Lecture 1

EHS is an abbreviation for **Environment, Health & Safety**. As the name relating to the protection of both people and the environment. Typically, EHS programs are designed to minimize or eliminate risks associated with exposure to hazardous materials, work-related injuries, and environmental accidents.

Environmental health and safety (EHS or HSE) is the department in a company or an organization tasked with ensuring that the work undertaken by the company does not cause undue environmental damage, put the workers' health and safety at high risk, complies with applicable legislation, and follows best practices.

EHS aims to prevent and reduce accidents, emergencies, and health issues at work, along with any environmental damage that could result from work practices

Other abbreviations than EHS are also used:

Acronym	**Name**	**Group**
OHS	Occupational health and safety	Occupational health and safety
WHS	Work health and safety	Work health and safety
HSE	Health, safety and environment	Health, safety and environment
EHS	Environment, health and safety	
SHE	Safety, health and environment	
QHSE	Quality, health, safety, and environment	Quality, health, safety, and environment
HSEQ	Health, safety, environment and quality	
HSSE	Health, safety, security and environment	Health, safety, security and environment
QHSSE	Quality, health, safety, security, and environment	Quality, health, safety, security, and environment
HSSEQ	Health, safety, security, environment, and quality	

The General EHS Guidelines (principles)contain the following information

1. Environmental

1.1 Air Emissions and Ambient Air Quality
1.2 Energy Conservation
1.3 Wastewater and Ambient Water Quality
1.4 Water Conservation
1.5 Hazardous Materials Management
1.6 Waste Management
1.7 Noise
1.8 Contaminated Land

2. Occupational Health and Safety

2.1 General Facility Design and Operation
2.2 Communication and Training
2.3 Physical Hazards
2.4 Chemical Hazards
2.5 Biological Hazards
2.6 Radiological Hazards
2.7 Personal Protective Equipment (PPE)
2.8 Special Hazard Environments
2.9 Monitoring

3. Community Health and Safety

3.1 Water Quality and Availability
3.2 Structural Safety of Project Infrastructure
3.3 Life and Fire Safety (L&FS)
3.4 Traffic Safety
3.5 Transport of Hazardous Materials
3.6 Disease Prevention
3.7 Emergency Preparedness and Response

4. Construction and Decommissioning

4.1 Environment
4.2 Occupational Health and Safety
4.3 Community Health and Safety

The Practical Approach

The Environmental health and safety principles can be discussed under the following principles according to Knoll, 2014.

1. Protection of the Biosphere
2. Sustainable Use of Natural Resources
3. Waste Reduction and Disposal
4. Conservation
5. Risk Reduction
6. Safe Products and Services
7. Environmental Restoration
8. Public Information

Environmental Health Resources

To find out more about the importance of environmental health, take a look at the following resources:

- World Health Organization, Environmental Health — An overview of some of the issues that relate to environmental health.
- Centers for Disease Control and Prevention, National Center for Environmental Health — A range of resources related to environmental health.

Lecture 2

Eight Environmental Factors that Affect Health

eight key environmental factors that affect health:

1. Chemical safety
2. Air pollution
3. Climate change and natural disasters
4. Diseases caused by microbes
5. Lack of access to health care
6. Infrastructure issues
7. Poor water quality
8. Global environmental issues

1. Chemical Safety

Different chemicals can impact human health in different ways, and often, exposure to dangerous or foreign substances creates health vulnerabilities. The chemical safety field is concerned with minimizing the effects of both natural and synthetic chemicals. More specifically, chemical safety seeks to safeguard human and environmental health from exposure to potential toxins; it focuses on chemicals that exist in the ambient world, as well as synthetic chemicals that are used in industrial processes or are the by-products of manufacturing activity.

Public health officials who work in chemical safety often focus on toxicology, which is the study of substances that have a toxic effect on the human body, whether when ingested or when absorbed through natural surroundings. Another important aspect of public health is chemical risk assessment, which involves scientists and clinicians working to determine a substance's full biological effects.

This is a critical field of public health: According to the World Health Organization (WHO), more than 1.6 million deaths in 2016 were due to exposure to selected chemicals. Some examples of dangerous chemicals in the environment are heavy metals and toxins that find their way into the water supply and harmful pesticides that make their way into the food supply chain.

2. Air Pollution

Studies have shown that air pollution effects on humans are a significant public health concern, not only because of their role in climate change, but also because exposure to air pollution can increase morbidity and mortality.

When environmental scientists talk about air pollution, they're describing any solid or liquid particles, as well as gases, that are suspended in the air and have harmful or poisonous effects. When we think about air pollution, we tend to think in terms of human-caused pollutants, and rightly so: Some of the most dangerous and ubiquitous examples of air pollution include car and truck exhaust, as well as polluting by products of industrial processes. However, many natural air pollutants can cause health concerns; for example, pollen and mold spores are often linked with asthma and allergies.

According to the WHO, air pollution effects on humans are significant. For example, air pollution causes:

- 29% of all global deaths from lung disease
- 24% of all global deaths from stroke
- 17 % of all global deaths and disease from acute lower respiratory infection

3. Climate Change and Natural Disasters

Another environmental issue with serious ramifications for human health is climate change, along with the increase in natural disasters that has accompanied the shift in Earth's climate. The National Environmental Health Association lists climate change as the single biggest human health threat of the 21st century.

Climate change disrupts the natural world in a number of ways that can impede health and increase vulnerability to disease; these include increases in the planet's temperature and more frequent heavy rains and runoff. The various impacts may result in greater vulnerability to nervous and respiratory diseases, diarrhea, and more.

Additionally, climate change increases the frequency of natural disasters, often having a ravenous effect on homes and communities and sometimes resulting in loss of life. Wildfires, hurricanes, cyclones, and droughts are just a few examples.

4. Diseases Caused by Microbes

Diseases caused by microbes — also known as microorganisms — present another area of public health concern. Trillions of microbes exist within the human body, and they also live in water, soil, and air. Most of them have no negative health effects, and many microbes perform important biological functions, such as supporting digestive and immune health, according to the National Human Genome Research Institute. Bacteria, viruses, and fungi are types of microbes.

Harmful microbes, which are more commonly called pathogens or germs, can infect humans and cause illness. Eating is one of the primary ways in which humans can contract diseases caused by microbes. One example is food poisoning from E. coli, a type of bacteria that can be found in the environment and in foods, and which can cause respiratory illness, urinary tract infections, and other adverse health effects.

There are also a number of harmful microbes that live in the soil. Humans can come into contact with them by ingesting them (through contaminated food) or through inhaling them (through soil particles in the air). Tetanus and botulism are examples of diseases caused by soil-borne microbes.

5. Lack of Access to Health Care

Another environmental factor that contributes to disease and overall poor health outcomes is living in an area with a lack of access to health care services.

According to Healthy People, "Many people face barriers that prevent or limit access to needed health care services, which may increase the risk of poor health outcomes and health disparities." Some factors that contribute to lack of access to health care are economic instability, unreliable transportation to clinical facilities, and simple lack of education about the importance of preventive care.

Individuals who don't have access to health care services (including pharmaceuticals as well as dental care) are at a higher risk for chronic conditions, which may include asthma, cancer, diabetes, or heart disease.

6. Infrastructure Issues
Infrastructure issues can also have a major impact on community health. Examples include the following:

- Poorly maintained roads (increasing risk of car accidents)
- Lack of access to clean drinking water
- Lack of local health care infrastructure, such as clinics capable of giving vaccinations

Overcoming poor infrastructure requires the right allocation of resources from local, state, and federal governments, as well as a qualified workforce to keep infrastructure properly maintained.

7. Poor Water Quality
Verywell Health reports that across the world, more than 780 million people don't have access to clean drinking water; shockingly, about a third of the world's population lacks access to proper sanitation services (e.g., clean bathrooms). The health implications are sobering: Each day, more than 2,200 children die due to diseases caused by poor water quality.
A number of factors can contribute to poor water quality, including industrial waste and pollution, lack of access to proper water treatment and sanitation services, and outdated plumbing infrastructure.

8. Global Environmental Issues
Global environmental issues account for more than 12.6 million deaths each year, according to WHO data. Along with the issues mentioned here, these can include soil pollution, ultraviolet radiation, and biodiversity loss. According to the data, more than 100 illnesses and injuries can be directly linked to environmental health concerns. Often, these issues have the greatest impact on communities that are poor and already have significant health care vulnerabilities.

Lecture 3

Environmental health and safety plan

is a document which provides a framework for ensuring compliance with regulations pertaining to protection of personnel and environment.

The primary purposes of the EHS plan are to provide:

1. Safety information for employees in an organization

2. To provide documentation of compliance with occupational and environmental regulations.

3. To provide information to the EHS Department for use in determining job specific training requirements.

According to WHO global plan of action for workers health, Capacities should be built for primary prevention of occupational hazards, diseases and injuries, including strengthening of human, methodological & technological resources, training of workers and employers, introduction of healthy work practices and work organization and of a health-promoting &protecting culture at the workplace.

Strategic priorities of EHS plan are made to <u>include</u>

1-Environment: To provide the guide for an environmentally responsible organization that preserves and protects the natural resources.

2-Health: To provide the framework needed to minimize exposure to health risks and protect the well-being of employees and management.

3-Safety: To provide workers the knowledge the need to work in a safe environment without hazards.

Essential Elements of health and safety plan

According to McLeod and Ketcham, 2007 an effective environmental health and safety plan will include the following essential elements.

1. Hazard recognition, evaluation and control

This involves proactive recognition in terms of environment, the people actually doing the work, equipment/materials used in the work process and the processes/practices involved. Once hazards have been identified and prioritized they be controlled. The generally accepted hierarchy of control is elimination/substitution, engineering controls, personal protective equipment and administrative controls.

2. Workplace design and Engineering

In designing a workplace safety of life and environment must be of paramount importance. Some of the safety codes are already done by building codes through legislation. These include electrical and fire suppression standards. Other aspects involve ventilation, equipment/machine safeguarding processes

3. Workplace planning and staffing

For an effective environmental health and safety plan, an effective human resource management is critical. It includes the development of accurate job descriptions to take into consideration job duties (such as respirator use or hearing protection use, manual material handling, exposure to allergens) that may trigger the need for preemployment evaluations and medical surveillance. Limiting exposures by administrative controls or other safety considerations and development of safety rules would both be considered in this element.

4. Environmental Management

Environmental management is a very important element of the EHS plan. The plan takes into consideration the air emissions and all aspect of the environmental pollution. Issues from proper permitting to preventing potential environmental liability are considered in this element.

5. Organizational Communication

Communication within the organization keeps employees informed of new and existing policies, procedures, lessons learned, and missions. Likewise it provides avenues from the front line to upper management for consideration in the development and revision of those polices. The flow of information in both directions is critical for an effective Environmental health and safety plan.

6. Occupational Health

The nature and scope of an occupational health program can vary widely from company to company. Often in animal care settings one might expect pre-employment health evaluations, periodic medical surveillance, injury protocols (including first aid and bite/scratch procedures) and maintenance of medical records, and coordination with the departments when work related health and safety issues arise. One might typically find coordination of respiratory protection and hearing conservation programs within the Occupational Health component of a program.

7. Collection of information

Information collection aids proper decision making in designing an EHS plan. Equally important to collection of information is its subsequent management. The safety and health information collected must be managed properly to maintain regulatory compliance.

8. Involvement of employee

The involvement of employee in all aspects of a safety and health plan benefits both the employees and management. It also serves as a bridge of understanding for actions taken by the employer in terms of health and safety.

9. Motivation, Behavior, and Attitudes

The goal of this element is to change behavior and attitude to promote a safer and healthier workplace. It places great value on visible management leadership and support for changing unsafe behaviours, attitudes, and work processes.

Lecture 4
Occupational health and safety

Annually, an estimated 160 million new cases of work-related diseases occur worldwide, including respiratory and cardiovascular diseases, cancer, hearing loss, musculoskeletal and reproductive disorders, mental and neurological illnesses.

Reasons for these are:-
1-Workplace
• Unsafe building
• Old machines
• Poor ventilation
• Noise
• Inaccessible to inspection

2-Workers
• Limited education
• Limited skill and training

3-Employers
• Limited financial resources
• Low attention and knowledge

According to WHO (1995), occupational safety and health can be defined as a multidisciplinary activity aiming at:
• Protection and promotion of the health of workers by eliminating occupational factors and conditions hazardous to health and safety at work
• Enhancement of physical, mental and social well-being of workers and support for the development and maintenance of their working capacity, as well as professional and social development at work
• Development and promotion of sustainable work environments and work organizations

The ILO/WHO definition of occupational health is "The promotion and maintenance of the highest degree of physical, mental social well- being of workers in all occupation" and the WHO considers occupational health service to be responsible for the total of worker and, if possible, his or her family.

Occupational Health is a diverse science applied by occupational health professionals engineers, environmental health practitioners, chemists, toxicologists, doctors, nurses, safety professionals and others who have an interest in the protection of the health of workers in the workplace.

The U.S. Congress has passed three landmark pieces of legislation related to safeguarding workers' health:
(1) the Metal and Nonmetallic Mines Safety Act of 1966,
(2) the Federal Coal Mine Safety and Health Act of 1969, and
(3) the Occupational Safety and Health Act of 1970 (OSH Act). Today, nearly every employer is required to implement the elements of an industrial hygiene and safety, occupational health, or hazard communication program and to be responsive to the Occupational Safety and Health Administration (OSHA) and its regulations.

Elements of the work environment

The basic elements in an occupational setting such as a manufacturing plant, industry, or offices are four. These are:
1. The worker
2. The tool:
3. The process
4. The work environment

Basically, there are three types of interaction in a working environment: -
1. man and physical, chemical and biological agents.
a. The physical agents. These include excessive level of .. noise.. heat and humidity .. dust .. Vibration .. Electricity or lighting .. Radiation etc.
b. Chemical agents. These arises from excessive air borne concentrations of
- Chemical dust
- Mists
- Fumes
- Liquids
- Vapors
- Gases
- dust

C. The biological agents. These include
- Presence of insects and rodents
- Microorganisms
- Poisonous plants and animals

D.Ergonomic hazards. These include excessive improperly designed tools, work areas, or work procedures. Improper lifting or reaching, poor visual conditions, or repeated motions in an awkward position can result in accidents or illnesses in the occupational environment.

2. Man and machine

An industry or factory uses power driven machines for the purpose of mass production. Unguarded machines, protruding and moving parts, poor electrical and machinery installation of the plant, and lack of safety measures are the causes of accidents. Working for long hours in an awkward postures or positions is the causes of fatigue, backache, diseases of joints and muscles and impairment of the workers health and efficiency.

3. Man and his psychosocial environment.

There are numerous psychosocial factors, which operate at workplace. These are the human relationships among workers themselves and those in authorities over them.

Examples of psychosocial factors include:-
- The type and rhythm of work.
- Work stability.
- Service conditions.
- Job satisfaction.
- Leadership style.
- Security.
- Workers` participation and communication.
- Motivation and incentives.

Lecture 5

Classifications of occupational health and safety hazards

The various hazards which give rise to occupational injuries, diseases, disabilities or death through work may be classified as: -

1- Physical Hazards
2 -Mechanical Hazards
3 -Chemical Hazards
4 -Biological Hazards
5 -Ergonomic Hazards
6 -Psychosocial Hazards

1 Physical Hazards

Physical hazards, which can adversely affect health, include noise, vibration, ionizing and non-ionizing radiation, heat and other unhealthy microclimatic conditions. Between 10 and 30% of the workforce in industrialized countries and up to 80% in developing and newly industrialized countries are exposed to a variety of these potential hazards.

Physical hazard has possible cumulative or immediate effects on the health of employees. Therefore, employers and inspectors should be alert to protect the workers from adverse physical hazards.

A. Extremes of Temperature
B. Vibration Motion Conditions
C. Pressure –Atmospheric (high and low)
D. Ionizing and Non-Ionizing Radiation

The biological effects of radiation are thought of in terms of their effect on living cells. For low levels of radiation exposure, the biological effects are so small they may not be detected in epidemiological studies. The body repairs many types of radiation and chemical damage. Biological effects of radiation on living cells may result in a variety of outcomes, including:

1. Cells experience DNA damage and are able to detect and repair the damage.
2. Cells experience DNA damage and are unable to repair the damage. These cells may go through the process of programmed cell death, or **apoptosis**, thus eliminating the potential genetic damage from the larger tissue.
3. Cells experience a nonlethal DNA mutation that is passed on to subsequent cell divisions. This mutation may contribute to the formation of a cancer.

E. Noise

Noise is defined as unwanted sound. Sound is any pressure variation or a stimulus that produces a sensory response in the brain. The compression and expansion of air created when an object vibrates.

2- Mechanical Hazards

Mechanical factors include unshielded machinery, unsafe structures at the workplace and dangerous unprotected tools are among the most prevalent hazards in both industrialized and developing countries. They affect the health of a high proportion of the workforce. Most accidents could be prevented by applying relatively simple measures in the work environment, working practices, and safety systems and ensuring appropriate behavioural and management practices. This would significantly reduce accident rates within a relatively short period of time. Accident prevention programmes are shown to have high cost-effectiveness and yield rapid results. However, ignorance of such precautions, particularly in sectors where production has grown rapidly, has led to increasing rates of occupational accidents.

3-Chemical hazards are dependent on their:-

• Amount
• Concentration
• Time of exposure
• Mode of entry to the body
• Age
• Sex
• Health status
• Resistance of the exposed workers

The effects of chemical agents are as follows:

1. Asphyxiation
2. Systemic intoxication
3. Pneumoconiosis
4. Carcinogens
5. Irritation
6. Mutagencity

Among all chemical agents in work place the most notorious and most in contact with the skin or respiratory system that deserve attention is **solvent**

The following terms are used in the classification of dangerous substances in the classification, packing and labeling of dangerous substances regulations 1984.

A. **Corrosive Hazard**: Living tissues as well as equipment are destroyed on contact with these chemicals.
Caution: Do not breathe vapors and avoid contact with skin eyes, and clothing

B. Oxidizing Hazard: ignite combustible material or worsen existing fire and thus make fire fighting more difficult.
Caution: Keep away from combustible material. Restrict smoking in that area.

C. Harmful Hazard: Inhalation and insertion of or skin penetration by these
Caution: Avoid contact with the human body, including inhalation of vapors and in cases of malaise consult doctor.
D. Very toxic and toxic Hazard: The substances are very hazardous to health whether breathed, swallowed or in contact with the skin and may even lead to death.
Caution: Avoid contact with human body, and immediately consult a doctor in case of malaise.

E. Irritant Hazard: May have an irritant effect on skin, eyes and respiratory organs
Caution: Do not breathe vapors and avoid contact with skin and eye

F. Highly Flammable Hazard: Substances with flash point less than 60 ^{0} C
Caution: keep away source of ignition.

G. Explosive Hazard: Substances which may explode under certain condition
Caution: Avoid shock, friction, sparks and heat.

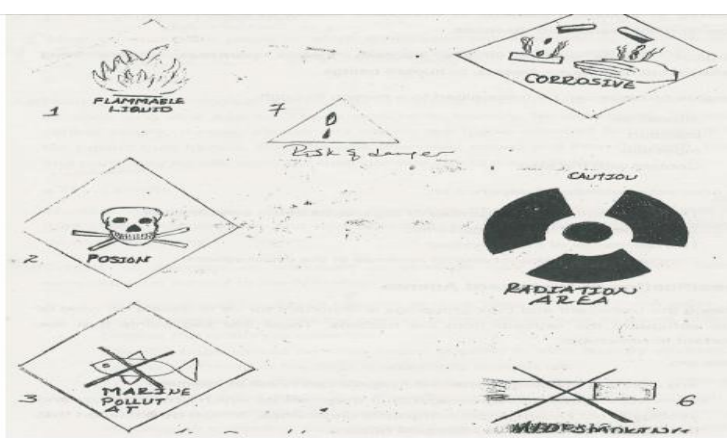

Figure 2-3. Hazard warning signs and symbols

Chemical Hazards Evaluation
• Toxicity assessment
• Work activity/risk assessment evaluation
• Assessment of controls effectiveness to block routes of entry
• Exposure monitoring
• Recommendations for improvement

4-Biological Hazards

Many biological agents such as viruses, bacteria, parasites, fungi, moulds and organic dusts have been found to occur in occupational exposures. In the industrialized countries around 15 % of workers may be at risk of viral or bacterial infection, allergies and respiratory diseases. In many developing countries the number one exposure is biological agents.

HIV/AIDS, Hepatitis B and C viruses and other blood borne pathogens, tuberculosis infections (particularly among health care workers), asthmas (among persons exposed to organic dust) and chronic parasitic infections (particularly among agricultural and forestry workers), are the most common occupational diseases that result from such exposures.

Exposure to biological hazards in workplace results in a significant amount of occupationally associated diseases.

Biological hazards include viruses, bacteria, fungus, parasites, or any living organism that can cause disease to human beings.

Biological hazards can be transmitted to a person through:
a. Inhalation
b. Injection
c. Ingestion
d. Contact with the skin

Biohazard Control Program
1. Employee health.
□ Pre-placement examination for new employee.
□ Periodic physical examination as part of a surveillance program.
□ Vaccination.

2. Laboratory safety and health.
 Employee training
 Avoid if possible entering into a biohazard areas.
 Avoid eating, drinking, smoking and gum chewing in biohazard areas
 Wearing personal protective equipment is always advisable.
3. Biological safety cabinet
 To protect workers from exposure to aerosols especially when there is contact with biohazards in laundry activities.
4. Animal care and handling
 Periodic examination, disposal of manure, cleanliness, collection of medical history and treatment.

5-Ergonomic Hazards

Ergonomics, also known as human engineering or human factors engineering, the science of designing machines, products, and systems to maximize the safety, comfort, and efficiency of the people who use them.

6-Psychosocial hazards

Up to 50% of all workers in industrial countries judge their work to be "mentally heavy". Psychological stress caused by time pressure, hectic work, and risk of unemployment has become more prevalent during the past decade. Other factors that may have adverse psychological effects include jobs with heavy responsibility for human or economic concerns, monotonous work or work that requires constant concentration.

Others are shift-work, jobs with the threat of violence, such as police or prison work, and isolated work. Psychological stress and overload have been associated with sleep disturbances, burn-out syndromes, stress, nervousness and depression. There is also epidemiological evidence of an elevated risk of cardiovascular disorders, particularly coronary heart disease and hypertension.

Lecture 6
Toxicology

Toxicology is the study of harmful interactions between chemicals and biological systems. Man, the other animals and plants in the modern world are increasingly being exposed to chemicals to enormous variety. These chemicals range from metals and inorganic chemicals to large complex organic molecules, yet they are all potentially toxic.

Routes of Entry into the Body

There are three main routes by which hazardous chemicals enter the body:

1. Inhalation. For industrial exposure, a major, if not predominant route of entry is inhalation. Any airborne substance can be inhaled. The total amount of a toxic compound absorbed via the respiratory pathways depends on its concentration in the air, the duration of exposure, and the pulmonary ventilation volumes, which increase with higher work loads.

2. Skin Absorption. An important route of entry for some chemicals is absorption through skin. Contact of a substance with skin results in these four possible actions.

- The skin can act as an effective barrier
- The substance can react with the skin and cause local irritation or tissue destruction
- The substance can produce skin sensitization
- The substance can penetrate skin to reach the blood vessels under the skin and enter the bloodstream

3. Ingestion. The problem of ingesting chemicals is not widespread in the industry; most workers do not deliberately swallow materials they handle.

Nevertheless ,workers can ingest toxic materials as result of eating in contaminated work areas; contaminated fingers and hands can lead to accidental oral intake when a worker eats or smokes on the job

4. Injection. Although infrequent in industry, a substance can be injected into some part of the body. This can be done directly into the bloodstream, peritoneal cavity, pleural cavity, skin, muscle, or any other place needle or high-pressure orifice can reach.

Dose-Response Relationships

Dose

The dose is the actual amount of a chemical that enters the body.
The dose received may be due to either acute (short) or chronic (long-term) exposure. An acute exposure occurs over a very short period of time, usually 24 hours. Chronic exposures occur over long periods of time such as weeks, months, or years. The amount of exposure and the type of toxin will determine the toxic effect.
What is dose-response?
Dose-response is a relationship between exposure and health effect that can be established by measuring the response relative to an increasing dose. This relationship is important in determining the toxicity of a particular substance. It relies on the concept that a dose, or a time of exposure (to a chemical, drug, or toxic substance), will cause an effect (response) on the exposed organism. Usually, the larger or more intense the dose, the greater the response, or the effect. This is the meaning behind the statement "the dose makes the poison."

Dose Response Assessment

The characteristics of exposure to a chemical and the spectrum of effects caused by the chemical come together in a correlative relationship that toxicologists call the dose-response relationship.
This relationship is the most fundamental and pervasive concept in toxicology.
To understand the potential hazard of a specific chemical, toxicologists must know both the type of effect it produces and the amount, or dose, required to produce that effect.
The relationship of dose to response can be illustrated as a graph called **a dose-response curve**. There are two types of dose response curves: one that describes the graded responses of an individual to varying doses of the chemical and one that describes the distribution of responses to different doses in a population of individuals. The dose is represented on the x-axis. The response is represented on the y-axis. The following graph shows a simple example of a dose-response curve for an individual with a single exposure to the chemical ethanol (alcohol), with graded responses between no effect and death.

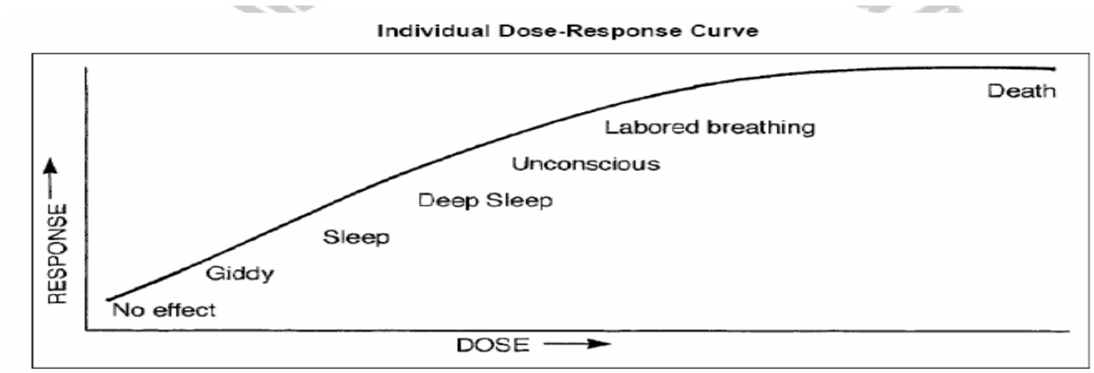

Figure 4-2. Individual Dose-Response Curve

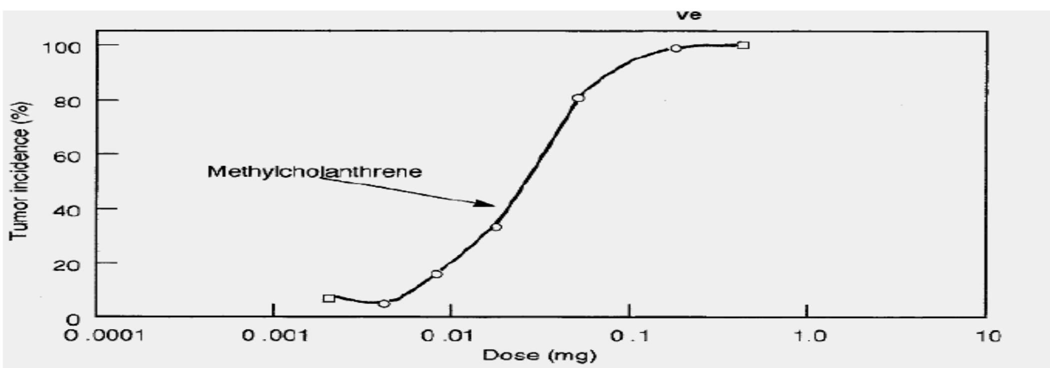

Figure 4-3. A dose-response curve for a population of mice in a study of a carcinogenic chemical

An important aspect of dose-response relationships is the concept of threshold. For most types of toxic responses, there is a dose, called a threshold, below which there are no adverse effects from exposure to the chemical. The human body has defenses against many toxic agents. Cells in human organs, especially in the liver and kidneys, break down chemicals into nontoxic substances that can be eliminated from the body in urine and feces. In this way, the human body can take some toxic insult (at a dose that is below the threshold) and still remain healthy.

LECTURE 7

Dose Estimates of Toxic Effects (LD, EC, TD)

Dose-response curves are used to derive dose estimates of chemical substances. A common dose estimate for acute toxicity is the LD50 (Lethal Dose 50%). This is a statistically derived dose at which 50% of the individuals will be expected to die. Other dose estimates also may be used. LD0 represents the dose at which no individuals are expected to die. This is just below the threshold for lethality. LD10 refers to the dose at which 10% of the individuals will die.

For inhalation toxicity, air concentrations are used for exposure values. Thus, the LC50 is utilized which stands for Lethal Concentration 50%, the calculated concentration of a gas lethal to 50% of a group. Occasionally LC0 and LC10 are also used. Effective Doses (EDs) are used to indicate the effectiveness of a substance. Normally, effective dose refers to a beneficial effect (relief of pain). It might also stand for a harmful effect (paralysis).

Toxic Doses (TDs) are utilized to indicate doses that cause adverse toxic effects. The knowledge of the effective and toxic dose levels aides the toxicologist and clinician in determining the relative safety of pharmaceuticals. As shown above, two dose-response curves are presented for the same drug, one for effectiveness and the other for toxicity. In this case, a dose that is 50-75% effective does not cause toxicity whereas a 90% effective dose may result in a small amount of toxicity.

Most exposure standards, Threshold Limit Values (TLVs) and Permissible Exposure Limits (PELs), are based on the inhalation route of exposure. They are normally expressed in terms of either parts per million (ppm) or milligrams per cubic meter (mg/m3) concentration in air. If a significant route of exposure for a substance is through skin contact, the MSDS will have a "skin" notation associated with the listed exposure limit. Examples include: some pesticides, carbon disulfide, phenol, carbon tetrachloride, dioxane, mercury, thallium compounds, ethylene, and hydrogen cyanide.

Toxic effects are generally categorized according to the site of the toxic effect. In some cases, the effect may occur at only one site.

This site is referred to as the specific target organ. In other cases, toxic effects may occur at multiple sites. This is referred as systemic toxicity. Following are types of systemic toxicity:

1. Acute Toxicity
Acute toxicity occurs almost immediately (hours/days) after an exposure. An acute exposure is usually a single dose or a series of doses received within a 24 hour period. Death is a major concern in cases of acute exposures. Examples are: In 1989, 5,000 people died and 30,000 were permanently disabled due to exposure to methyl isocyanate from an industrial accident in India. Many people die each year from inhaling carbon monoxide from faulty heaters. Non-lethal acute effects may also occur, e.g., convulsions and respiratory irritation.

2. Sub-chronic Toxicity
Subchronic toxicity results from repeated exposure for several weeks or months. This is a common human exposure pattern for some pharmaceuticals and environmental agents. Examples are: Ingestion of coumadin tablets (blood thinners) for several weeks as a treatment for venous thrombosis can cause internal bleeding. Workplace exposure to lead over a period of several weeks can result in anemia.

3. Chronic Toxicity
Chronic toxicity represents cumulative damage to specific organ systems and takes many months or years to become a recognizable clinical disease.

4. Carcinogenicity
Carcinogenicity is a complex multistage process of abnormal cell growth and differentiation which can lead to cancer.

5. Developmental Toxicity
Developmental Toxicity pertains to adverse toxic effects to the developing embryo or fetus. This can result from toxicant exposure to either parent before conception or to the mother and her developing embryo-fetus.

6. Genetic Toxicity (somatic cells)
Chemicals cause developmental toxicity by two methods. They can act directly on cells of the embryo causing cell death or cell damage, leading to abnormal organ development. A chemical might also induce a mutation in a parent's germ cell which

is transmitted to the fertilized ovum. Some mutated fertilized ova develop into abnormal embryos.
Genetic Toxicity results from damage to DNA and altered genetic This process is known as **mutagenesis**. The genetic change is referred to as a mutation and the agent causing the change as a mutagen. There are three types of genetic change: If the mutation occurs in a germ cell the effect is heritable. There is no effect on the exposed person; rather the effect is passed on to future generations. If the mutation occurs in a somatic cell, it can cause altered cell growth (e.g. cancer) or cell death (e.g. teratogenesis) in the exposed person.

Types of organ specific toxic effects are:

Blood and Cardiovascular Toxicity results from xenobiotics acting directly on cells in circulating blood, bone marrow, and heart. Examples of blood and cardiovascular toxicity are:
- hypoxia due to carbon monoxide binding of hemoglobin preventing transport of oxygen
- decrease in circulating leukocytes due to chloramphenicol damage to bone marrow cells
- leukemia due to benzene damage of bone marrow cells

Dermal Toxicity may result from direct contact or internal distribution to the skin. Effects range from mild irritation to severe changes, such as corrosivity, hypersensitivity, and skin cancer. Examples of dermal toxicity are:
- Dermal irritation due to skin exposure to gasoline
- Dermal corrosion due to skin exposure to sodium hydroxide(lye)

Eye Toxicity results from direct contact or internal distribution to the eye. The cornea and conjunctiva are directly exposed to toxicants. Thus, conjunctivitis and corneal erosion may be observed following occupational exposure to chemicals. Many household items can cause conjunctivitis. Chemicals in the circulatory system can distribute to the eye and cause corneal opacity, cataracts, retinal and optic nerve damage. For example:
- Acids and strong alkalis may cause severe corneal corrosion
- Corticosteroids may cause cataracts
- Methanol (wood alcohol) may damage the optic nerve

Hepatotoxicity is toxicity to the liver, bile duct, and gall bladder. The liver is particularly susceptible to xenobiotics due to a large blood supply and its role in metabolism. Thus it is exposed to high doses of the toxicant or its toxic metabolites. Immunotoxicity is toxicity of the immune system. It can take several forms: hypersensitivity (allergy and autoimmunity), immunodeficiency, and uncontrolled proliferation (leukemia and lymphoma). The normal function of the immune system is to recognize and defend against foreign invaders.

Nephrotoxicity The kidney is highly susceptible to toxicants for two reasons. A high volume of blood flows through it and it filtrates large amounts of toxins which can concentrate in the kidney tubules. Nephrotoxicity is toxicity to the kidneys. It can result in systemic toxicity causing:
- decreased ability to excrete body wastes
- inability to maintain body fluid and electrolyte balance

Neurotoxicity represents toxicant damage to cells of the central nervous system (brain and spinal cord) and the peripheral nervous system (nerves outside the CNS). The primary types of neurotoxicity are:
- neuronopathies (neuron injury)
- axonopathies (axon injury)
- demyelination (loss of axon insulation)
- interference with neurotransmission

Reproductive Toxicity involves toxicant damage to either the male or female reproductive system. Toxic effects may cause:
- infertility
- interrupted pregnancy (abortion, fetal death, or premature delivery)
- infant death or childhood morbidity
- chromosome abnormalities and birth defects
- childhood cancer

Respiratory Toxicity relates to effects on the upper respiratory system (nose, pharynx, larynx, and trachea) and the lower respiratory system (bronchi, bronchioles, and lung alveoli). The primary types of respiratory toxicity are:
- pulmonary irritation
- asthma/bronchitis
- reactive airway disease

- emphysema
- allergic alveolitis
- Pneumoconiosis
- lung cancer

Lecture 8

Evaluation Of Occupational Health And Safety Hazards

1.Explain methods used to evaluate workplace hazards
3. Discuss types of sampling
4. Interpreter the results

Once the contaminants have been identified, it is necessary to measure the extent of the contamination. Evaluation is an important part of the procedure for measurement. Measured level of contamination must be compared with existing hygiene standards (always assuming there is such a standard applicable to the material in question), such as exposure limits, control limits and recommended limits. In addition, the duration and frequency of exposure to the contaminants must be taken into account. Following a comprehensive evaluation, a decision must be made as to the actual degree of risk to workers involved. This degree of risk will determine the control strategy to be applied.

Evaluation of occupational hazards
Evaluation can be defined as the decision making process that results in an opinion as to the degree of risk arising from exposure to chemical, physical, biological, or other agents. It also involves making a judgment of the magnitude of these agents and determines the levels of contaminants arising from a process or work operation and the effectiveness of any control measures used.

Method of sampling
Grab Sampling Vs integrated Sampling
Air sampling can be conducted for long or short periods depending upon what type of information is needed.
Instantaneous or grab Sampling is the collection of an air sample over a short period whereas longer period of sampling is called integrated sampling.
1. Grab samples represent the environmental concentration at a particular point in time. It is ideal for following cyclic process and for determining air- borne

concentration of brief duration but it is seldom used to estimate eight-hour average concentration.
2. In integrated sampling, a known volume of air is passed through a collection media to remove the contaminant from the sampled air stream. It is the preferred method of determining time weighted averages exposure.

Types of sampling

Area or environmental sampling Vs personal sampling

Environmental sampling includes sampling for gases, vapors, aerosol concentrations, noise, temperature etc. Which are found on the worker or the general work area or environment.

Area or general room air samplings are taken at fixed locations in the work place. This type of sampling does not provide a good estimate of worker exposure. For this reason it is used mainly to pinpoint high exposure areas, indicate flammable or explosive concentrations, or determine if an area should be isolated or restricted to prevent employees from entering a highly contaminated area.

Personal sampling

The objective of personal sampling is to see the extent of exposure of the person working on a particular contaminant while he/she is working at a location or work place. For example, if the worker is working in a garage where cars are painted the area as a whole is sampled to see how much lead which is present in all car paints, is on the air but with personal sampling one can determine how much are inhaled by the person performing the work or those who are working near by. In short it is the preferred method of evaluating workers exposure to air contaminants.

Health surveillance

The Occupational Health and Safety act requires medical surveillance of workers for the protection of worker's health At its simplest health surveillance might just be to keep medical records but there is also sophisticated tests that can be used

Biological measurements

Biological effect measurements
• Medical tests e.g. Kidney function tests, Lung function tests, Chest x-rays, etc.
• Biological Sampling

Biological sampling provides us with different information than air sampling. It indicates exactly what has been absorbed into the body rather than what is in the environment. Biological Sampling can be defined as the measurement of a substance or it's metabolites in body tissues or fluids to assess the working environment or the risk to exposed workers.

LECTURE 8

Measurement of occupational hazards

a. Particulate matter measurement

To measure dust exposure, it is necessary to determine the composition of dust that are suspended in the air where workers breathe. Operation that involves the crushing, grinding, or polishing of minerals or mineral mixtures frequently do not produce airborne dusts that have the same size composition.

When air samples are collected in the immediate vicinity of dust producing operation, larger particles that have not yet had time to settle from the air may be collected. If a larger number of these particles appear in the dust sample, the effect of their presence may have to be evaluated separately.

To evaluate either the relative hazard to health posed by dusts or effectiveness of dust control measures, one must have a method of determining the extent of the dust problem. Ideally the method employed should be as closely related to the health hazard as possible. The basic methods are briefly discussed below.

1. Count Procedure

The concern of industrial hygienists has been to measure the fraction of dust that can cause pneumoconiosis. Since it has been recognized that only dust particle smaller than approximately 10 micrometer are deposited and retained in the lung method were sought to measure the concentration of these tiny particles. Microscopic counting of dust collected has long been used for this purpose.

2. " Total" Mass Concentration Method

The simplest method of measuring dust concentration is to determine the total weight of dust collected in a given volume of air. The "total" mass, however, is determined to a considerable extent by the large dust particle, which can not penetrate to the pulmonary space and cause adverse health effect. Thus the total dust concentration by weight is not a reliable index of "respirable" dust concentration. This is because in this method of measurement the proportion of dust that is small enough to penetrate into the pulmonary space (respirable dust 2.5-micrometer) is extremely variable ranging from 5 percent to 60 percent.

3. Respirable Mass Size Selection Measurement (Personal sampling)

When measuring respirable dust the method now commonly used is personal or breathing zone respirable mass sampling? Dust collection devices now available for this method of sampling also provide a means for a size frequency analysis of the collected dust.

Respirable mass samples are preferably taken over a full 8 hour shift. However, multiple, shorter period samples (over a 2-4 hour period) may be collected during an individual full shift period.
In general, any dust particle producing activity will have respirable dust. For example road construction, cotton ginning, stone crushing and milling site, farm sites etc all produce same amount of dust. By practice 30-40% of dust are respirable. Even if we cannot measure the particle size using instrument, we can tell by the mass produced in a certain work site that the worker is exposed to respirable dust particle.

Air sampling instruments
The sampling instruments are geared to the type of air contaminants that occur in the work place that will depend upon the new materials used and the processes employed.
Air contamination can be divided into two broad groups depending upon physical characteristics.
- Gases and vapors
- Particulate

Type of Air Sampling
The type of air sampling to be used depends upon a number of factors.
- The type of sampling
- The equipment available
- The environmental condition
- The nature of the toxic contaminants

b. Noise Evaluation
The purposes of a detailed noise survey are:
1. To obtain specific information on the noise levels existing at each employee Workstation
2. To develop guidelines for establishing engineering and/or administrative Controls.
3. To define areas where hearing protection will be required.
4. To determine those work areas where audiometric testing of employees is desirable and/or required.

Surveys will help us to determine:
- Whether noise problems exist or not;
- How noisy is created in each work place or station,
- What equipment or process is producing the noise,

- Which employees are exposed to the noise often,
- Duration of exposure to the noise, etc.

Therefore, for evaluation purposes noise measurement is conducted using such strategy such as:
1. Measuring noise levels using area measurement methods
2. Work station measurement

Sound Survey
Sound measurement falls into two broad categories.
1. Source measurement
2. Ambient-noise measurement

Source measurement involves the collection of acoustical data for the purpose of determining the characteristics of noise radiated by a source.
Ambient noise measurement ranges from studying a single sound level to making a detailed analysis showing hundreds of components of complex variations.

Because of the fluctuating nature of many industrial noise levels, it would not be accurate or meaningful to use a single sound level meter reading. For this reason a preliminary and a detailed noise survey has to be conducted in the industry.

There are wide assortments of equipment available for noise Measurement. Some of these instruments are:
1. Sound Survey meter / Sound level meter/
2. Octave band analyzers
3. Narrow band analyzers
4. Tape and graphic level recorders
5. Impact sound level meters
6. Dosimeter

For most noise problems encountered in industries, the sound level meter and octave band analyzer, and if available noise dosimeter provide ample information.
Sound level Meter/Sound survey meter/ This is one of the basic instruments used to measure sound pressure variations in air. This instrument contains a microphone, an amplifier with a calibrated attenuator, a set of frequency response networks, and an indicating meter. It is an electronic voltmeter that measures the electrical signal emitted from a microphone attached to the instrument. Exposure duration at workstation where the regular noise levels varies above 85 dBA.

Assessing the thermal environment Heat stress

This is a real challenge as there is not only one but four environmental parameters which must be considered. The extent of stress suffered depends on:

Air temperature: commonly what we would call the room temperature. At its simplest we could measure it with ordinary mercury in glass thermometer.

Radiant Temperature: This is measured by using a globe thermometer. This consists of a hollow copper sphere measuring about 15cm in diameter, and painted black. A mercury-in-glass thermometer is inserted into the sphere to a point such that the bulb of the thermometer is at its center. Radiant heat is absorbed by the sphere, which gives this as a higher reading.

Humidity:

The classical instrument for determining humidity is the whirling hygrometer. It contains two thermometers side by side. The bulb of one thermometer is covered with a wetted fabric, whereas that of the other is left dry. As the instrument is whirled the water evaporates from the fabric and the evaporative effect cools the thermometer bulb referred to as the wet-bulb thermometer. The wet bulb reading is usually lower than the dry bulb reading. The differences between these two thermometers depend upon the amount of moisture already in the air. The greater the difference between the thermometers the drier the air and the greater the potential to cool down through sweating.

Air movement

This is commonly measured with hot wire anemometers and vane anemometers. The older but still very accurate instrument is the kata thermometer.

Kata thermometer: This is an alcohol filled thermometer with a large bulb coated with silvery material. When used, the bulb is heated in warm water until the alcohol rises into the upper reservoir. Then the bulb is dried with a clean dry cloth and suspended in the air. The time the alcohol takes to fall from the upper limit to the lower limit on the stem is timed using a stopwatch. From the cooling time, the drybulb temperature and the kata factor, which is usually printed on the stem, air speed can be read from the monogram provided with the instrument.

Illumuinance

Use photocells based upon silicon or selenium and they also incorporate colour-correcting filters to match the sensitivity of the human eye. The photocell also needs to be cosine corrected. Without this, light arriving at glancing angles is underestimated.

Questions and Exercises

1. Take a walk around your college or university. Assess the safety of your campus. Look at traffic, lighting, accessibility, indoor air, obstruction, classroom conditions, sanitation, and related factors. Make suggestions to improve the safety of campus and submit the suggestions to the responsible body in your campus.
2. Explain the difference between grab sampling and integrated sampling?
3. How can you evaluate the level of noise in occupational setting?
4. Mention the occupational exposure to noise in your college or university ”Community”.
5. Evaluate your classroom in terms of biological hazard, noise, dust, ergonomic and other physical hazards.

Lecture 9

Hierarchy of Prevention and control methods

Generally, there are five major categories of prevention and control measures: elimination, substitution, engineering controls, administrative controls and personal protective equipment.

1. Elimination

2. Substitution

substitutions include using:

- Less hazardous instead of toxic ones.
- Detergent plus water cleaning solutions instead of organic solvents
- Freon instead of methyl bromide chloride as a refrigerant
- Leadless glazes in the ceramics industry
- Leadless pigments in paints
- Synthetic grinding wheels (such as aluminum oxide) instead of sandstone wheels.

3. Engineering controls

An engineering control may mean changing a piece of machinery (for example, using proper, machine guards) or a work process to reduce exposure to a hazard; working a limited number of hours in a hazardous area ; and there are number of common control measures which are called engineering control. This includes enclosure, isolation and ventilation.

3.1 Enclosure

If a hazardous substance or work process cannot be eliminated or substituted, then enclosure the hazard is the next best method of control. Many hazards can be controlled by partially or totally enclosing the work process. Highly toxic materials that can be released into the air should be totally enclosed, usually by using a mechanical handling device or a closed glove system that can be operated from the outside.

3.2 Isolation

Isolation can be an effective method of control if a hazardous material can be moved to a part of work place where fewer people will be exposed, or if a job can be changed to a shift when fewer people are exposed (such as weekend or midnight shift).

3.3 Ventilation

Ventilation in work place can be used for two reasons:

1) to prevent the work environment from being too hot, cold, dry or humid.

2) to prevent contaminates in the air from getting into the area where workers breathe.

4. Administrative Controls

Administrative controls limits the amounts of time workers spend at hazardous job locations. Administrative control can be used together with other methods of control to reduce exposure to occupational hazards.

<u>Some examples of administrative controls include:</u>

- Changing work schedules, for example two people may be able to work 4 hours each at a job instead of one person working for 8 hours at that job.
- Giving workers longer rest periods or shorter work shits to reduce exposure time
- Moving a hazardous work process so that few people will be exposed
- Changing a work process to a shift when fewer people are working
- Workers promotion
- Provision of health and sanitation facilities

An example of administrative controls being used together with engineering controls and personal protective equipment is: a four hour limit for work in a fully enclosed high noise area where ear protectors are required.

Remember: administrative controls only reduce the amount of time you are exposed to hazard – they do not eliminate exposure.

5. Personal protective equipment

Personal protective equipment (PPE) is the least effective method of controlling occupational hazards and should be used only when other methods cannot control hazards sufficiently. PPE can be uncomfortable, may decrease work performance and may create new health and safety hazards. For example, ear protectors can prevent hearing warning signals, respirators can make it harder to breathe, earplugs may cause infection and leaky gloves can trap and spread hazardous chemicals against the skin.