
UNIT 3 BIOLOGICAL HAZARDS

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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 antibiotics. 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.

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

