenomena of our Mother Earth and results in most varied health, occupational and environmental hazards than any other type of natural disaster.

2.8 NATURE, EXTENT AND CAUSES OF VOLCANISM

According to the U.S. Geological Survey, more than 80% of the Earth's surface, both above and below sea level, actually has volcanic origins. The study of Earth's history shows volcanism is a constructive process because emissions from volcanoes during Earth's early history played a significant role in the origin of the atmosphere. Not only this, they are believed to have created all the oceans and mountains we see today as well as will continue to do this into the future. Volcanology is the study of volcanoes.

2.8.1 Volcanic Features: Background and Associated Terminology

Volcanism refers to all the processes encompassing origin of volcanoes, volcanic features, eruptions and volcanic (i.e. extrusive igneous rocks) rocks. A volcano is a hill or mountain landform formed around a vent when molten rock known as magma from deep interior the earth erupts on the surface in the form of lava, gases and pyroclastic materials. It is usually conical in shape and the tip of the cone is breached by the erupting magma. Magma erupting from a volcano is called lava and is the material which builds up the cone surrounding the vent.

2.8.2 Volcanic Features Formed in the Crust

Magma chamber comprises the store house of magma found below Earth's surface. ***Batholith*** is a huge mass of magma in the crust and is composed of granite. It is a discordant pluton which is irregular in shape having at least 100 Km^2 of surface area. It forms the root or core of a mountain chain. ***Laccolith*** is a concordant pluton with mushroom-like geometry. ***Sill*** is a planar sheet of magma parallel to the surrounding rock/s. ***Dyke*** is a mass of magma which is deposited/ intruded in such a way that it cuts across surrounding rocks.

2.8.3 Volcanic Features Formed on the Surface

Vent is a hole through which magma reaches Earth's surface. ***Fissure*** is a crack in the subsurface rocks through magma reaches Earth's surface. ***Lava plain or lava plateau*** is a landform formed when magma ejected lava through a fissure. ***Volcano*** is a cone-shaped hill formed when magma ejected lava through a vent. The mound of a volcano is named as ***cone*** which may consist of lava or a mixture of lava and other pyroclastic material. ***Pipe*** of a volcano is used for the channel through which lava rises and the exit of the pipe is called the ***crater***, which is usually a shallow depression. ***Pyroclastic material*** includes all the solid material ejected from volcano. It includes volcanic blocks/ bombs (partially molten solid material > 64mm in diameter), cinder/ lapilli (fragment size varies between 2-64mm in diameter), ash/ dust (fragment size < 2mm in diameter).

Check Your Progress 4

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Differentiate between magma and lava.

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2) What is pyroclastic material?

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2.8.4 Nature and Extent of Volcanoes/ Volcanism

Volcanoes greatly vary in shape and size; however all are characterized by having magma chamber beneath the surface rising through a conduit or conduits. We can classify volcanoes and volcanic eruption on the basis of nature and extent of volcanism as discussed below.

2.8.5 On the Basis of Frequency of Volcanic Eruptions

We can classify volcanic eruption on the basis of frequency into three types:

- Active
- Passive
- Dormant

Active volcanoes can erupt at any time. Active volcanoes keep erupting lava and/ or gas, even generating seismicity. Examples: Barren Island in the Andaman Islands (India), Sakurajima volcano (Japan), Mayon in Albay (Philippines), volcanoes Kilauea and Mauna Loa on the island of Hawaii. ***Dormant*** volcanoes have not been known to erupt for a long time but could erupt again in the future. Examples: Mt. Apo and Mt. Isarog (Philippines).

Extinct volcanoes have not been erupted since historic times. An extinct volcano is one which has been dormant for more than 10,000 years. Example/s: Mount Kenya in Kenya, Mount Ashitaka in Japan, Dhinodhar hills in Gujarat (India), Dhosi hill in Haryana (India).

Are volcanoes always active? No, they are active during their early stage. Volcanoes like other landforms pass through three stages in their life cycle. The early stage is the active stage as it has frequent eruptions, then becomes dormant (i.e. sleeping stage) and finally the old stage i.e. extinct stage, which is represented by long historic periods of inactivity.

2.8.6 On the Basis of Morphology/ Appearance

Volcanoes vary in size and shape with some showing perfect cone shapes while others are deep depressions (Fig. 2.1). Some have steep slopes whereas others have very gentle slopes.

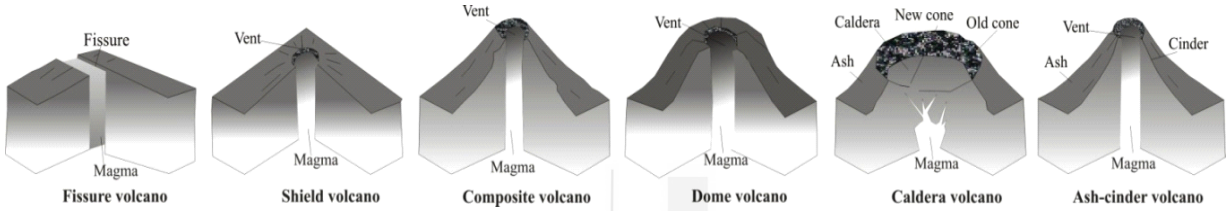

Fig. 2.1: Different types of volcanoes on the basis of morphology

Shield: These volcanoes are characterized by broad, flattened dome-like shape with the convex side up. Thus, they have low, rounded profiles. These are formed almost entirely of mafic lava flows having low viscosity that cools and form basalt. Because of this lava flows easily and gradually spread over great distance in the form of thin layers with very gentle slopes. Slopes commonly range between 2-10 degrees. These dominantly comprise basalt lava flows and are most common in the ocean basins. These pose little danger to humans because the lava flows are sufficiently slow and quiet. Example/s: Volcanoes Kilauea and Mauna Loa on the island of Hawaii.

Composite (Strato volcano): As the name suggests these consist of pyroclastic layers as well as lava flows. They are made up of intermediate magma composition (i.e. andesite). These have steep slopes (i.e. as much as 30 degrees) near their summits, but the slope reduces to less than 5 degrees towards the base. These are typical large volcanoes occurring on continents and island arcs. Volcanic mudflows called lahars are common on composite volcanoes. These volcanoes erupt regularly and sometimes very violently. Example/s: Fuji (Japan), Colima (Mexico), Narcondom and Barren Island in the Andaman Islands (India), Mayon volcano in the Philippines.

Lava domes: They are also known as volcanic domes or plug domes. Lava domes are viscous bulbous masses of lava, dominantly consisting of felsic magma (occasionally may comprise intermediate magma). These form steep sided mountains. Lava domes are one of the most dangerous and destructive because they erupt violently and explosively. Examples: Lava domes Augustine and Mount St. Helens (USA) and Unzen volcano (Japan). Mount Pelee on the island of Martinique.

Caldera: When the volcanism is so explosive that the top of volcano is blown off and only little material builds up near the vent, then the underlying magma

chamber is partly or entirely removed. It further sinks or collapses under its own weight with time. This result in creation of a huge crater-like depression called caldera. This basin-like depression is roughly circular and several kilometers in diameter. It dominantly comprises rhyolitic magma. Caldera volcanoes are most dangerous but are uncommon. Many times calderas become sites of lakes. Examples: Yellowstone caldera in Wyoming (USA), Crater Lake caldera in Oregon (USA).

Cinder cone: These volcanoes comprise particles resembling cinders which form when pyroclastic materials that accumulates around the volcanic vent. These are small, rarely exceed 400 m high, and steep-sided conical hills. Many of these volcanoes represent final stage of volcanism and commonly form on the flanks or within calderas of huge volcanoes. For example a small cinder cone volcano, Wizard Island in Crater Lake (Oregon) is the outcome of Mount Mazama whose summit collapsed to form a caldera. Examples: Cinder cone volcanoes Eldfell (in Iceland) and Paricutin (in Mexico).

Three major types of volcanoes are Composite, Shield and Cinder Cone volcanoes. They differ from each other significantly in composition and in their overall shape. For example, shield volcanoes comprise basaltic magma and are broad with very low slopes whereas cinder cone volcanoes comprise dominantly rhyolitic magma and are small, steep-sided conical hills. In contrast, composite volcanoes comprise andesitic magma and are steep-sided near their summits but becomes very gentle towards base.

2.8.7 On the Basis of Tectonic Settings

Different types of volcanoes have been classified on the basis of their occurrence along tectonic plate margins (Fig. 2.2).

Subduction Volcano: These occur on continental margins or island arcs along subduction zones where the edge of one plate thrusts beneath another plate. They comprise 80% of active volcanoes and are most explosive and destructive in nature. Examples: Barren Island (India); Volcano Vesuvius (Italy); Circum Pacific ring like Pinatubo (Philippines), Mount Fuji (Japan), Mount St Helens (USA) are some other examples.

Rift Volcano: This is generally less explosive and occurs along divergent/ spreading plate boundaries, particularly on the ocean floor. Example/s: Volcanoes in the African Rift Valley.

Hot Spot Volcano: They are not related to tectonic plates and can occur at great distances from plate boundaries. They form above hot mantle plumes/ upwellings which rise due to convective processes operating within the Earth's mantle. These occur in both oceanic and continental regions. Example: Volcanoes of Hawaii and Yellowstone in USA.

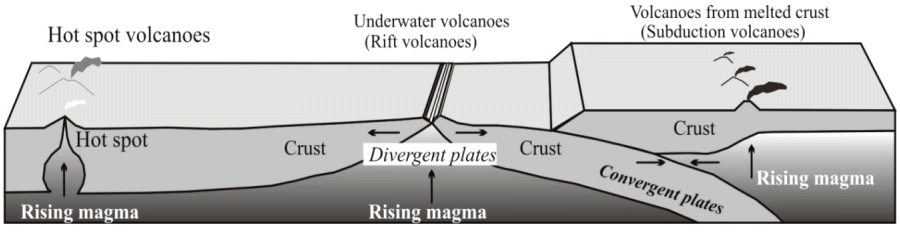

Fig. 2.2: Volcanoes on the basis of tectonic setting

2.8.8 On the Basis of Volcanic Eruption Style/ Strength

The explosive and effusive nature of a volcanic eruption also depends on how easily magma can flow and the amount of trapped gas. They can be grouped into two:

Destructive/Explosive: Gas driven eruptions are explosive which propel magma and tephra. Large amounts of water and carbon dioxide are dissolved in magma causing it to behave in a similar way to gas expanding in fizzy drinks, which forms bubbles and escapes after opening. As magma rises quickly through the Earth's crust, gas bubbles form and expand up to 1000 times their original size. They are characterised by voluminous lava flows and the magma is sticky (less fluid) with lots of gases. Extreme violent eruptions eject pyroclastics. Heavy particles settle near crater whereas lighter particles can be deposited hundreds of miles away by the action of wind. Examples: Climatic eruption of Pinatubo (Philippines) in 1991.

Non-destructive/Effusive: These form quiet emissions of lava. Such types of eruptions are characterized by lava outpouring without significant explosion due to lesser quantities of gases and so are more fluid. Example/s: Kilauea, Hawaii.

Can volcanic eruptions be measured?

Volcano Explosivity Index (VEI) is used to measure strength of volcanic eruptions which is a simple descriptive index ranging from zero to eight. The volume of material erupted with the height of an eruption plume/ column and the duration of the eruption are considered irrespective of fatalities and property damage.

2.8.9 On the Basis of Different Mechanisms of Eruptions

There are three different major mechanisms through which volcanic eruptions arise.

Magmatic eruptions are the most well documented which are driven by the decompression of gas within magma.

Phreatomagmatic eruptions are driven by the compression of gas within magma. In other words, thermal contraction from due to chilling process on contact with water cause these types of volcanic eruptions.

Phreatic eruptions are driven by superheating of steam when contacted with magma. Several subtypes of these major eruptions include Icelandic, Hawaiian, Strombolian, Vulcanian, Vesuvian, Kratatoan, Pelean, Plinian eruptions which are shown in Figure 2.3.

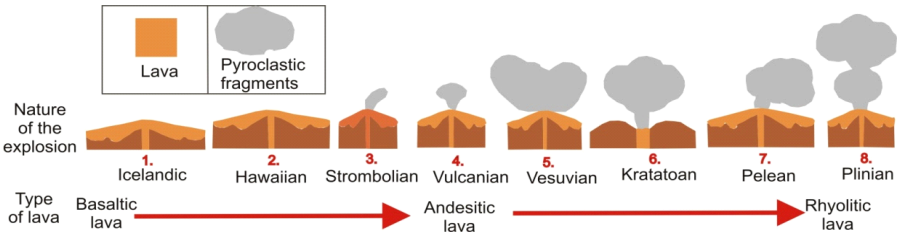

Fig. 2.3: Various subtypes of volcanic eruptions

Chemically, magmas are further subdivided which greatly influences volcanic eruptions: basaltic magmas are rich in elements such as Mg, Ca and Fe with about 50% silica and rhyolitic magmas are are rich in alkali elements such as Na, K and as much as 75% silica. There are many other magma types intermediate between basaltic magma and rhyolitic magma, the most common being andesitic magmas. Basaltic magmas are less viscous compared to andesitic and rhyolitic magmas.

Check Your Progress 5

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Distinguish between a crater and a caldera.

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2) Why do some volcanoes erupt violently?

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2.8.10 Causes of Volcanism

In simplest way, scientists explain that movement of plates actually causes earthquakes and volcanoes/ volcanism. However, for a layman to understand what actually causes a volcano to form or volcanism to take place, think of a chimney of fireplace/ furnace. The chimney acts a favourable passage which allows smoke out of the house due to energy source below. In the case of a volcano, chimneys are the zones of structural weakness/ fissures/ conduits and hot magma chamber inside Earth's mantle is the fireplace/ furnace. Therefore, presence of a magma chamber or molten rock reservoir is the basic requisite for the origin of volcanoes. Now question arises that from where comes the energy for these rocks to remain molten and in constant flux inside the Earth. Deep interior the Earth, various radioactive substances generate a lot of heat through varied chemical reactions and therefore keep the molten/ semi-molten material (i.e. magma) in constant flux. Also, this magma is under sufficiently high pressure and the various gases create outward pressure. This when combined with the friction of the moving tectonic plates and even the crust of the Earth results in rising of the magma from the mantle to the Earth's surface causing volcanic eruptions. Intensity of volcanic eruption depends on the composition, buoyancy and viscosity of the magma as well as pressure from the gases in the magma. The erupted material can be liquid rock, gas, ash and/ or cinders which gives rise to different types of volcanoes and volcanism as already been discussed. The three important ways by which magma rises to the surface and causes volcanism are along divergent plate boundaries, convergent plate boundaries and intraplate/ hot spot volcanism. Magma rises to fill up the space between diverging tectonic plates (i.e. tectonic plates which slowly move away from each other). This commonly forms underwater/ sea-

floor volcanoes which are called rift volcanoes and are generally less explosive. Magma also rises when tectonic plates move toward each other or along convergent plate boundaries. This forms subduction volcanoes which are the most explosive in nature. Another way that magma rises is over hot spots. As the name sounds- hot spots are hot areas inside Earth. These areas heat up magma because of which it becomes less dense and therefore rises up.

Check Your Progress 6

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Are the causes of volcanism related to earthquakes?

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2.9 GEOGRAPHIC DISTRIBUTION OF VOLCANOES

There are about 1500 potentially active volcanoes in the world which have been erupted in the last 10,000 years. The distribution of these volcanoes is such that they are located on or near tectonic plate boundaries, particularly convergent (i.e. destructive) and divergent (i.e. constructive) plate boundaries. Active volcanoes commonly occur close to the major tectonic plate boundaries. Following are the major areas of active volcanoes:

i. Circum Pacific region around the Pacific Ocean (also known as 'Ring of Fire')

ii. Southern Europe

iii. Along Mid Atlantic Ridge

iv. East Coast of Africa

However, majority of the world's active volcanoes occur in well defined belts rather than random occurrence. Majority of active volcanoes are located in and around the Pacific Ocean and others are in the Mediterranean belt across the Mediterranean Sea, Alpine-Himalayan belt and in the Atlantic and Indian Oceans.

The circum-Pacific belt is known as the 'Ring of Fire' because of the largest number, more than 60%, of active volcanoes. It includes volcanoes in the Andes of South America; volcanoes in the Alaska; volcanoes of Central America, Mexico, and Cascade Range of North America; volcanoes in Japan as well as those of Philippines, Indonesia and New Zealand.

The Mediterranean belt comprises the second region of active volcanoes. The Italian volcanoes like Mounts Etna and Vesuvius as well as the Greek volcano Santorini in this belt comprise 20% of all active volcanism.

The African continent occupies third place having active volcano on the west coast, an extinct one in Mount Kilimanjaro (Tanzania) and several others in the rift valley belt (such as Nyiragongo in Zaire and Erta Ale in Ethiopia) passing through the Red Sea and extending up to Palestine. However except circum-Pacific and Mediterranean belts, all the remaining active volcanoes occur dominantly at or near mid-oceanic ridges or on the extensions of these ridges on continents/ land. These largely include the Mid-Atlantic Ridge (which is the longest of all mid-oceanic ridges located nearly in the centre of the Atlantic Ocean basin) and East Pacific Rise.

2.9.1 Volcanoes of India

The Indian plate separated from the Gondwanaland and later collided with the Eurasian plate at about 50 Ma ago to form the Himalayan mountain belt. Deccan trap volcanism took place about 66 Ma ago by the reunion hotspot whereas subduction volcanism resulted in the formation of volcanoes in the Andaman Islands of India. Following are the major volcanoes of India:

Barren Island volcano is located in the Andaman and Nicobar Islands. It was formed due to subduction of the Indian Plate under the Burmese Plate along the Andaman Trench. It is a kind of active, stratovolcano with summit elevation of about 350m. Recent eruptions (i.e. February 17, 2017) have been reported at Barren Island volcano.

Narcondom volcano is located in the Andaman and Nicobar Islands (India) and is a kind of andesitic, dormant, stratovolcano with summit elevation of about 710m.

Barren 1 Volcano is an active mud volcano located in the Baratang Island of Middle Andaman

Andaman Islands with summit elevation of about 76m.

Deccan Traps are located on the Deccan Plateau in the west-central India and represents ~66 Ma ago volcanic eruption. It is considered to be an outcome of deep mantle plume and consists of multiple layers of flood basalt lava flows.

Dhinodhar Hills are considered to consist of an extinct volcano located in Gujarat (India) with summit elevation of about 386m.

Dhosi Hill is considered to consist of an extinct volcano located in the north-west end of Aravalli mountain range on the borders of Haryana and Rajasthan states of India, with maximum summit elevation of 1170m.

Check Your Progress 7

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Which country has the most active volcanoes?

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2) Are there volcanoes elsewhere in our solar system?

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2.10 VOLCANISM AND CLIMATE

Volcanism directly or indirectly affects Earth's climate at regional and/ or global scale. It can significantly produce both long-term and short-term climatic changes. Indeed it is considered as one of the important natural factor responsible for climate change at various timescales. For example, after the eruption of Mount Pinatubo in 1991 average global temperatures dropped to about a degree Fahrenheit for almost two years. Volcanism drastically changes gaseous composition of the atmosphere resulting in increase in temperature of the atmosphere and blocking solar radiation resulting in a decrease in temperature. Volcanism brings primary and secondary climatic hazards that must be identified and assessed accordingly. The change in climate ranges from ice age, global warming, and fire to raining mud. It not only affects the lower atmosphere (i.e. troposphere) but also the upper atmosphere (i.e. stratosphere) because large volcanic eruptions can significantly release ozone-depleting chemicals, particularly by injecting sulfur gases in to the stratosphere. Even though volcanoes and volcanic chains occur at specific places on Earth, their effects are widely distributed because gases, ash, and dust particles released easily spread into the atmosphere. Further, volcanic eruptions in the tropical belt can have a dominant effect on the climate in both hemispheres due to specific atmospheric circulation patterns. In contrary, volcanic eruptions occurring within mid or high latitudes only have impact on climate of the hemisphere they are within.

In general, three major types of material injected through volcanism result in specific changes in climate. Three major types of material include: particles of ash or dust, sulfur and greenhouse gases.

Particles of Ash or Dust: Explosive volcanic eruptions inject ash and tephra into the atmosphere resulting in darkness of the atmosphere and cause temporary cooling. Falling volcanic ash accompanied with rainfall leads to raining mud. Huge concentration of volcanic ash into the atmosphere can be transported by prevailing winds hundreds to thousands of kilometers. This airborne ash in the atmosphere is one of the major hazards in civil aviation. The size and concentration of ash particles control the intensity and duration of cooling. Sand grain-size ash particles stay closer to the volcano and have little effect on the climate because they remain into the atmosphere for only few minutes as they fall out of the air quickly. Tiny dust-size ash particles usually reach lower moist atmosphere and stay there for hours to days forming ash cloud and cause darkness and cooling beneath. These particles are washed out of the atmosphere with rainfall. However, tiny ash particles travel faster, reach the dry upper atmosphere, the stratosphere and remain there for months. They significantly affect climate as they block sunlight for longer duration, thereby causing cooling over large regions of Earth.

Radar is the main navigation aid for aircraft. However volcanic ash is not visible by radar thereby damaging aircraft engines and therefore the volcanic ash clouds pose major hazard in aviation.

Sulfur: Volcanic eruptions can also release large amounts of sulfur and compounds like sulfur dioxide or sulfur oxides which are by far much more effective in cooling of climate than the ash particles. Sulfur dioxide released from volcanic eruptions easily moves in to stratosphere and there combines with water to form a haze of tiny droplets of sulphuric acid (aerosols). These tiny droplets cause cooling of the Earth's surface by reflecting larger percent of incoming solar radiation. These sulfur hazes eventually grow larger from tiny droplets and fall back to the Earth's surface; however this takes years to happen as the stratosphere lacks sufficient moisture. It is believed that global cooling happened after Pinatubo and Tambora volcanic eruptions was due to these sulfur hazes.

Greenhouse gases: Volcanic eruptions emit large amounts of greenhouse gases such as carbon dioxide and water vapor which could cause a temporary warming in climate. Global amounts of these gases do not very much change even after large volcanic eruptions because the atmosphere already comprises larger concentration of water and carbon dioxide. These have much significant indirect effects like larger amounts of water vapor bring intense rainfall. Likewise, larger concentration of carbon dioxide either readily dissolves in the ocean or is absorbed by plants leading to greater plant cover. Nevertheless, there have been times in Earth's history which records increased carbon dioxide levels in the atmosphere due to intense volcanism triggered global warming. For example, multiple giant volcanic eruptions such as flood basalts over thousands to millions of years would cause significant global warming due to greater release of carbon dioxide in the atmosphere.

Check Your Progress 8

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Do volcanic eruptions cause ozone depletion?

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2.11 EFFECTS OF VOLCANIC ERUPTIONS

Volcanic eruptions are considered as one of the Earth's great natural disasters. Many powerful eruptions not only change Earth's climate at varied timescales but also pose threat to environment and health of exposed living beings as well as deterioration of social and economic conditions. Indeed, volcanic eruptions result in a wide range of health and occupational impacts. At least 500 million people worldwide live within exposure range of an active volcano. Further, atmospheric winds result in dispersion of volcanic gases and materials to areas hundreds or thousands of kilometers away from the place of volcanic activity. Airborne ash is a major hazard for aviation. Volcanic eruptions eject not only magma and steam (H_2O) but also various other gases in to the atmosphere like CO_2, CO, SO_2, H_2S, HCl, H_2, CS, CS_2, CH_4, HBr, HF along-

with heavy metals as well as various other organic compounds. The hazardous effects of volcanic eruptions depend on the distance from volcano, magma viscosity and composition particularly gas concentrations. Volcanic hazards like pyroclastic flows, earthquakes, mud flows/ lahars, gases and steam, blasts of air and tsunamis occur in the close vicinity of volcanoes. Whereas effects of toxic volcanic gases and ashes create problems of the respiratory system, skin and eyes as well as psychological effects, injuries, water availability and pollution, transport and communication problems, waste disposal issues, collapse of buildings and power outage are some of the distant volcanic hazards. Further effects are abrupt changes in weather conditions, crop and vegetation damages, and destruction of other means of livelihood. Broadly, volcanic hazards can be divided into primary and secondary hazards. Primary hazards are the direct result of eruption, for example lava flows, lava bombs (tephra), pyroclastic flows (nuee ardentes), ash clouds and poisonous gases whereas secondary hazards are those which have been caused due to primary hazards, for example acid rains, lahars, fires and climate change. All these hazards are discussed briefly in Table 2.1.

Table 2.1: Various volcanic hazards (after Hansell et al., 2006)

Hazard type	Brief description	Potential health effects	Example
Acid rain	Rain becomes acidic while falling through the volcanic gas and acid particle emissions and may dissolve metal roofs	Irritant to eyes, skin. Secondary effects on vegetation, property and water quality. Rainwater collected from metal roofs may be contaminated with metals such as lead.	Masaya, Nicaragua which has been degassing since 1986 till present.
Ash and tephra	Ash is a collective term for fine pyroclasts (solid frangments< 2mm in diameter, ejected from volcanoes). Tephra is a collective term for solid fragments such as ash and pumice ejected from volcanoes that have fallen to ground from eruption clouds.	Airborne ash–respiratory and cardio-vascular hazard (asthama, bronchitis, pneumoconiosis), irritant to eyes and skin. Ash falls – can lead to property damage, contaminate water (eg. With fluorine carried on ash or by causing turbidity), contaminate and bury agricultural land. Mesothelioma risk reported from weathered volcanic ash in certain areas.	Soufriere Hills, Montserrat 1995 to present. Mount St. Helens, USA, 1980 Laki, Iceland, 1783-84. Biancavilla, Eastern Sicily
Ballistics (bombs and blocks)	Rocks or lava lumps ejected during major and minor eruptions.	Impact injuries, burns. Secondary property damage.	Galeras, Columbia, 1993.
Global Climate Change	Massive eruptions cause release of acid aerosols and fine ash into stratosphere that block sunlight and are associated with global and may accelerate ozone loss.	Indirect impact via reduced crop yield.	Laki fissure eruption, Iceland, 1783-84. Krakatau eruption Indonesia, 1883.

Earthquakes	Earthquakes can be associated with volcanic activity.	Property damage resulting in impact injuries. May cause Tsunami.	El Chichon, Mexico, 1982.
Gas and acid particle emissions	Emissions of SO_2, sulphuric acid, aerosol, HCl, HF, CO_2, H_2S, radon and other gases may occur in association with eruptions and through degassing activity.	Acid gases: bronchoconstriction, aggravation of respiratory disease, eye and skin irritation	Acid gas effects: occupational study of park rangers in Hawaii Volcanoes National Park.
	Soil gas emissions of gases such as CO_2, H_2S and radon are common in many volcanic areas (radon emissions are problematic only in houses with ground gas diffusion where CO_2 forms a carrier gas).	CO_2: asphyxiation, secondary effects on vegetation, eg. Areas of tree kill. H_2S: asphyxiation, low level long term population exposures potentially impacting on respiratory, cardio-vascular and nervous system. Radon: lung cancer risk with long term exposure.	CO_2: Sinila volcano, Dieng Plateau, Indonesia, 1979. H_2S: death in a geothermal power plant. No specific studies in relation to volcanic exposures.
Ground deformation	Subsidence and ground cracking. Meltwater flood resulting from a volcanic eruption under a glacier.	Secondary effects on property and roads. Those of flooding, drowning and impact injuries. Secondary effects on property and agricultural land.	Mount Etna, Italy, 2001.
Landslides, debris avalanches and lahars	Debris avalanches are fast moving, gravity driven currents of partially or fully water saturated volcanic debris. If the debris flow consists of a significant fraction of clay sized particles it is called a lahar or mudflow. May be triggered by eruptions, gravity, earthquakes and heavy rain.	Drowning impact injuries. Secondary impact to property and agricultural land.	Nevado del Ruiz/ Armero, Columbia, 1985. Mount St. Helens, USA, 1980
Lava flows	Flows of molten rock. May emit acidic gases. Steam explosions may result from contact with groundwater.	Usually relatively slow moving, therefore allowing evacuation. Thermal injuries. May cause forest and property fires. Methane explosions can occur as lava moves over vegetation.	Nyiragongo, Congo, 1977 and 2002.
Laze	HCl gas clouds resulting from lava entering sea water.	Chemical conjunctivitis and respiratory effects.	Lava from Puu'Oo vent, Hawaii.

Lightening in volcanic clouds	Common in volcanic ash clouds related to eruptions.	Electrocution.	Paricutin, Mexico, 1943.
Pyroclastic density currents	Flows of hot gas, ash and rocks resulting from the effects of gravity on a volcanic eruption cloud.	Thermal injury and death. A high death: injury ratio of 10: 1 among exposed individuals.	Vesuvius, Italy AD 79. The major cause of death in Herculaneum, Pompeii, Mont Pelee, Martinique, 1902.
Tsunami	Tidal wave from volcanic debris avalanches into oceans or lakes or occasionally volcanogenic earthquakes.	Drowning and injuries from property damage.	Krakatau eruption Indonesia, 1883.

Check Your Progress 9

Note: a) Write your answer in about 50 words.

b) Check your progress with possible answers given at the end of the unit.

1) Is volcanism always hostile/ destructive?

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2) Which proved the most destructive volcano to human beings in known history?

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2.12 LET US SUM UP

Seismology is a field and laboratory based science of earthquakes. The earthquakes and the other natural hazards triggered by them such as tsunamis, landslides etc. which cause destruction and devastation of human life and property. The advancement in the field of seismology has led to many new concepts to explain the causes of earthquakes, contrary to the old beliefs and myths which were prevalent until 18th century. The better networking of seismic observatories, mammoth data on seismic events (generated through state-of-the-art seismographs) of the past and present has led to explain the vulnerable location on earth which are prone to seismicity. The plate tectonics theory has been instrumental in delineating earthquake prone zones on earth. The plate boundaries which experience stress conditions due to movement of plates are the most vulnerable sites for earthquakes. To date, it is not possible to predict with certainty the location and time of an earthquake in spite of the enormous advancement in understanding of seismic activity around the globe. The

governments of earthquake prone countries have implemented various measures to mitigate the effects of earthquake destruction and have launched programmes to educate people to deal with such natural calamities.

Volcanoes are always a subject of fascination because they are one of the most dynamic geological features, believed to have created all the Earth's oceans and mountains. Further, they have the most varied health, occupation and environment hazards. Volcanoes greatly vary in shape, size, nature and extent of volcanism and so are divided in to a number of types, however all consists of a magma chamber beneath the surface. Depending on the magma composition and percentage of gases in the magma, their eruptions vary. Presence of magma reservoir is the basic requisite for the origin of volcanoes and friction of moving tectonic plates and even the crust of the Earth results in rising of magma from the mantle to the Earth's surface causing volcanism. The energy for the same is from various radioactive substances as well as high pressure deep inside the Earth.

There are about 1500 potentially active volcanoes in the world and the distribution of these volcanoes is such that they are located on or near tectonic plate boundaries, particularly convergent (i.e. destructive) and divergent (i.e. constructive) plate boundaries. The circum-Pacific belt is known as the 'Ring of Fire' because of the largest number, more than 60%, of active volcanoes. Volcanism directly or indirectly affects Earth's climate at regional and/ or global scale. It can significantly produce climatic changes for both long-term and short-term periods of time. Three major types of material injected through volcanism are particles of ash or dust, sulfur and greenhouse gases which result in specific changes in climate. The change in climate ranges from ice age, global warming, and fire to raining mud. It not only affects the lower atmosphere (i.e. troposphere) but also the upper atmosphere (i.e. stratosphere) because large volcanic eruptions can significantly release ozone-depleting chemicals, particularly by injecting sulfur gases in to the stratosphere.

Volcanic hazards can be divided in to primary and secondary hazards. The hazardous effects of volcanic eruptions depend on the distance from volcano, magma viscosity and composition particularly gas concentrations. Volcanic hazards like pyroclastic flows, earthquakes, mud flows/ lahars, gases and steam, blasts of air and tsunamis occur in the close vicinity of volcanoes. Whereas effects of toxic volcanic gases and ashes create problems of the respiratory system, skin and eyes as well as psychological effects, injuries, water availability and pollution, transport and communication problems, waste disposal issues, collapse of buildings and power outage are some of the distant volcanic hazards. Further effects are abrupt changes in weather conditions, crop and vegetation damages, and destruction of other means of livelihood.

2.13 KEY WORDS

Seismology : Science of earthquakes by studying seismic waves.

Active fault : A fault that is likely to slip again and cause an earthquake. Faults are termed active faults if they have moved one or more times in the last 10,000 years.

Tsunamis : Sea waves created by earthquakes, volcanic eruptions and landslides. Tsunamis of great amplitude can be highly destructive if they reach coastal regions.

Liquefaction : A process by which water-saturated sand, soil act as a fluid caused by an earthquake shaking.

Seismogram : Record by a seismograph in response to ground motions produced by seismic waves produced by an earthquake, natural or artificial explosion.

Lava domes : They are also known as volcanic domes or plug domes. Lava domes are viscous bulbous masses of lava, dominantly consisting of felsic magma.

Cinder cone : These volcanoes comprise particles resembling cinders which form when pyroclastic materials that accumulates around the volcanic vent. These are small, rarely exceed 400 m high, and steep-sided conical hills.

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2.15 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answers should include the following points:

1. To answer this question, you have to read historic account on earthquakes briefly described by Agnew, 2002. The paper can be downloaded and you will enjoy reading the text about how this science of seismology evolved. The earlier notions were based on movement of giant creature beneath the earth's surface etc.

2. Plate tectonics theory propounded by Wilson in 1965.

3. Epicentre is a location point on the surface of the earth directly above focus which is a point inside the earth where an earthquake actually initiates in form of seismic waves. You can draw a simple sketch from section 1.3.

4. You have to write about your experience during an earthquake. Write about your awareness during an earthquake. If you walk towards an open ground and alert your friends etc. Write down your about your initial reaction and how mentally prepared you are for an earthquake.

5. Three types: Convergent; Divergent and Transform. Read section 1.2 carefully and write about the movement of plates with respect to each other. Also give example for each boundary type. Draw simple sketches to show movement of plates with respect to each other. Take help from USGS sites and list the major plates. After reading section 1.2 you will be able to answer the second part that is the relationship between plate margins and earthquakes!

Answers to Check Your Progress 2

Your answers should include the following points:

1. An instrument to measure ground movement in different directions and record the arrival of seismic waves created by earthquakes, volcanic eruptions and artificial explosions.

2. Surface waves are the most destructive waves.

3. Richter magnitude is based on ground movement whereas moment magnitude is based on the attributes of the fault itself i.e. area of the fault, slip and the nature of the rocks which suffered faulting. Read section 1.4 to answer this question.

4. Seismic waves (P, S and surface waves). Read sections 1.2 and 1.3 to answer this question. A table in the section on seismic waves will also help you with the answer.

Answers to Check Your Progress 3

Your answers should include the following points:

1. During ground shaking caused by earthquakes the sand and silt saturated with water can behave as liquids and start to flow just like liquids.
2. Tohoku earthquake of Japan in 2011 and Sumatra earthquake of 2004.
3. Read sections 1.5 and 1.6 to answer this question. Take help from media reports and think of destruction that can be caused in coastal areas to answer this question.
4. First you should know how Himalayas were formed. Think of Indian plate's movement with respect to the Eurasian plate. If a mountainous regions experiences an earthquake it can also lead to landslides, avalanches and mass movement. In the light of above facts try to answer this question. Try to give facts of the recent 2015 Nepal earthquake.

Answers to Check Your Progress 4

Your answers should include the following points:

1. Magma is the molten rock within the Earth's crust whereas when the same molten rock erupts or comes on Earth's surface it is called lava.
2. Tephra is a general term for any fragmentary material originally ejected by volcanoes, while ash refers to tephra particles less than 2 mm in diameter.

Answers to Check Your Progress 5

Your answers should include the following points:

1. A Crater is a circular depression at the summit of volcanoes or on their flanks which forms due to explosion or collapse. Craters are generally less than 1 Km across whereas calderas are larger than 1 Km depressions.
2. Some volcanoes erupt violently because of the presence of large percentage of gases in their magma. This magma with gases is under great pressure and it rises, the sudden decrease in pressure causes the gases to expand very rapidly which results in violent explosions.

Answers to Check Your Progress 6

Your answers should include the following points:

1. Some but not in all cases the two phenomena are directly related to each other. Though most volcanoes and earthquakes are along the edges of tectonic plates (e.g. along subduction zones of 'Ring of Fire'), however the former is caused by movement of magma whereas the latter by the interaction of plates.

Answers to Check Your Progress 7

Your answers should include the following points:

1. Indonesia comprises a chain of more than 13,000 islands, having 147 volcanoes and out of which 76 are still active making it the world's most active volcano country.

2. Yes there are lots of volcanoes on other planets. According to NASA, some places in our solar system have active volcanoes erupting right now, for example moons of Saturn, Jupiter and Neptune have ongoing eruptions. Venus and Mars are covered with extinct volcanoes.

Answers to Check Your Progress 8

Your answers should include the following points:

1. Scientists have observed that although volcanic gases from large volcanic eruptions do not play a direct role in destroying ozone and their effects are short-lived (i.e. a few years) but they do play an indirect role in accelerating ozone destruction. They enhance chlorine-driven depletion by providing a surface suitable for such chemical reactions. They account for about 3% of chlorine in the stratosphere and if the concentrations of hydrogen chloride released from them reach high levels (about 15-20 ppb by volume) can cause drastic ozone depletion.

Answers to Check Your Progress 9

Your answers should include the following points:

1. No, not always because in many volcanic environments, lavas weather to fertile soils especially in the equatorial/ humid tropical regions; many results in formation of precious stones and minerals; water resources are commonly plentiful; formation of hot springs and geysers can be used for geothermal systems.

2. The most destructive volcano to human beings, in the world is Mount Tambora (Indonesia). The eruption was 100 times more powerful than Mount Vesuvius and killed 100,000 people along the way.

UNIT 3 FLOODS AND LANDSLIDES

Structure

3.0 INTRODUCTION

This unit introduces you to the natural phenomena of floods, droughts and landslides. These are natural processes and affect human life and property. They can be due to natural or anthropogenic factors. Torrential rains, flash floods and landslides have killed many people. They also have ravaged farms, pasture and damaged buildings. These hazards have forced people to migrate. The science of forecasting and prediction of the hazards is to be understood. Landslides cause hazards that are accidental and dynamic. They occur in mountainous regions and on slopes. Climate controls the form of the precipitation and snowmelt. These changes include the frequency, intensity, magnitude, and seasonality including the occurrence of cyclones. They are the significant external drivers for these hazardous events. Land use changes, field drainage, changes in forest covers can multiply runoff and floods. Further, a decrease in vegetation enhances landslide activity. Take an example of Southern Europe, where there is a reported increase in shallow landslides. This is due to soil erosion and the abandonment of the lands in the terraced slopes. In this unit, you will also learn about the hydrological cycle, the different causes of

floods and the types of floods. Further, you will be able to distinguish floods and droughts, along with the different stages of drought. The unit will finally deal with landslides, its causes and effects.

3.1 OBJECTIVES

After reading this unit, you should be able to:

- describe the nature of floods;
- understand the different types of droughts; and
- analyze the causes and effects of landslides.

3.2 FLOODS

Dear Learners, let us now learn about floods in the following paragraphs.

3.2.1 Overview of Floods

Water is in constant motion in the earth in various forms powered by the solar energy. This cycle is called hydrological cycle. Even small additional amounts of precipitation more than the average amounts can result in streams to run out of its confines. This leads to flooding. Rivers are sources of water for consumption. It is of utility to agriculture, and industry. Transportation routes, energy, and means of waste disposal are some other services. Also, the topography of the stream valleys is relatively flat, suitable for constructions. Throughout the history of human civilizations, cities have grown along streams. Human populations that live along and near the streams by default face the risk of floods as the flow of water in streams is not constant. When large amounts of water enter into the streams, it can cause flooding. Some of the causes for flooding can be that during heavy rainfall the rivers overflow its bank or when the ocean waves come onshore. Flooding can also occur when rapid snow melt occurs or due to dam/ levees failures. Flooding can range from a few inches of water to covering a house rooftop. Floods that occur in a very short time are called flash floods. A flood occurs when the stream overflows its bank. This submerges surrounding areas. Flood plain is that area which is flat or nearly flat land adjacent to a stream or river. It experiences occasional or periodic flooding. (Figure 3.1, 3.2) This consists of floodway (stream channel and adjacent areas that carry flood flows) and the flood fringe (areas covered by the flood which do not experience a strong current).

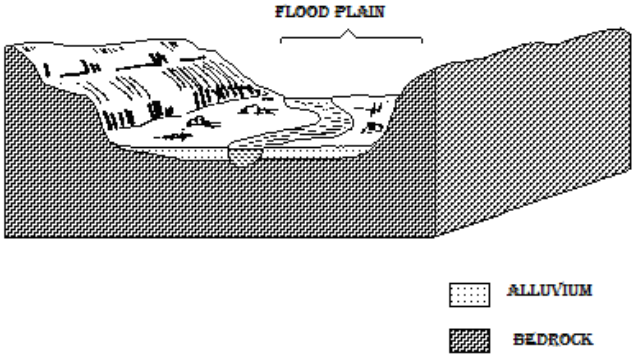

Fig.3.1: Flood Plain

Source: Baskar S and Baskar R, 2009. Natural Disasters.

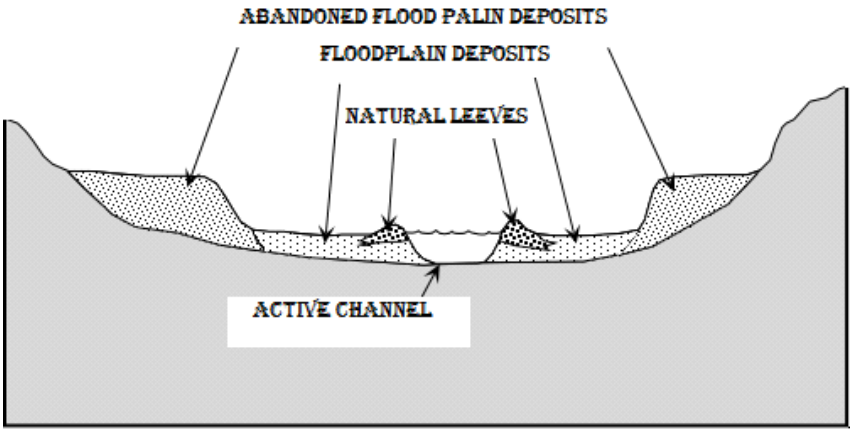

Fig. 3.2 Cross Section of a Flood Plain

Source: Baskar S and Baskar R, 2009. Natural Disasters.

Floods have caused several hazards, more damaging especially in the less developed and developing countries. High population densities, absence of land use planning, and reduced flood control measures, lack of early warning systems are cited as some of the reasons. One classic example of a country that is most vulnerable to flood disasters is Bangladesh. Floods and tropical cyclones have caused approximately 200,000 deaths in 1991.

In the developed countries, on a relative scale the flood hazard causing loss of life is lesser. This is due to the existence of proper flood control structures, land use planning that do not allow the habitation of vulnerable areas, and also emergency preparedness. Additionally, advanced engineering techniques such as levees, bunds, reservoirs, and weirs are also used to prevent and reduce the impact of flooding. Sea walls and artificial beach nourishment have been constructed to prevent coastal flooding in several cities in Europe. For example, in the city of London a huge mechanical barrier, the Thames barrier, across the River Thames has been constructed to prevent flooding. This barrier is raised when the water level reaches a certain point. Another interesting example is Venice, which has a similar arrangement, although it is already unable to cope with very high tides. Needless to mention even in these developed countries, there are always reports of property damage and disruption of life. Despite the availability of flood control structures and proper land use planning, floods still do occur. This disrupts normal life.

Because of the topography, areas in the low-lying coastal areas and rivers are at the greatest threat from flood disasters. Heavy rain can result in increase in the water level of streams and rivers. The people living near the coastal regions also are at risk from floods.

Case Study: Kerala Floods, 2018: Calamity of a severe nature

Kerala in August, 2018 received heavy monsoon rainfall. This was about 256% more than the usual rainfall in the state. Further, approximately 65% of the dams in the state were opened. All five overflow gates of the Idukki Dam were opened simultaneously. The secondary effects of heavy rains were severe with landslides in some regions. It was the worst flood in Kerala. The Government of India classified it as a Level 3 Calamity, or "calamity of a severe nature". About one-sixth of the total

populations of the state were directly affected by the floods. The rescue and relief operations were coordinated by the National Crisis Management Committee. Some reasons for the disaster of this scale are because for the first time, 35 of its 54 dams were opened. Added to this, the sudden release of water from the Mullaperiyar Dam by the Tamil Nadu government aggravated the situation. Another factor could be due to the discharge of excess water from 80 reservoirs across the state.

Source: https://www.downtoearth.org.in/news/kerala-floods-reveal-the-horror-that-is-climate-change-61435

3.2.2 Causes of Floods

Floods have been occurring throughout geological history of the earth. It will occur as long as the water cycling occurs. Precipitation is one of the main sources for water for streams. For example, in drainage basins, the precipitation amount falling varies on a daily, yearly and centennial basis. Thus, from a geological point of view, floods are a natural outcome of stream flow in a dyanamic environment.

a) ***Precipitation*:** Weather patterns determine and control the amount and location of precipitation. This includes rainfall and snow. This can vary from area to area. Overall, the water cycle is a balanced system. Though water flowing into one part of the cycle is balanced by water flowing back to the ocean, sometimes the amount flowing in to one area is greater than the capacity of the system to hold it within natural confines. This results in a flood. Various factors along with exceptional precipitation can also lead to flooding. For example, heavy snow melts, water saturated ground, unusually high tides, and drainage modifications when combined with heavy rain can result in flooding.

b) ***Coastal Flooding:*** Coastlines get subjected to flooding as a direct result of tsunamis, hurricanes and unusually high tides. Even long term processes like subsidence and rising sea level as a result of global warming can lead to the encroachment of the sea on to the land.

c) ***Dam and Levee Failures:*** Dams can be either natural or man-made. Natural dams are created by natural processes. For example, volcanic events (lava flows and pyroclastic flows), landslides, or blockage by ice. Dams are constructed or single or multiple purposes. The utility of dams is for storing water, electrical power generation and to act as flood control structures. All dams can fail. This can cause sudden release of water into the downstream drainage. Some examples of dam and levee failures include that resulting in flooding downstream include:

- The St. Francis Dam, near Saugus, California, failed in 1929 killing 450 people.
- The Johnstown, Pennsylvania dam, built of earthen material (soil and rock) collapsed after a period of heavy rainfall in 1889. 2,200 people were killed by the flood.
- The Vaiont Dam in Italy did not fail in 1963, but the landslides that moved into the reservoir behind the dam caused water to overtop the dam killing over 3,000 people.
- During the Hurricane Katrina in New Orleans (August 2005), levee systems designed to prevent flooding failed and lead to catastrophic flooding and loss of life.

d) ***Cloudbursts:*** It is an extreme amount of precipitation in a short period of time. It can be accompanied by hail and thunder that is capable of creating flood conditions.

3.2.3 Types of Floods

Let us now learn about the different kinds of floods and the extent of floods. Floods can be rapid or slow. It could also be classified as riverine, estuarine, coastal, catastrophic or muddy floods.

a) Riverine Floods: Heavy rains from monsoons, hurricanes and tropical depressions causes riverine floods which are slow but rapid riverine flooding is caused by intense thunderstorm.

b) Estuarine Floods: Storm force winds generate sea tidal surges which can flood estuarine areas.

c) Coastal Floods: Tsunami, hurricanes and severe sea storms are known to flood coastal areas.

d) Catastrophic Floods: Catastrophic events like earthquakes, volcanic eruptions and dam failure cause these types of floods.

e) Muddy Floods: Runoffs on croplands can result in muddy floods.

Case Study: Assam floods, 2016

The Assam floods in July 2016 were caused by large rains over the state of Assam, India. The state of Assam received around 60% more rains when compared with the rainfall in July 2015. The flooding had affected about 1.8 million people. People abandoned their households and livestock and escaped with help of homemade rafts. The rainfall resulted in flooding of various rivers. The Brahmaputra River had crossed its danger mark level in the seven districts of Lakhimpur, Dhemaji, Nagaon, Jorhat, Golaghat, Morigaon and Biswanath. It also flooded the Kaziranga National Park-famous for the Rhinos. Severe flooding affected the mobile phone networks. Power transmission in many regions of the state was out of gear. Around 200,000 hectares of farming land was affected by the floods.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. What are the causes of flooding?

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2. Describe the types of floods.

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3.3 ENVIRONMENTAL EFFECTS OF FLOODING

Let us see how the flooding affects the environment. Hazards associated with flooding can have primary or secondary or tertiary effects. Primary effects occur due to direct contact with water. Secondary effects occur because of the flooding event. They cause famine and health disease outbreaks. They can also cause disruptions in essential services. Tertiary effects include changes in the position of river channels.

3.3.1 Primary Effects

They occur as a result of immediate and direct contact with the flood waters. In this case, the velocities of the flood waters tend to be high. As discharge increases the velocity also increases.

a. Higher velocities can transport larger particles such as suspended particles, rocks and sediment. Further, large objects such as automobiles, houses and bridges can also be disrupted and transported.

b. Erosion can occur at very large scales due to floods. These erosion processes can undermine bridge structures, levees, and buildings. As a result these structures can collapse.

c. Water entering human built structures cause water damage. Even with minor flooding of homes, furniture, floors and walls are damaged. Automobiles are also affected by flooding.

d. When the flood waters retreat, sediment or a thick layer of stream deposited mud is deposited.

e. Flooding of farmlands causes damages to crops. Livestock, pets, and other animals are often carried away by floods.

f. Human beings can get drowned in the flood waters in extreme cases.

3.3.2 Secondary Effects

Secondary effects are those that occur as a consequence of the primary effects. Among the secondary effects of a flood are:

a. Drinking water supplies can get contaminated and there are health risks, if sewerage treatment plants are affected. This is more commonly observed in under developed countries.

b. Floodwaters can result in the accumulation of solid wastes and some pollutants. This can cause the secondary effects of health hazards.

c. Gas lines may leak and electrical service may be disrupted.

d. Transportation systems may be affected. It can result in the reduction of food supplies. Such food shortages have been reported to cause starvation in many under developed countries.

3.3.3 Tertiary Effects

Tertiary effects occur as a result of the long term changes that take place. They include the following:

a. Shifting of river channels may occur. New river new channels can form and the old channels may dry.

b. Sediment deposited as a result of flooding can totally devastate vast agricultural lands. The silt deposited by floodwaters is useful in increasing agricultural productivity.

c. Changes in of ecology of the area.

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. What are the primary effects of floods?

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2. What are the secondary and tertiary effects of floods?

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3.4 DROUGHTS

Unlike cyclones, tornadoes, hurricanes which tend to bring high quantities of rainfall; a drought is a period of abnormal dryness in a region. When a region experiences a noticeable deficit in water supply or rains for extended periods such as months or years, a drought occurs. A region is termed drought affected when it receives consistent below average precipitations. Intense drought can cause significant damage to the local economy. Droughts as hazards are unique in the sense that they are slow onset hazards. They may lead to secondary effects like famine. It damages the ecosystem and agriculture of the affected region.

3.4.1 Drought Consequences

It can have significant environmental, agricultural, health, socio-economic consequences. The consequences of drought vary according to vulnerability. People working on farming and agriculture migrate during drought because they do not have alternative food sources. Drought can reduce the quality of water and result in contamination. This is because the lower water flows reduce dilution of pollutants and thereby contaminate water supplies.

Do you think drought can have consequences? Let us now learn them in following paragraph.

- Decreased crop growth
- Decreased carrying capacity for livestock
- Erode the landscapes
- Dust storms
- Famine can occur as a result of low water for irrigation
- Health problems such as malnutrition and dehydration
- Habitat and ecosystem damage
- Mass migration, resulting in internal displacement
- Shortage of water for industrial users
- Disputes over natural resources, including water and food and social unrest
- Wildfires.

3.4.2 Stages of Drought

Droughts undergo three critical stages before their ultimate manifestation.

- Meteorological drought: This precedes the other kinds of drought. This occurs when there is an extended period with less than average precipitation.
- Agricultural droughts: They affect the crop production of the region. It also occurs as a result of extended periods of below average precipitation.
- Hydrological drought: This stage of drought occurs when the water reserves in aquifers, lakes and other reservoirs falls down below the statistical average.

Some Case studies: Drought in India

The Indian agriculture is dependent on the climate of India which is a favourable southwest summer monsoon. This is critical in securing water for irrigating Indian crops. In certain parts of India, the failure of the monsoons result in water shortages, resulting in below average crop yields. This is particularly true for the major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Orissa, Gujarat, and Rajasthan. In the past, droughts have periodically led to major Indian famines, including the Bengal famine of 1770, in which up to one third of the population in affected areas died; the 1876–1877 famine, in which over five million people died; and the 1899 famine, in which over 4.5 million died.

Source: https://www.deccanherald.com/national/stares-drought-rains-elude-682491.html

3.5 LANDSLIDES

Down slope movement of small stones, soil and rock fragments, even if very slow should not be underestimated. These processes can ultimately result in landslide hazards. When rocks, soils, artificial fill move downward, landslides can occur. These are also known as slope forming materials. These materials can move by the following ways: falling, toppling, sliding, spreading, or flowing. Landslides or mass wasting is the down-slope movement of regolith (loose uncemented mixture of soil and rock particles that covers the Earth's surface) due to gravity. It occurs without the help of geological agents such as water, ice, or wind. Contributory factors include soil saturation from rainfall or seepage, or human activity (i.e. vegetation removal, construction of roads, railways or buildings on steep terrain). In some cases they can also be natural hazards like earthquakes, volcanoes. Down slope displacements of regolith, rock, and soil are referred to as landslides. It can also occur under the sea, it is better to term them as mass movements. Mass movements are one of the most serious hazards in areas with steep slopes. Mass-wasting is part of a continuum of erosion processes between weathering and stream transport. Mass-wasting causes regolith to move down-slope. Sooner or later the loose particles will be picked up by another geological agent. It will eventually be moved to a site of deposition such as an ocean basin or a lake bed. In order for regolith to move in a mass wasting process, it must be on a slope, since gravity will only cause motion if the material is on a slope.

3.5.1 Causes of Landslides

When the stability of the slope changes landslides occur. The change is from a stable to an unstable condition. Such changes in slope stability may be caused due to multiple factors. They can act together or alone. They can be due to natural or anthropogenic reasons.

a) Natural causes include:

- pressure of groundwater that causes slope destabilization
- little or no vertical vegetative structure,
- absence of soil nutrients/structure
- erosion of the top of a slope by rivers or ocean waves
- weakening of a slope through saturation by snowmelt, glaciers melting, or heavy rains
- earthquakes adding loads to barely-stable slopes or earthquake-caused liquefaction destabilizing slopes volcanic eruptions

b) Human induced causes include:

- vibrations from machinery or traffic
- mine and blast activities
- certain types of earthwork which changes the slope shape
- the removal of deep-rooted vegetation that binds colluvium to bedrock
- Construction, agricultural, or forestry activities which change the amount of water which infiltrates into the soil

3.5.2 Failure of Slope

Failure of slope is a significant natural hazard. Slope failure can be defined as a downward movement of a large amount of material. They can occur suddenly in one easily recognized movement. It may also occur almost imperceptibly over a long period of several years. A slope failure is classified based on its movement and the material type being moved. It damages highways, homes, and other property. These occur due to natural events like earthquakes, heavy rainfall from thunderstorms, volcanic eruptions, floods, freezing and thawing of soil. Slope failure events and their scientific analysis have confirmed that almost any modification of a slope by people increases the risk of slope movement. This is particularly true in areas already susceptible to natural hazards.

1. Factors Leading to Slope Failures:

Regions situated in the mountainous terrains, hills and coastlines are prone to slope failures. Tectonically active regions are prone to slope failures. Earthquakes and volcanic activity in most cases accompany slope failures. Sinkholes are a common geological feature in karst landscapes, where water has dissolved underlying bedrock, typically limestone or gypsum. It causes subsidence and slope failures. Slope failures can occur in any season. But, they can be triggered by extreme weather events such as rain,

snow, or freezing and thawing of soil water. Slopes can become unstable when streams erode their banks or surf action undercuts a slope (Figure.3.3).

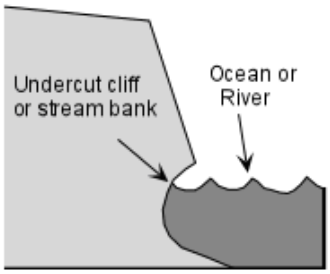

Fig. 3.3: Undercutting

Slope failures can occur nearly everywhere slopes exist. This can be triggered by weather conditions, geologic events, human modification of the landscape, or most commonly, some interaction of all of the above (Figure 3.4).

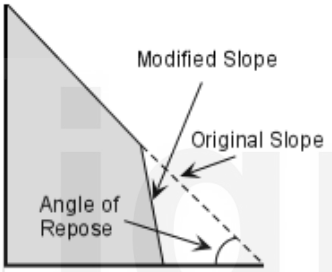

Fig. 3.4: Unstable Slopes due to Slope Modification

3.5.3 Factors that Affect Mass Movement

- ***Rate of Land Movement:*** This can be exceptionally slow, only a few centimetres per year (which can damage roads, buildings, pipelines, etc). This can also be sudden total collapse or avalanche of perhaps millions of tonnes of debris, with the potential to crush vehicles, buildings and people, or to sweep away roads, power and telephone lines.
- ***Degree of Land Movement:*** The distance travelled by landslide debris can also vary by many degrees. This may range from a few centimetres to many kilometres. It can occur when large mudflows follow river valleys.

Two types of forces combine in any type of mass movement: Driving forces that promote movement and resisting forces that deter movement. The material on the slope breaks loose and moves down slope whenever the driving forces are greater than the resisting forces.

1. Driving Forces:

i) Gravity: Steeper the slope, the greater is the tendency of materials to move down slope. Gravity is the primary driving force. It can be influenced by human activity. When a portion of a slope moves downward as a result of either, natural conditions or human activity, this process is known as slope failure.

ii) **Rock Structure:** Rock structure can be an important driving force. Rocks are far from being completely solid and most have pore spaces. These pore spaces allow water and air to infiltrate. Rocks can break along natural fractures and joints in the rock caused by stress. In all highway and building construction, engineering geologists conduct studies to determine the stability of the slopes when building highways, railways, canals, and any type of construction site. Plate tectonic movements may cause rock layers to become tilted. The slope can become unstable if they're tilted in the same direction as the slope itself.

iii) **Water:** Water is an important driving force. Its role is complex as it acts as resisting force in certain circumstances. Water increases the weight of slope material by filling previously empty pores and fractures. This promotes mass movement. For example, a sandy slope can have up to 35% pore space. After a prolonged period of rain, the pores may be completely filled, increasing the weight of the sediment. This will increase the probability for movement by gravity. Water can decreases the strength of the rock or sediment by reducing cohesion among the particles. For example, water circulating in limestone can dissolve the calcium carbonate particles, reducing cohesion of the rock. Water can also infiltrate pore space, then freeze (frost heaving), breaking the rock apart. Water can create shrink-swell clays, which are a common hazard in the construction of building foundations. In clay-rich sediments, clay-sized particles attract and absorb water molecules, causing the sediment to swell to many times its original volume. The best known of these clays is bentonite. Between rains, these clay-rich sediments can shrink and contract, forming large surface cracks that can damage any structures built on top. Finally, clays can be turned to liquid in a process called liquefaction. Quick clay is formed by this process, and can occur when saltwater ions, which normally help to hold the sediment together, are flushed out and replaced with freshwater. Solid clay-rich sediment transforms to very unstable quick clay.

2. Resisting Forces

Water can also act as a resisting force to mass movement in certain cases. In sediment pore spaces that are not completely filled, the thin film of water actually makes the particles stick together due to cohesion. Water molecules that line the pore spaces tend to hold other molecules - this attraction is called surface tension, a force that holds water together.

The complex role of water can be appreciated by taking the sand castle as an example. Without water, it is impossible to build a sand castle. With just the right amount of water, one can build a sand castle because the water creates surface tension that holds particles together. When the sand castle becomes saturated with high tide, the castle breaks apart, because the pore spaces have been completely filled with water which is now a driving force.

The angle of repose is the maximum angle on a slope to which sediment particles can be piled. Some sediment can accumulate in large volumes, yet remain stable. Some factors that affect the stability of particles on a slope include:

- **Particle Size:** larger particles maintain a steeper slope than smaller particles.
- **Particle Shape:** particles with angular edges can have a steeper slope than ones with rounded edges
- **Particle Sorting:** poorly sorted particles have all sizes represented. These can have steeper slopes because the smaller particles can fill the spaces between the larger particles.
- **Particle Moisture:** particles with some water can have a steeper slope than particles with no or too much water.

Finally, particle packing will affect the ability of sediment to move down slope. Packing describes the arrangement of particles in sediment. Cubic packing occurs when grains are aligned with their centers above one another, and represents loose sediment. Rhombohedron packing occurs when the centers of the grains of sediment are located over the spaces between the grains. This type of packing occurs in sediments that have "settled" due to shaking or sorting by water movement.

Case Study: Landslides in Uttarakahand, 2010

Tectonic activities in the Himalayas contribute to hill slope instability.Anthropogenic interventions are additional factors contributing to terrain instability. This is the reason for the increasing frequency and magnitude of landslides observed since 1970. During the month of August and September 2010, Uttarakhand Himalaya witnessed large scale slope destabilization. This was evident along the roads where widening work was in progress. The landslides killed about 220 people in the entire rainy season of 2010 and 2138 houses were partially damaged due to heavy precipitation. The cause of regional-scale landslides has been attributed to exceptionally high rainfall in the region during September. In September 2010, 336% higher rainfall was received by the area when compared with the average rainfall for the month of August and September from 2000 to 2009. There are also suggestions that inadequate consideration of geology and geomorphology during the road alignment and poor, faulty engineering techniques were additional factors responsible for the recent landslides.

3.5.4 Effects of Landslides

- ***Landslides and Water:*** **One of the** main causes of landslides is the slope saturation by water. This effect can occur in the form of intense rainfall, snowmelt, changes in ground-water levels, and water-level changes along coastlines, earth dams, and the banks of lakes, reservoirs, canals, and rivers.
- ***Land Sliding and Flooding:*** They are closely connected. Both are related to precipitation, runoff, and the saturation of ground by water. These two events often occur simultaneously in the same area. Landslides can cause overtopping of reservoirs and/or reduced capacity of reservoirs to store water. In addition, debris flows and mudflows usually occur in small, steep stream channels and often are mistaken for flood. Landslides can cause flooding by forming landslide dams that block valleys and stream

channels, allowing large amounts of water to back up. This causes backwater flooding and, if the dam fails, subsequent downstream flooding. Also, solid landslide debris can "bulk" or add volume and density to otherwise normal stream flow or cause channel blockages and diversions creating flood conditions or localized erosion.

- ***Landslides and Seismic Activity:*** The occurrence of earthquakes in steep landslide-prone areas greatly increases the likelihood that landslides will occur. This is due to ground shaking alone or shaking-caused dilation of soil materials, which allows rapid infiltration of water. Widespread rock falls also are caused by loosening of rocks as a result of ground shaking. The 1964 Great Alaska Earthquake caused widespread land sliding loss due to the earthquake. Many mountainous areas that are vulnerable to landslides have also experienced at least moderate rates of earthquake occurrence in recorded times.

- ***Landslides and Volcanic Activity***: Volcanic lava can melt snow at a rapid rate, causing a deluge of rock, soil, ash, and water that accelerates rapidly on the steep slopes of volcanoes, devastating anything in its path and are some of the most devastating types. These volcanic debris flows (also known as lahars) reach great distances and can damage structures in flat areas surrounding the volcanoes. The 1980 eruption of Mount St. Helens, in Washington triggered a massive landslide on the north flank of the volcano, the largest landslide in recorded times.

- ***Landslide Effects on Buildings*:** Landslides can occur where the terrain has been altered geologically or anthropogenically and can damage buildings. As pressures on the ground increase, so does the likelihood of buildings being devastated.

- ***Landslide Effects on Plant-life:*** Landslides can affect plant-life and ecology. Any kind of plant-life in the slides way will get washed down with the slide. The steeper a slope, the more likely a slide will occur. The weaker rock and sediments are, the more prone they become to a landslide occurring. If land becomes saturated, the land may flow more easily.

Case Study: Good Landslide Risk Management Practice

This good management practice is reported in Hong Kong, China. On 18th June 1972, heavy rainfall resulted in two destructive landslides in Sau Mau Ping and Po Shan Road in Hong Kong. It killed one hundred and thirty-eight people and a high-rise building also collapsed. In 1977, a Geotechnical Engineering Office was set up. The main objective was to implement a comprehensive system to maintain slope safety. The key components of the system included: comprehensive enforcement of geotechnical standards, community participation for slope safety, systems for early warning and emergency response., They also created comprehensive databases of landslide events and implemented various risk mitigation measures. As a result of the implementation of the Slope Safety System. For about a decade, there has been no fatalities. Among the natural hazards Landslides are considered potentially manageable. There are now available a range of approaches and techniques to reduce the level of hazard. There is ample scope to reduce their impacts.

Check Your Progress 3

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. What are landslides?

.....

.....

.....

2. How does slope failure occur?

.....

.....

.....

3.6 LET US SUM UP

In this unit we have studied about the floods, its types and causes of floods. We have also understood why drought occurs. The unit also discusses how drought proceeds from the initial stage to the most severe stage and when famine can occur. We have also discussed the driving and resisting forces in the landslide occurrence. We have analyzed the causes and effects of landslides. In conclusion, the chapter gives an overview of these hazards.

3.7 KEY WORDS

Floods : Additional amounts of precipitation more than the average amounts can result in streams to run out of its confines. This results in flooding.

Landslides : Down slope movement of small stones, soil and rock fragments, even if very slow should not be underestimated. These processes can ultimately result in landslide hazards.

Droughts : A drought is an extended period (of months or years) when a region experiences a noticeable deficiency in water supply.

Hydrological cycle : Water is in constant motion in the earth in a cycle. This is called hydrological cycle.

Sinkholes : They are a common geological feature in karst landscapes, where water has dissolved underlying bedrock, typically limestone or gypsum.

3.8 REFERENCES AND SUGGESTED FURTHER READINGS

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3.9 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

1. Your answer should include the following points:
   - **Precipitation**
   - **Coastal Flooding**
   - **Dam and Levee Failures**
   - Cloudbursts
2. Your answer should include the following points:
   - Riverine floods
   - Estuarine floods
   - Coastal floods
   - Catastrophic floods
   - Muddy floods

Answers to Check Your Progress 2

1. Your answer should include the following points:
   - The primary effects of floods are those due to direct contact with the flood waters. Water velocities tend to be high in floods. As discharge increases velocity increases.
   - Give examples
2. Your answer should include the following points:
   - Secondary effects are those that occur because of the primary effects
   - Tertiary effects are the long term changes that take place.
   - Give examples

Answers to Check Your Progress 3

1. Your answer should include the following points:
   - Downward movement of slope-forming materials (like rock, soil, artificial fill, or a combination) can lead to landslides. These materials can move by the following ways: falling, toppling, sliding, spreading, or flowing.

- Landslides or mass wasting is the down-slope movement of regolith (loose uncemented mixture of soil and rock particles that covers the Earth's surface) due to gravity.
- Write with case studies

2. Your answer should include the following points:
   - Failure of slope is a significant natural hazard.
   - Slope failure can be defined as a downward movement of a large amount of material.
   - These occur due to natural events like earthquakes, heavy rainfall from thunderstorms, volcanic eruptions, flooding, or even freezing and thawing of soil moisture.
   - Write some factors leading to slope failures

The Disaster Management Cycle

Corina Warfield

Goals of Disaster Management:

(1) Reduce, or avoid, losses from hazards;
(2) Assure prompt assistance to victims;
(3) Achieve rapid and effective recovery.

Disaster management aims to reduce, or avoid, the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The Disaster management cycle illustrates the ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after a disaster has occurred. Appropriate actions at all points in the cycle lead to greater preparedness, better warnings, reduced vulnerability or the prevention of disasters during the next iteration of the cycle. The complete disaster management cycle includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

The mitigation and preparedness phases occur as disaster management improvements are made in anticipation of a disaster event. Developmental considerations play a key role in contributing to the mitigation and preparation of a community to effectively confront a disaster. As a disaster occurs, disaster management actors, in particular humanitarian organizations, become involved in the immediate response and long-term recovery phases. The four disaster management phases illustrated here do not always, or even generally, occur in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.

- Mitigation - Minimizing the effects of disaster.
  Examples: building codes and zoning; vulnerability analyses; public education.
- Preparedness - Planning how to respond.
  Examples: preparedness plans; emergency exercises/training; warning systems.
- Response - Efforts to minimize the hazards created by a disaster.
  Examples: search and rescue; emergency relief .
- Recovery - Returning the community to normal

Examples: temporary housing; grants; medical care.

Sustainable Development

Developmental considerations contribute to all aspects of the disaster management cycle. One of the main goals of disaster management, and one of its strongest links with development, is the promotion of sustainable livelihoods and their protection and recovery during disasters and emergencies. Where this goal is achieved, people have a greater capacity to deal with disasters and their recovery is more rapid and long lasting. In a development oriented disaster management approach, the objectives are to reduce hazards, prevent disasters, and prepare for emergencies. Therefore, developmental considerations are strongly represented in the mitigation and preparedness phases of the disaster management cycle. Inappropriate development processes can lead to increased vulnerability to disasters and loss of preparedness for emergency situations.

Mitigation

Mitigation activities actually eliminate or reduce the probability of disaster occurrence, or reduce the effects of unavoidable disasters. Mitigation measures include building codes; vulnerability analyses updates; zoning and land use management; building use regulations and safety codes; preventive health care; and public education.

Mitigation will depend on the incorporation of appropriate measures in national and regional development planning. Its effectiveness will also depend on the availability of information on hazards, emergency risks, and the countermeasures to be taken. The mitigation phase, and indeed the whole disaster management cycle, includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

Preparedness

The goal of emergency preparedness programs is to achieve a satisfactory level of readiness to respond to any emergency situation through programs that strengthen the technical and managerial capacity of governments, organizations, and communities. These measures can be described as logistical readiness to deal with disasters and can be enhanced by having response mechanisms and procedures, rehearsals, developing long-term and short-term strategies, public education and building early warning systems. Preparedness can also take the form of ensuring that strategic reserves of food, equipment, water, medicines and other essentials are maintained in

cases of national or local catastrophes.

During the preparedness phase, governments, organizations, and individuals develop plans to save lives, minimize disaster damage, and enhance disaster response operations. Preparedness measures include preparedness plans; emergency exercises/training; warning systems; emergency communications systems; evacuations plans and training; resource inventories; emergency personnel/contact lists; mutual aid agreements; and public information/education. As with mitigations efforts, preparedness actions depend on the incorporation of appropriate measures in national and regional development plans. In addition, their effectiveness depends on the availability of information on hazards, emergency risks and the countermeasures to be taken, and on the degree to which government agencies, non-governmental organizations and the general public are able to make use of this information.

Humanitarian Action

During a disaster, humanitarian agencies are often called upon to deal with immediate response and recovery. To be able to respond effectively, these agencies must have experienced leaders, trained personnel, adequate transport and logistic support, appropriate communications, and guidelines for working in emergencies. If the necessary preparations have not been made, the humanitarian agencies will not be able to meet the immediate needs of the people.

Response

The aim of emergency response is to provide immediate assistance to maintain life, improve health and support the morale of the affected population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transport, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations. It also may involve initial repairs to damaged infrastructure. The focus in the response phase is on meeting the basic needs of the people until more permanent and sustainable solutions can be found. Humanitarian organizations are often strongly present in this phase of the disaster management cycle.

Recovery

As the emergency is brought under control, the affected population is capable of undertaking a growing number of activities aimed at restoring their lives and the infrastructure that supports them. There is no distinct point at which

immediate relief changes into recovery and then into long-term sustainable development. There will be many opportunities during the recovery period to enhance prevention and increase preparedness, thus reducing vulnerability. Ideally, there should be a smooth transition from recovery to on-going development.

Recovery activities continue until all systems return to normal or better. Recovery measures, both short and long term, include returning vital life-support systems to minimum operating standards; temporary housing; public information; health and safety education; reconstruction; counseling programs; and economic impact studies. Information resources and services include data collection related to rebuilding, and documentation of lessons learned.

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National Conference on

Media in Disaster Management – 2020

A pre-event for 3rd National Platform for Disaster Risk Reduction (NPDRR)

Thursday, 16th April 2020, The Ashok Hotel, New Delhi, India

Concept Note

The growing multi-hazard environment to which millions of people in the world are exposed highlights the importance of making sure that the affected population is increasingly better prepared. About 12% (over 40 million hectares) of landmass is prone to floods and river erosion; more than 58.6% of the landmass is prone to moderate to very high intensity earthquakes; out of the 7,516 kms long coastline, close to 5,700 kms are prone to cyclones and tsunamis; about 0.42 million sq.km of India's land area is vulnerable to landslide hazard; and, 68% of its cultivable area is vulnerable to droughts. In addition, the country is also vulnerable to other man-made disasters such as Chemical, Biological, Radiological and Nuclear (CBRN) emergencies. Unplanned urbanization and industrialization, population expansion, environmental degradation, climate change, construction, development in high-risk zones, changing demographics and socio-economic conditions further increase the vulnerability of India to disaster (NDMA). The combination of human and economic losses, together with reconstruction costs, makes natural disasters both a humanitarian and an economic problem.

In any disaster event, communication is a core component and plays a very crucial role in rescue, response and recovery operation. Media forges a direct link between the public and emergency organizations and plays a very important role in disseminating vital information to the public before, during and after disasters. Mass media such as newspapers, television, radio, community radio, internet, and social media are used quite extensively before, during and after a disaster

event for broadcasting and dissemination of information. The media assists in the management of disasters by educating the public about disasters; warning of hazards; gathering and transmitting information about affected areas; alerting government officials, relief organizations and the public to specific needs; and facilitating discussion about disaster preparedness and response for continuous improvement. The need for effective early warning systems and its dissemination in disaster management has been released internationally. During Sendai Framework for Disaster Risk Reduction, 2015-2030 that was decleared at the 3rd UN World Conference on Disaster Risk Reduction (WCDRR) in Sendai, Japan, from 14th to 18th March March 2015, one of the expected outcomes was "substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries". During this conference, countries and partners highlighted the need to invest, develop, maintain and strengthen people-centred, end-to-end early warning systems; promote the application of simple and low-cost early warning equipment and facilities; broaden the dissemination channels for early warning information to facilitate early action.

For past few decades, there is an increasing trend in the use of different news media to manage disasters in all the phases of disaster management (Denis et al., 2014; Hiltz et al., 2014; Hughes, 2014; Yates & Paquette, 2011). Effective media communications prevent or lessen the impact of disaster whereas ineffective disaster communication by media makes its effects worse. For the media to discharge its role properly on disaster scenario, it is also necessary to have complete cooperation between media and all governmental and non-governmental agencies. And the extent of the coordination and cooperation between them determines the nature, the degree and the scale of the preparation to prevent and meet the challenges of disasters.

As per the Television Audience Measurement (TAM), Annual Universe Update - 2015, India had over 167 million households (out of 234 million) with television sets, of which over 161 million have access to Cable TV or Satellite TV, including 84 million households which are DTH subscribers. Media offers huge potential and opportunity for improving disaster resilience and risk management capabilities in the country if used effectively for early warning and education purposes. Existing broadcasting networks can work as a very effective backbone for issuing Emergency Public Alert (EPA) to the people at risk in the remotest corner of the country.

INDIAN CONTEXT

The Indian subcontinent is among the world's most disaster prone areas and India is one of the ten most disaster prone countries of the world. Assam flood (2019), Kerala Flood (2018), Gujarat Flood (2017), Indian heat wave (2016), Kashmir Floods (2014), Maharashtra Drought (2013), Uttarakhand Flash Floods (2013), Bihar Flood (2007), Mumbai Catastrophes (2005), Indian Ocean Tsunami (2004), Gujarat Earthquake (2001), Odisha Super Cyclone (1999), Latur Earthquake (1993) etc are some of the major disaster that occurred in India and resulted in immense loss of life, property and environment.

Media and communication plays a crucial role in disaster management by disseminating information about the disasters, educating public about disaster, highlighting vulnerable zones, spreading warning and alert, reporting of disaster events, gathering and transmitting informatifon about affected areas, assisting in rescue and relief operations, disseminating information about public safety, informing and alerting the concern authorities and government officials, assisting volunteers, relief organizations etc. The continuous and factual coverage of disaster event by media immediately after a disaster aids response and decision making activities, thereby saving lives and property.

There are many examples where public education and the rapid, widespread dissemination of early warnings saved thousands of lives. The 1977 cyclone in Andra Pradesh, India killed more than 10,000 people, while a similar storm in the same area 13 years later killed only about 910. The dramatic difference - was due to the fact that a new early-warning system connected with radio stations to alert people in low-lying areas, was put into place (R. K. Dave, www.training.fema.gov).

Uttarakhand witnessed a multi-day cloudburst on June 2013 leading to devastating flash floods and landslides where as on 09 May 2014, a total of 169 people died and 4021 people were reported missing (presumed to be dead) (Satendra et. al 2014). It became the country's worst natural disaster since the 2004 tsunami. Community radios were among the first responders and were involved in broadcasting and sensitizing vital information to victims and response teams. At several community stations, Gram Vaani established operating Relief News lines for Uttarakhand flood victims to provide help with three community radios namely Kumaon Vani (Mukteshwar), Henvalvani (Chamba Valley) and Mandakini Ki Awaz (Rudraprayag).

The 2004 Great Sumatra earthquake and the Indian Ocean tsunami, also known as Boxing Day Tsunami, occurred on 26th December 2004, with a magnitude of 9.3 M_w, causing extensive damage to Andaman and Nicobar Islands (UT) and mainland coast in the states of Kerala, Tamilnadu. The tsunami was considered as one of the deadliest natural hazards in the history, killing over 230,000 people in fourteen countries. In India it claimed 10,745 lives according to official estimates (INCOIS, Indian Tsunami Early Warning Centre User Guide). In the immediate aftermath of the disaster, Ham radio, Community radio, Immersat and VSAT phones were used to assist in relief and rescue operations. Community media is often considered a medium of broadcasting that gives voice to the voiceless and brings into limelight the issues and problems faced by the affected community. Though the concept of community radio is decades old, it is still in a

nascent stage and also needs support from the district, state and central level to develop, grow and become an integral part of disaster management.

The 1999 Odisha cyclone was the most intense recorded tropical cyclone in the North Indian Ocean (NIO) and among the most destructive in the region. The cyclone resulted in over 10,000 deaths fatalities (ww.ndma.gov.in) and total damage cost amounted to US 4.44 billion dollars. Throughout the storm's lifetime, Indian Meteorological Department (IMD) periodically issued cyclone warning bulletins. Hourly dissemination of cyclone bulletins was carried out by Doordarshan and All India Radio to affected areas which have greatly reduced the number of death.

Ham radio and community radio plays a tremendous role during natural disasters such as cyclones, floods, landslides, tsunami, earthquakes etc. However, the level of awareness of these radio communications in India is still low. Volunteers from community radio and amateur radio can become frontline reporters in a disaster emergency. Persons involved in media such as community radio have a close relationship with the community and understand the local existing environmental conditions and the reality faced by victims better than journalists from the mainstream media.

India's zero casualty approach to managing extreme weather events is a major contribution to the implementation of the Sendai framework and the reduction of loss of life from such events. India's Zero Casualty Policy refers to Indian Meteorological Department's "almost pinpoint accuracy" of early warnings that helped authorities conduct a well-targeted evacuation plan and minimise the loss of life against extremely severe cyclonic storm Fani.

There a need to focus on promotion of efficient, safe and resilient communication environment for emergencies and disaster situations, better linkage, coordination and cooperation among stakeholders and media for exchange of ideas, information, knowledge and experiences on disaster risk management, encouragement of the media to be partners in disaster relief, build a culture of

proactive than reactive reporting culture, establishment of community based media and communication network throughout the nation ensuring last mile connectivity.

GLOBAL CONTEXT

At the global level, there has been considerable concern over natural disasters. Even as substantial scientific and material progress is made, the loss of lives and property due to disasters has not decreased. In fact, the human toll and economic losses have mounted. It was in this background that the United Nations General Assembly, in 1989, declared the decade 1990-2000 as the International Decade for Natural Disaster Reduction with the objective to reduce the loss of lives and property and restrict socio-economic damage through concerted international action, especially in developing countries. Some of the major natural disasters world has witnessed are Europeam heatwave (2019), Greece wildfire (2018), Papua New Guinea Earthquakes (2018), Phillipines landslide (2018), Gorkha Nepal earthquake (2015), Haiti earthquake (2010), Sichuan earthquake (2008), Pakistan earthquake (2005), Iran earthquake (2003), Tangshan earthquake (1976), Huascarán avalanche (1970), Vargas tragedy (1999), Typhoon Nina (1975), Daulatpur–Saturia tornado (1989) etc. According to EM-DAT (1900 to 2019), there is an increasing trend worldwide in the number of disasters event and their economic impacts.

There are numerous examples where the media role has reduced the casualties tremendously. In Bangladesh, a tropical cyclone struck in 1970 causing more than 300,000 causalities people and nearly 1.3 million homeless. A comparable cyclone and storm surge hit the same area in May 1985 but with better dissemination of disaster warnings, the death was reduced to about 3% of that in 1970 (about 10,000). However, in May 1994 when a devastating cyclone struck the same area, fewer than 1,000 people died (R. K. Dave, www.training.fema.gov).

The 2015 Gorkha Nepal earthquake struck Central Nepal on 25th April 2015, with earthquake magnitude of 7.8 M, caused tremendous damage and loss with 8,857 death, 22,304 injuries and estimated 10 billion US dollar (about 50% of Nepal's nominal GDP). The post-disaster assessment showed that the majority of the building affected was stone/brick masonry structures lacking structural design whereas most of RCC buildings were undamaged. When all the local communication system collapsed, community Radio stations played an important role in restarting the vital link to help the affected community after the earthquake. The community radio services were broadcasting from tents and open air.

On May 12, 2008, Sichuan Province in the People's Republic of China was struck by one of the most catastrophes earthquakes with measured 8.0 M, the death toll has reached about 69,227 deaths, 374,643 injuries, 17,923 missing and an estimated direct economic loss of 845.2 billion RMB. The communication network was completely cut-off in some of the worst affected areas, while communications in other areas were facing high congestion due to drastically increased traffic. In this situation, radio operators stepped in to provide emergency communications and vital on-ground information. Research has shown that during majority of natural disasters, the one item that people picked from their homes to escape with is a radio. Similar research was done in El Salvador, survivor's and even dead bodies were found with a radio in their hands or in the vicinity.

In Kasaya village, located in the Kazungula District of Zambia's Southern Province and on Mbeta Island, in the Western Province of Zambia, the flood was a severe problem and in 2006 it experienced a worse flood causing huge loss to life, property, crops and livestock, leaving people with nothing to live on. However, with the increasing involvement of media and community volunteers and installation of flood early warning systems in 2017 by International Telecommunication Union (ITU) partnered with the Zambia Information and

Communication Telecommunication Authority (ZICTA) the impact of the flood has been reduced drastically.

Hurricane Katrina, a category 5 hurricane, struck the United States in August 2005 causing over 1,200 deaths and $125 billion (Tied as costliest tropical cyclone on record). U.S. amateur radio operators carried out the largest disaster response with involvement of more than 1000 ham operators from all over the U.S.

In the immediate aftermath of the July 2006 Java earthquake, the Indonesian government received tsunami warnings from the Hawaii center and the Japan Meteorological Agency but failed to relay the alert to its citizens. At least 23,000 people did evacuate the coast after the quake, either fearing a tsunami or because their homes had been destroyed. After the post-disaster assessment, it was suggested that in Muslim-dominated coastal areas, the loudspeakers fitted to mosques could be used to broadcast warnings.

Many countries in the world (to name few like Japan, China, United States, France, Germany, Bangladesh, Cuba etc) have developed appreciable early warning and communication network for dissemination and communication of risk information and warnings to reach those in danger in a way that is clear and understandable. The international effort coordinated by World Meteorological Organization (WMO), documented a book entitled “Institutional Partnerships in Multi-Hazard Early Warning Systems” for good practices from early warning systems in the above-mentioned countries and developed guidelines on the necessary institutional arrangements to capitalize on national successes of these countries in early warning systems and facilitate sharing of experiences for the benefit of others.

The Indian Ocean Tsunami Warning System, a tsunami warning system, set up to provide warning to inhabitants of nations bordering the Indian Ocean of approaching tsunamis. It was agreed to in a United Nations conference held in January 2005 in Kobe, Japan as an initial step towards an International Early

Warning Programme. Nanometrics (Ottawa, Canada) and Results Marine Private Limited (RMPL), India delivered and successfully installed 17 Seismic VSAT stations with 2 Central Recording Station to provide the seismic event alert to the scientists through SMS and E-mail automatically within 2 min who will further dissipate the warning and alerts via various mode of transmission. The system became active in late June 2006 following the leadership of UNESCO. It consists of 25 seismographic stations relaying information to 26 national tsunami information centers, as well as 6 Deep-ocean Assessment and Reporting of Tsunami (DART) buoys (UNESCO, Unescopress, 28 June 2006). Its creation was prompted by the 2004 Indian Ocean earthquake and resulting tsunami, which left some 230,000 people dead or missing. Many analysts claimed that the disaster would have been mitigated if there had been an effective warning system in place, citing the well-established Hawaii-based Pacific Tsunami Warning Center, which operates in the Pacific Ocean.

Global Disaster Alerting Coordination System (GDACS) is a cooperation framework between the United Nations, the European Commission and disaster managers worldwide to improve alerts, information exchange and coordination in the first phase after major sudden-onset disasters. GDACS provides real-time access to web-based disaster information systems and related coordination tools with an objective of filling the information and coordination gaps in the first phase after major disasters.

ABOUT NIDM

National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India is a premium institute and a Statutory Body (under Disaster Management Act 2005) for training, research, documentation, awareness and human resources and capacity development in the field of disaster mitigation and management. The institute lays emphasis on multi-stakeholder interdisciplinary cross-sectoral approach for an efficient proactive continuum disaster risk

management based on participatory integrated multi-risk management concept. It aims towards a disaster free/resilient India. NIDM has a specialized centre on Early Warning and Communication (EWC) under Geo-meteorological Risks Management Division (GMRD). The centre carries out various training, workshops, seminar, conferences, research, documentation to sensitizing, institutionalizing and promoting information, knowledge, and innovation on components of early warning systems, needs and gaps in early warning and communications for disaster situations, dissemination/broadcasting related to early warning and communication in disasters situations, response capability, technology, infrastructure, and forecasting capability, strengthening community-based resilience and environmental emergency preparedness capacities etc.

OBJECTIVES

The conference is directed towards sensitizing, institutionalizing and promoting exchange of information, knowledge, and innovation on understanding the role of media and communication in disaster management with the following objectives:

- To develop better understanding about disaster risk management
- To assess the needs and gaps in communications during emergencies and disaster situations
- To promote linkages among stakeholders from disaster management and media
- To discuss about role and responsibilities of media and communication during disaster reporting
- To discuss common technical characteristics and guidelines for media and communication systems for early warning
- Understanding how the existing media and communication infrastructure can be used to manage emergency disaster situation

- To promote community based broadcasting and communication for disaster risk reduction and resilience
- To promote knowledge dissemination, capacity building and networking towards disaster risk reduction and resilience

EXPECTED OUTCOMES

- Promotion of efficient, safe and resilient communication environment for emergencies and disaster situations
- Promotion of better linkage and coordination among stakeholders and media for the exchange of ideas, information, knowledge and experiences on disaster risk management
- Build a culture of ethical reporting during disaster
- Explore possibilities for disaster resilient communication systems, technologies and networks
- Encouragement of the media to be partners in disaster relief
- Build a culture of proactive than reactive reporting culture
- Establishment of community based media and communication network throughout the nation to ensure last-mile connectivity

TARGET GROUP: The target groups for this conference are delegate including expert and relevant functionaries from the government and international agencies, NGOs, media personals, academics and research institutes.

UNIT 1 :- INTRODUCTION TO HAZARDS AND DISASTER

1.1 Meaning, types and nature of natural and man made disaster; an introduction

INTRODUCTION

We know that all the earth processes have been operating throughout the geological history, but these processes have become hazardous only because they negatively affect us. The earth is an open system with respect to energy but essentially a closed system with respect to materials. The earth is also a dynamic, evolving system with complex interactions of internal and external processes. While the internal processes are primarily responsible for movement of plates, earthquakes, volcanic activities; the external processes are responsible for the wave generation, floods, hurricanes, tornadoes and droughts. The source of energy of the internal process is essentially radioactivity, where as the source of energy for the external process is the sun.

MEANING OF THR TERM HAZARDS AND DISASTER

Hazard: A hazard can be defined as a potential threat to humans and their welfare and risk as the probability of hazard occurrence. Hazard can also be defined as: "Those elements of the physical environment, harmful to man and caused by forces extraneous to him" (Burton et al. 1978). A hazard has the potential to cause harm to:

- People: death, injury, disease and stress
- Human activity: economic, educational etc.
- Property: property damage, economic loss of
- Environment: loss fauna and flora, pollution, loss of amenities.

Disaster: "Disaster is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property including death and injury to a large number of people, and requires therefore, mobilisation of efforts in excess of that which are normally provided by statutory emergency services".

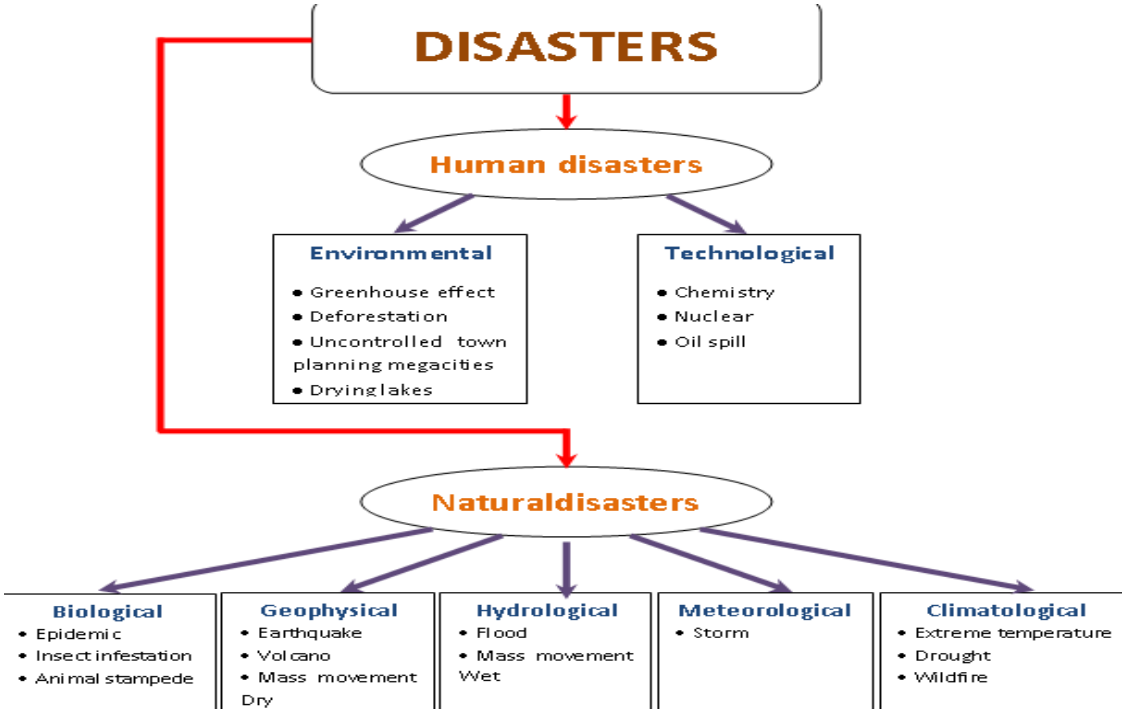
TYPES OF DISASTER

Natural hazards are naturally occurring physical phenomena. They can be:

- **Geophysical:** a hazard originating from solid earth (such as earthquakes, landslides and volcanic activity)

- **Hydrological:** caused by the occurrence, movement and distribution of water on earth (such as floods and avalanches)
- **Climatological:** relating to the climate (such as droughts and wildfires)
- **Meteorological:** relating to weather conditions (such as cyclones and storms)
- **Biological:** caused by exposure to living organisms and their toxic substances or diseases they may carry (such as disease epidemics and insect/animal plagues)

Man-made and technological hazards are events that are caused by humans and occur in or close to human settlements. They include complex emergencies, conflicts, industrial accidents, transport accidents, environmental degradation and pollution.



NATURE OF HAZARDS/DISASTER

- Duration: the longer the hazard is experienced the greater the danger. For example an earthquake lasting for a minute is more severe than one that lasts 2 seconds.
- Magnitude: the strength of the hazard which is measured on the Richter scale or the VEI, Volcanic Explosivity Index.

- Predictability: some hazards give warning signs prior to their arrival. Volcanoes can show signs of smoke prior to eruptions and tropical storms can be predicted with weather stations and forecasts.
- Regularity: Some hazards are regular occurrences and this makes people aware of their arrival and prepared to face the risk of damages.
- Frequency: some hazards subject people to more danger because they occur often making living conditions very difficult.
- Speed of onset: a hazard that arrives with very little warning becomes a disaster as no one is prepared for the devastation.
- Areal extent: a widespread hazard will easily turn into a disaster if the area is not contain and assistance offered.

UNIT 2 CHEMICAL HAZARDS

Structure

2.0 INTRODUCTION

Chemistry benefits the life of humans in this wonderful world in many ways. Most of the chemicals are instrumental in providing fundamentals rights of food, clothing, and shelter and making our lives more pleasant in cultural, vocational, and recreational ways. They also help us as pharmacological agents for our healthy lives so that we may continue to contribute for higher standard of living in the society. But when misused, the same chemicals can be hazardous and put us to troubles. Nowadays there are problems cropping up from misapplication of chemical compounds in industrial, natural and domestic environments. Exposure to the hazardous chemicals causes systemic reactions which can follow inhalation, ingestion or absorption through the skin. Every year billions of people unintentionally consume chemical toxicants and die while many people sustain permanent and crippling ailments. The list of hazardous chemicals which may cause adverse health effects grows longer every year. Mainly employees in the industries are directly exposed to chemicals in the form of liquid, dust or vapor through direct contact, inhalation or absorption. Chemical hazard is considered to an occupational hazard.

Dear learners, in this unit we will discuss about some important chemical hazards that shows adverse health effects on human beings.

2.1 OBJECTIVES

After studying this unit you will be able to:

- define chemical hazards;
- discuss the types of chemical hazards;
- understand the cancer causing chemicals;
- identify various types of flammable chemicals and
- understand the effects of hazardous chemicals.

2.2 DEFINITION

A chemical hazard is one of the occupational hazards that are caused by exposure to chemical substances in the form of either liquid or gaseous form in the workplace. Chemical exposure in certain occupations causes acute or long-term deleterious effects on health. When exposed a chemical substance can act in three different ways: 1. Local action 2. Inhalation and 3. Ingestion.

2.3 TYPES OF CHEMICAL HAZARDS

Depending on the nature of a chemical the chemical hazards are classified into the following types.

1. **Flammable Chemical Material**: Any form of a chemical substance either solid, liquid, vapor, or gas that ignites instantly and burns immediately in the presence of air.
2. **Corrosive Chemical Material:** Corrosive chemicals are the substances which can cause destruction or permanent damage to human skin tissue in the contacted area, or any metal. They can be liquids, solids, or gases and can also have adverse health effects to the eyes, skin, and respiratory tract.
3. **Reactive Material:** Reactive chemicals are the substances which have a tendency to decompose spontaneously and sometimes vigorous reaction take place when contact with other chemicals due their inherent properties.

2.3.1 Flammable Chemical Material

A flammable chemical is any solid, liquid, vapor, or gas that ignites easily and burns rapidly in air. Flammable chemicals are classified on the basis of the following criteria.

1. flashpoint
2. boiling point
3. fire point, and
4. auto-ignition temperature.

1) Flash Point (FP): FP is the lowest temperature where a flammable chemical's vapor burns when it catches fire.

2) Boiling Point (BP): Boiling Point is the temperature at which the vapor pressure of a chemical is equal to the atmospheric pressure under which the liquid vaporizes.

3) Fire Point (FP): Fire Point is the temperature of a chemical at which it will burn.

4) Auto-ignition Temperature is the lowest temperature where a chemical will burn without any source of ignition.

Conditions for a Fire

Inappropriate use of flammable liquid chemicals can cause a fire. The other conditions for a chemical disaster are as follows:

i. Flammable chemicals must be present in enough concentration to support a fire.

ii. In the presence of oxygen or chemical oxidizer.

iii. Source of ignition like heat, spark must be present in the vicinity.

Hazards

Most of the flammable liquid chemicals are volatile in nature and when exposed their vapors come in contact with air, it catches fire when source of ignition is present. These vapors are heavier than air that will not diffuse in the air easily until adequate air movement is present. The increase in temperature of a flammable liquid is directly proportional with increase in vaporization. In some cases explosions may occur when the vapor attains the lower explosive limit (L.E.L.) in the presence of source of ignition. LEL of a chemical is the lowest concentration of a vapor present in the air that can generate a flash of fire in presence of a source of ignition. It is also called lower flammable limit (LFL).

Effect of Health

Organic solvents like ether, alcohols, benzene and toluene are extremely volatile and flammable. Solvents like carbon tetrachloride (CCl_4), are non-flammable while hydrogen-containing chlorinated solvents like chloroform, are flammable. When exposed to heat or flame, these solvents produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

These flammable liquid chemicals are basically skin irritants and are capable of damaging tissue, some are skin sensitizers. Adverse health hazard by inhalation of flammable chemicals depends on concentration of the chemical and toxicity of its vapor. Flammable chemicals and their toxic vapors present in the natural environment at below their lower explosive limit pose adverse health effects on human beings.

Inhalation of these toxic vapors causes bronchial irritation, depression, dizziness, damage to central nervous system, nausea, headache, coma and finally death. Long term exposure to these solvent vapors with higher concentrations cause liver and kidney damage. These health effects will be enhanced with alcoholic consumption. The exposure through skin leads to skin irritation drying and defatting. The odor of toxic chemicals like chloroform and benzene can also cause health effects.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Define Chemical Hazard

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2. What are the health effects of a chemical hazard by an inflammable material?

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2.3.2 Corrosive Chemical Material

Corrosive chemicals destroy or damage living tissue on direct contact. Corrosive chemicals can cause serious, sometimes permanent, damage to any part of the body coming into contact with the chemical. Some acids, bases, dehydrating agents, oxidizing agents, and organic compounds are some examples of corrosive chemicals. Some examples are presented in table-1

Table 2.1: Corrosive Chemical Materials

Acid Corrosives(Inorganic)	Hydrochloric acid Nitric Acid Sulfuric acid
Acid Corrosives(Organic)	Acetic Acid Propionic acid
Alkaline or basic, corrosives	Sodium hydroxide Potassium hydroxide
Corrosive dehydrating agents	Phosphorous pentoxide Calcium oxide
Corrosive oxidizing agents	Halogen gases Hydrogen peroxide (concentrated) Perchloric acid
Organic corrosive	Butylamine

All types of acid substances are considered as corrosive. Sulfuric acid is one of the most extensively used corrosives in dyes, paints, petroleum processing and automobile batteries.

HAZARDS

The hazards of acid are:

i. Either the form of liquid or vapor states, acids are extremely toxic and produce irritation to the eyes, skin, and respiratory tract.

ii. On contact with skin causes pain and serious burns.

iii. Contact with the eyes directly can cause instant blindness.

iv. Some acids causes fire and explosion hazard.

Effects on Health

i. Acids with high concentration cause pain and severe burns.

ii. Inorganic hydroxides can cause significant damage to skin tissues because a protective protein layer does not form. Dilute potassium or sodium

hydroxide will react with the fat tissues and forming a soapy, slick film with pain.

iii. Compounds like phenol on exposure to skin turn white because of severe burn. Systemic poisoning also occurs through dermal exposure.

iv. Skin contact with dilute hydrofluoric acid (HF) cause tissue damage without causing pain. While concentrated of HF cause painful damage to tissues.

For example glutaraldehyde is used in medical and dental treatment as a disinfectant and sterilizing agent but when inhaled or swallowed it shows harmful health effects. It has potential to cause respiratory tract, eyes and skin irritation and finally cause permanent eye damage. Some corrosives are flammable or combustible in nature which can catch fire and burn or explode at higher concentrations under pressure. Some corrosive compounds are resistant with other chemicals and undergo chemical reactions produce toxic or explosive products when they contact each other.

Bases like caustic soda that is generally used in soaps, detergents; water treatment plants can cause burning, swelling and blister formation. When it comes in contact with the eyes it causes permanent eye blindness. While inhaling these chemicals it damages the tissues of the nose, mouth, throat and lungs. Ingestion or swallowing results in extreme pain, damages internal organs sometimes even death. The diluted form of corrosive chemicals is known as irritants. Substances like ammonia, antifreeze chemicals, thinners, degreasers and acids are some examples of irritants. Irritants also generated during combustion as by-products, example like nitrogen dioxide is produced in the automobile exhaust is an irritant. Other examples are

i. Aromatic nitro and amino compounds like trinitrotoluene (TNT) and aniline cause systemic effects when absorbed through the skin.

ii. Occupational dermatitis can be caused due to the contact with substances like rubber, machine oil, X-rays, lime and caustic alkali.

2.3.3 Reactive Material

Reactive chemicals are chemicals which may be sensitive to friction, shock and react quickly in the presence of air, water, light, heat and other chemicals. Some of them are unstable and decompose quickly by releasing energy in the process and some may generate and release toxic gases. Reactive and explosive chemicals release significant amounts of heat and gas when stimulated. On reaction the reactive materials may cause any one or more of the following hazards.

Table 2.2: Reactive Materials

S.No.	Hazards
1.	dispersal of toxic dusts, mists, particles
2	Fire & explosion
3	solubilization of toxic substances
4	formation of flammable gases
5	formation of shock or friction sensitive compounds

6	formation of substances of greater toxicity
7	formation of toxic vapors
8	heat generation
9	pressurization in closed vessels
10	violent polymerization & volatilization of toxic or flammable substance

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

Match the following:

1.	Basic corrosive	a.	Butylamine
2.	Organic corrosive	b.	Toxic vapors
3.	Reactive material	c.	Sodium hydroxide
4.	Glutyraldyde	d.	Occupational dermatitis
5.	Rubber	e.	respiratory irritation

2.4 CHEMICAL TOXINS

The toxicity of a chemical is defined as it is the ability to destroy an organ system or disturb a biochemical process or a cell function in an area distant from the site of contact. The toxicity is mainly depends on the factors like dose, duration of exposure, route of entry, persons response, exposure to other chemicals, gender and mixing the toxin with other chemicals. The acute and chronic toxicity of a chemical can be diagnosed by the dose-time relationship of a particular chemical. The acute toxicity of a chemical is its ability to cause damage from a single exposure or even death. Hydrogen cyanide, hydrogen sulfide, nitrogen dioxide, Organophosphate pesticides and arsenic are some examples of acute toxins. Chronic toxicity of a chemical is the ability to impose systemic damage after repeated exposures of a chemical with relatively low levels for a prolonged duration. Examples of chronic toxins are mercury, lead and formaldehyde. The chronic health effects occur when the chemical exposure is repeated and severe.

Dear learners, here we will discuss some other types of chemical carcinogens known as toxins.

Types of Toxins

Dear learner in this unit we will introduce the types of toxins in brief and you will learn about detailed study of them in the following units.

Carcinogens: Carcinogens are the substances which are capable of causing cancer. Abnormal or unrestrained growth of new cells in any part of the body

is known as cancer. Carcinogens are persistent toxins that cause damage to humans after long-duration exposure. They do not have immediate visible harmful effects but develop cancer only after a long latency period.

Mutagens: Mutagens have the potential to cause mutation. Mutagens are the substances that can cause damage to chromosomes by altering DNA commonly known as mutation. Mutations can occur spontaneously but the risk is enhanced by exposure to some of the chemicals and radiation as well. They are chronic toxins and have adverse effects on fertility and the function of reproductive system. Examples of mutagens are: ethidium bromide, Nitrous acid and radiation.

Teratogens: Teratogens are the agents or factors which cause abnormalities on the embryo, fetus malformations, growth retardation and post- natal deficiencies. These toxins can affect both men and women.

Chemical Carcinogen

Any specific chemical compound which is able to induce cancer in humans and animals is a chemical carcinogen. The exposure of these chemicals is commonly observed in laboratory operations, shops and art studios.

Cancer causing materials

Asbestos

Specific chemicals

Coal tars and emissions from coke oven

Hardwood sawdust

Natural products

Tobacco smoke

Ultraviolet radiation and Ionizing radiation

Check Your Progress 3

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Explain the health effects of the following:
   a. Carcinogen
   b. Mutagen
   c. Teratogen

Examples of chemical carcinogens are presented in Table 2.3.

Group	Examples
Epoxides	Ethylene oxide & Propylene oxide
Organohalogens	Vinyl chloride, Carbon tetrachloride Chloroform, Hexachlorobenzene, Trichloroethylene

Hydrazines	Hydrazine, 1,2-Dimethylhydrazine
N-Nitroso compounds	N-Nitrosodimethylamine
Aromatic Amines	Benzidine, Aniline, o-Anisidine, o-Toluidine
Aromatic hydrocarbons	Benzene, Benz[a]anthracene Benzo[a]pyrene
Some organic compounds	Formaldehyde, Acetaldehyde, 1, 4-Dioxane, Ethyl carbamate, 2-Nitropropane, Styrene, Thiourea Thioacetamide
Some inorganic compounds	Arsenic, Chromium, Thorium dioxide, Beryllium Cadmium, Lead, Nickel, Selenium sulfide and compounds

Cancer can also be caused by other factors like environmental or 'lifestyle' factors. They are Cigarette smoking (co-carcinogen), Alcohol consumption (co-carcinogen), Diet—high fat consumption, natural antioxidants, geographic location like industrial areas, UV light, some therapeutic drugs and Inherited conditions.

Determination of Chemical Carcinogens

Epidemiological studies are the best criteria to determine the relationship between a cancer suspect chemical and a human population. *In vivo* studies like animal research induce cancer directly in test animals, generally of two or more species with different dose and time parameters. These *in vivo* experiments with animals are based on the concept of chemicals that produce cancer in animals will have similar effects on human cells.

2.5 LET US SUM UP

Chemicals compounds can be degraded into various types of physical and chemical hazards. A chemical hazard can be considered a type of occupational hazard that is caused by work place exposure to chemicals that can have acute or long-term detrimental health effects. In this unit we have discussed chemical hazard by flammable chemical material, corrosive chemical material, reactive chemicals, and chemical toxins including neurotoxins, carcinogens, reproductive toxins, systemic toxins, and sensitizers that causes adverse health effects.

2.6 KEY WORDS

Acid : Any compound that releases hydrogen ions when dissolved in water

Cancer : A number of cellular changes that result in uncontrolled cellular growth

Corrosive : A corrosive substance is one that will damage or destroy other substances with which it comes into contact by means of a chemical reaction.

Hazard : Anything that can cause injury, disease or death to humans or damage to property or degradation of the environment.

Chemical Hazard : Any chemical that can cause injury, disease or death to humans and the natural environment.

Carcinogenic : Any compound or metal or substance having the property of cancer at least in animals and by implication, in humans.

Hazardous material : Any material having one or more of the attributes like ignitability, corrosivity, reactivity and toxicity.

Hydrocarbons : Natural or synthetic organic substances that are composed mainly of carbon and hydrogen.

Mutagenic : Causing mutations

Mutation : A random change in one or more genes of an organism.

Radioactive emission : Various forms of radiation or particles that may be given off by unstable isotopes. These emissions have very high energy and can destroy biological tissues or cause mutations leading to cancer or birth defects.

Teratogenic : Causing birth defects

2.7 REFERENCES & SUGGESTED FURTHER READINGS

Nick H. Proctor, James P. Hughes, Michael L. Fischman. 1988. Chemical Hazards of the work place. Lippincott Williams and Wilkins, 573 p.

Phillip Carson and Clive Mumford, 2002. Hazardous Chemical Hand Book. Butterworth-Heinemann ISBN 0 7506 4888 0, An imprint of Elsevier Science.

2.8 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answer should include the following points:

1. A chemical hazard is a type of occupational hazard caused by exposure to chemicals in the workplace. Exposure to chemicals in the workplace can cause acute or long-term detrimental health effects.

   Ex: Hazard by flammable material like methanol, acetonitrile etc.

2. The flammable liquid chemicals are basically skin irritants and are capable of damaging tissue, some are skin sensitizers. Adverse health hazard by inhalation of flammable chemicals depends on concentration of the chemical and toxicity of its vapor. Flammable chemicals and their toxic vapors present in the natural environment at below their lower explosive limit pose adverse health effects on human beings.

The effects of exposure to a chemical are dependent on many factors. Those factors include:

The **dose** is the amount of a chemical that actually enters the body. The dose of a chemical that a person receives is dependent on the concentration of the chemical and frequency and duration of the exposure.

Route of exposure. How the hazardous chemical enters the body determines how the material may travel through the body and effect organs or systems, physical **properties** of the chemical and the **susceptibility** of the individual receiving the dose. The toxic effects of hazardous materials may be local or systemic. Local injuries involve the area of the body in contact with the hazardous material and are typically caused by reactive or corrosive chemicals, such as strong acids, alkalis, or oxidizing agents. Systemic injuries involve tissues or organs unrelated to or removed from the contact site when toxins have been transported through the bloodstream. Certain hazardous materials may affect a target organ.

Answers to Check Your Progress 2

Your answer should include the following points:

1. c 2. a 3. b 4. e 5. d

Answers to Check Your Progress 3

Your answer should include the following points:

1. Carcinogen: A carcinogen is any substance, radionuclide, or radiation that promotes carcinogenesis, the formation of cancer. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes. Ex: gamma rays and alpha particles, which they emit. Common examples of non-radioactive carcinogens are inhaled asbestos, certain dioxins, and tobacco smoke

2. Mutagen: A mutagen is a physical or chemical agent that changes the genetic material, usually DNA, of an organism and thus increases the frequency of mutations above the natural background level. Common mutagens include: bromine, sodiumazide, benzene, x-rays, **gamma rays**, alpha particles, ultraviolet radiation, etc.

3. Teratogen: Any agent or factor which causes malformation of an embryo.Ex: alcohol, phenytoin, Varicella etc.