INTRODUCTION TO ENVIRONMENTAL TOXICOLOGY

Toxicology

Toxicology is the study of how natural or man-made poisons causes undesirable effects in living organisms.

Harmful or adverse effects

Harmful or adverse effects are those that are damaging to either the survival or normal function of the individual.

What is Toxic?

This term relates to poisonous or deadly effects on the body by inhalation (breathing), ingestion (eating), or absorption, or by direct contact with a chemical.

What is a Toxicant?

A toxicant is any chemical that can injure or kill humans, animals, or plants; a poison. The term "toxicant" is used when talking about toxic substances that are produced by or are a by-product of human-made activities. For example, dioxin (2,3-7,8-tetrachlorodibenzo- p-dioxin {TCDD}), produced as a by-product of certain chlorinated chemicals, is a toxicant. On the other hand, arsenic, a toxic metal, may occur as a natural contaminant of groundwater or may contaminate groundwater as a by-product of industrial activities. If the second case is true, such toxic substances are referred to as toxicants, rather than toxins.

What is a Toxin?

The term "toxin" usually is used when talking about toxic substances produced naturally. A toxin is any poisonous substance of microbial (bacteria or other tiny plants or animals), vegetable, or synthetic chemical origin that reacts with specific cellular components to kill cells, alter growth or development, or kill the organism.

What is a Toxic Symptom?

This term includes any feeling or sign indicating the presence of a poison in the system.

What are Toxic Effects?

This term refers to the health effects that occur due to exposure to a toxic substance; also known as a poisonous effect on the body.

The Field of Toxicology

Toxicology addresses a variety of questions. For example, in agriculture, toxicology determines the possible health effects from exposure to pesticides or herbicides, or the effect of animal feed additives, such as growth factors, on people. Toxicology is also used in laboratory experiments on animals to establish dose-response relationships. Toxicology also deals with the way chemicals and waste products affect the health of an individual

Sub-disciplines of Toxicology

The field of toxicology can be further divided into the following sub-disciplines or sub-specialities:

Environmental Toxicology is concerned with the study of chemicals that contaminate food, water, soil, or the atmosphere. It also deals with toxic substances that enter bodies of waters such as lakes, streams, rivers, and oceans. This sub-discipline addresses the question of how various plants, animals, and humans are affected by exposure to toxic substances.

Occupational (Industrial) Toxicology ;

is concerned with health effects from exposure to chemicals in the workplace. This field grew out of a need to protect workers from toxic substances and to make their work environment safe. Occupational diseases caused by industrial chemicals account for an estimated 50,000 to 70,000 deaths, and 350,000 new cases of illness each year in the United States

Regulatory Toxicology;

gathers and evaluates existing toxicological information to establish concentration-based standards of "safe" exposure. The standard is the level of a chemical that a person can be exposed to without any harmful health effects.

Food Toxicology;

is involved in delivering a safe and edible supply of food to the consumer. During processing, a number of substances may be added to food to make it look, taste, or smell better. Fats, oils, sugars, starches and other substances may be added to change the texture and taste of food.

All of these additives are studied to determine if and at what amount, they may produce adverse effects. A second area of interest includes food allergies. Almost 30% of the American people have some food allergy. For example, many people have trouble digesting milk, and are lactose intolerant. In addition, toxic substances such as pesticides may be applied to a food crop in the field, while lead, arsenic, and cadmium are naturally present in soil and water, and may be

absorbed by plants. Toxicologists must determine the acceptable daily intake level for those substances.

Clinical Toxicology ;

is concerned with diseases and illnesses associated with short term or long term exposure to toxic chemicals. Clinical toxicologists include emergency room physicians who must be familiar with the symptoms associated with exposure to a wide variety of toxic substances in order to administer the appropriate treatment.

Descriptive Toxicology;

is concerned with gathering toxicological information from animal experimentation. These types of experiments are used to establish how much of a chemical would cause illness or death. The United States Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food

and Drug Administration (FDA), use information from these studies to set regulatory exposure limits.

Forensic Toxicology

is used to help establish cause and effect relationships between exposure to a drug or chemical and the toxic or lethal effects that result from that exposure.

Analytical toxicology

identifies the toxicant through analysis of body fluids, stomach content, excrement, or skin.

Mechanistic Toxicology

makes observations on how toxic substances cause their effects. The effects of exposure can depend on a number of factors, including the size of the molecule, the specific tissue type or cellular components affected, whether the substance is easily dissolved in water or fatty tissues, all of which are important when trying to determine the way a toxic substance causes harm, and whether effects seen in animals can be expected in humans.

What is Selective Toxicity?

“Selective toxicity” means that a chemical will produce injury to one kind of living matter without harming another form of life, even though the two may exist close together.

How Does Toxicity Develop?

Before toxicity can develop, a substance must come into contact with a body surface such as skin, eye or mucosa of the digestive or respiratory tract. The dose of the chemical, or the amount one comes into contact with, is important when discussing how "toxic" an substance can be.

What is a 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."

What is the threshold dose?

Given the idea of a dose-response, there should be a dose or exposure level below which the harmful or adverse effects of a substance are not seen in a population. That dose is referred to as the 'threshold dose'. This dose is also referred to as the no observed adverse effect level (NOAEL), or the no effect level (NEL). These terms are often used by toxicologists when discussing the relationship between exposure and dose. However, for substances causing cancer (carcinogens), no safe level of exposure exists, since any exposure could result in cancer.

'individual susceptibility'

This term describes the differences in types of responses to hazardous substances, between people. Each person is unique, and because of that, there may be great differences in the response to exposure. Exposure in one person may have no effect, while a second person may become seriously ill, and a third may develop cancer.

"sensitive sub-population"

A sensitive sub-population describes those persons who are more at risk from illness due to exposure to hazardous substances than the average, healthy person. These persons usually include the very young, the chronically ill, and the very old. It may also include pregnant women and women of childbearing age. Depending on the type of contaminant, other factors (e.g., age, weight, lifestyle, sex) could be used to describe the population.

Classification of Toxic Agents ;

Toxic substances are classified into the following:

A. Heavy Metals

Metals differ from other toxic substances in that they are neither created nor destroyed by humans. Their use by humans plays an important role in determining their potential for health effects. Their effect on health could occur through at least two mechanisms: first, by increasing the presence of heavy metals in air, water, soil, and food, and second, by changing the structure of the chemical. For example, chromium III can be converted to or from chromium VI, the more toxic form of the metal.

B. Solvents and Vapors

Nearly everyone is exposed to solvents. Occupational exposures can range from the use of "white-out" by administrative personnel, to the use of chemicals by technicians in a nail salon. When a solvent evaporates, the vapors may also pose a threat to the exposed population.

C. Radiation and Radioactive Materials

Radiation is the release and propagation of energy in space or through a material medium in the form of waves, the transfer of heat or light by waves of energy, or the stream of particles from a nuclear reactor

D. Dioxin/Furans

Dioxin, (or TCDD) was originally discovered as a contaminant in the herbicide Agent Orange. Dioxin is also a by-product of chlorine processing in paper producing industries.

E. Pesticides

The EPA defines pesticide as any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest. Pesticides may also be described as any physical, chemical, or biological agent that will kill an undesirable plant or animal pest

F. Plant Toxins

Different portions of a plant may contain different concentrations of chemicals. Some chemicals made by plants can be lethal. For example, taxon, used in chemotherapy to kill cancer cells, is produced by a species of the yew plant.

G. Animal Toxins

These toxins can result from venomous or poisonous animal releases. Venomous animals are usually defined as those that are capable of producing a poison in a highly developed gland or group of cells, and can deliver that toxin through biting or stinging. Poisonous animals are generally regarded as those whose tissues, either in part or in their whole, are toxic.

Subcategories of Toxic Substance Classifications

All of these substances may also be further classified according to their:

Effect on target organs (liver, kidney, hematopoietic system),

Use (pesticide, solvent, food additive),

Source of the agent (animal and plant toxins),

Effects (cancer mutation, liver injury),

Physical state (gas, dust, liquid),

Labeling requirements (explosive, flammable, oxidizer),

Chemistry (aromatic amine, halogenated hydrocarbon), or

Poisoning potential (extremely toxic, very toxic, slightly toxic)

General Classifications of Interest to Communities

Air pollutants

Occupation-related

Acute and chronic poisons

All chemicals (or any chemical) may be poisonous at a given dose and through a particular route. For example, breathing too much pure oxygen, drinking excessive amounts of water, or eating too much salt can cause poisoning or death