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Toxicology
(B.Sc.- Zoology Sem. - V)

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Toxicology

Introduction

Toxicology is the study of the toxic or harmful effects of chemicals. It is also concerned with the symptoms and treatment of poisoning and the identification of the poison.

There are several fields of toxicology, including environmental (e.g., air and water pollution), economic (e.g., food additives, pesticides), legal (e.g., forensics, regulation of emissions, and additives), laboratory (e.g., analytical testing for chemicals), and biomedical (e.g., toxicities of drugs used to treat disease in humans and animals).

Intentional and accidental poisonings are major medical problems. Every natural or synthetic chemical can cause injury if the dose is high enough.

Heavy metal toxicity

Heavy metal poisoning refers to excessive exposure to a heavy metal which affects the normal function of the body. Examples of heavy metals that can cause toxicity include lead, mercury, arsenic, cadmium, and chromium. Toxicity can result from sudden, severe exposure, or from chronic exposure over time.

Main causes of heavy metal pollution

Emissions from activities and sources such as industrial activities, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues and spillage of petrochemicals lead to soil

Heavy metals are among the most important sorts of contaminant in the environment. Several methods already used to clean up the environment from these kinds of contaminants, but most of them are costly and difficult to get optimum results. Currently, phytoremediation is an effective and affordable technological solution used to extract or remove inactive metals and metal pollutants from contaminated soil and water. This technology is environment friendly and potentially cost effective. Many species of plants have been successful in absorbing contaminants such as lead, cadmium, chromium, arsenic, and various radionuclides from soils. One of phytoremediation categories, phytoextraction, can be used to remove heavy metals from soil using its ability to uptake metals which are essential for plant growth (Fe, Mn, Zn, Cu, Mg, Mo, and Ni). Some metals with unknown biological function (Cd, Cr, Pb, Co, Ag, Se, Hg) can also be accumulated.

LEAD POISONING

Lead production workers, battery plant workers, welders and solders may be overexposed to lead if proper precautions are not taken. Lead is stored in the bone but may affect any organ system. The effects of lead poisoning vary depending on the age of the individual and the amount of exposure.

In children, symptoms vary depending upon the degree of exposure to lead. Some affected individuals may not have any noticeable symptoms. Symptoms usually develop over a three to six-week time period. Lead overexposure may cause children to be less playful, clumsier, irritable, and sluggish (lethargic). In some cases, symptoms include headaches, vomiting, abdominal pain, lack of appetite (anorexia), constipation, slurred speech (dysarthria), changes in kidney function, unusually high amounts of protein in the blood (hyperproteinaemia), and unusually pale skin (pallor) resulting from a low level of iron in the red blood cells (anaemia). Neurological symptoms associated with lead overexposure include an impaired

ability to coordinate voluntary movements (ataxia), brain damage (encephalopathy), seizures, convulsions, swelling of the optic nerve (papilledema), and/or impaired consciousness. Some affected children experience learning or behavioural problems such as mental retardation and selective deficits in language, cognitive function, balance, behaviour, and school performance. In some cases, symptoms may be life-threatening.

In adults, overexposure to lead may cause high blood pressure and damage to the reproductive organs. Additional symptoms may include fever, headaches, fatigue, sluggishness (lethargy), vomiting, loss of appetite (anorexia), abdominal pain, constipation, joint pain, loss of recently acquired skills, incoordination, listlessness, difficulty sleeping (insomnia), irritability, altered consciousness, hallucinations, and/or seizures. In addition, affected individuals may experience low levels of iron in the red blood cells (anaemia), peripheral neuropathy, and, in some cases, brain damage (encephalopathy). Some affected individuals experience decreased muscle strength and endurance; kidney disease; wrist drop; and behavioural changes such as hostility, depression, and/or anxiety. In some cases, symptoms may be life-threatening.

Lead is excreted in urine and faeces. However, it may also appear in hair, nails, sweat, saliva, and breast milk.

CADMIUM POISONING

Cadmium is used for many items, including electroplating, storage batteries, vapor lamps and in some solders. The onset of symptoms may be delayed for two to four hours after exposure. Overexposure may cause fatigue, headaches, nausea, vomiting, abdominal cramps, diarrhoea, and fever. In addition, progressive loss of lung function (emphysema), abnormal build-up of fluid within the lungs (pulmonary

edema), and breathlessness (dyspnea) may also be present. In some cases, affected individuals may exhibit increased salivation; yellowing of the teeth; an unusually rapid heartbeat (tachycardia); low levels of iron within the red blood cells (anaemia); bluish discoloration (cyanosis) of the skin and mucous membranes due to insufficient oxygen supply to these tissues; and/or an impaired sense of smell (anosmia). Individuals with cadmium poisoning may also experience improper functioning of the canals with the kidney (renal tubular dysfunction) characterized by excretion of abnormally high levels of protein in the urine (proteinuria), minor changes in liver function, and/or softening of certain bones (osteomalacia).

MERCURY POISONING

Mercury is used by dental assistants and hygienists, and chemical workers. Mercury can affect the lungs, kidneys, brain, and/or skin. Symptoms of mercury poisoning include fatigue, depression, sluggishness (lethargy), irritability, and headaches.

Respiratory symptoms associated with inhalation to mercury vapours include coughing, breathlessness (dyspnea), tightness or burning pain in the chest, and/or respiratory distress. Some affected individuals may experience abnormal build-up of fluid in the lungs (pulmonary edema); pneumonia; and/or abnormal formation of fibrous tissue (fibrosis).

There may be behavioural and neurological changes associated with overexposure to mercury poisoning, such as excitability and quick-tempered behaviour, lack of concentration, and loss of memory. Shock and permanent brain damage may also be result from mercury poisoning. Some affected individuals experience mental confusion. A progressive cerebellar syndrome with impaired ability to coordinate voluntary movements (ataxia) of the arms may also be present. Abnormal involuntary movements of the body such as uncontrolled jerky movements

combined with slow, writhing movements (choreoathetosis) are common. Additional symptoms include non-inflammatory degenerative disease of the nerves (polyneuropathy); impaired ability to coordinate voluntary movements (cerebellar ataxia); tremors of the legs and arms and, in some cases, of the tongue and lips; seizures; and/or slurred speech (dysarthria). Changes in mood, behaviour, and consciousness may also occur.

In some cases of chronic exposure to inorganic mercury a personality disorder known as erethism or mad hatter syndrome may occur. Symptoms associated with mad hatter syndrome include memory loss, excessive shyness, abnormal excitability, and/or insomnia. This syndrome was described in workers with occupational exposure to mercury in the felt-hat industry.

Many affected individual experience sensory impairments such as visual problems (e.g. constriction of visual fields, tunnel vision, and blindness) as well as hearing loss.

Some individuals may experience skin changes such as painful swelling and pink coloration of the fingers and toes (acrodynia); persistent redness or inflammation of the skin (erythema); extreme sensitivity (hyperesthesia) of the affected areas; and tingling and sensory disturbances.

In some cases, other affected individuals may experience stomach and intestinal disturbances; kidney damage; dehydration; acute renal failure; inflammation of the gums (gingivitis); severe local irritation of the mouth and pharynx, accompanied by vomiting; and/or abdominal cramps with bloody diarrhoea.

Mercury is mainly excreted through the urine and faeces.

ARSENIC poisoning (As)

Arsenic (atomic number 33) is a silver-grey brittle crystalline solid with atomic weight of 74.9, specific gravity 5.73, melting point 817°C (at 28 atm), boiling point 613°C, and vapour pressure 1 mm Hg at 372°C. Arsenic is a semi-metallic element with the chemical symbol “As”. Arsenic is odorless and tasteless. Arsenic can combine with other elements to form inorganic and organic arsenicals. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Inorganic arsenic compounds are mainly used to preserve wood. Organic arsenic compounds are used as pesticides, primarily on cotton plants.

It is a hard acid and preferentially complexes with oxides and nitrogen. Trivalent arsenites predominate in moderately reducing anaerobic environments such as groundwater. The most common trivalent inorganic arsenic compounds are arsenic trioxide, sodium arsenite, and arsenic trichloride. Trivalent (+3) arsenates include As(OH) 3 , , AsO 2 OH 2− , and . Arsenite (As(OH) 3 , As 3+) is predominant in reduced redox potential conditions.

LC 50

LC stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air but in environmental studies it can also mean the concentration of a chemical in water.

According to the (Organisation for Economic Cooperation and Development) (OECD) Guidelines for the Testing of Chemicals, a traditional experiment involves groups of animals exposed to a concentration (or series of concentrations) for a set period of time (usually 4 hours). The animals are clinically observed for up to 14 days.

The concentrations of the chemical in air that kills 50% of the test animals during the observation period is the LC_{50} value. Other durations of exposure (versus the traditional 4 hours) may apply depending on specific laws.

LD 50

LD stands for "Lethal Dose". LD_{50} is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD_{50} is one way to measure the short-term poisoning potential (acute toxicity) of a material.

Toxicologists can use many kinds of animals but most often testing is done with rats and mice. It is usually expressed as the amount of chemical administered (e.g., milligrams) per 100 grams (for smaller animals) or per kilogram (for bigger test subjects) of the body weight of the test animal. The LD_{50} can be found for any route of entry or administration but dermal (applied to the skin) and oral (given by mouth) administration methods are the most common.

In 1927, J.W. Trevan attempted to find a way to estimate the relative poisoning potency of drugs and medicines used at that time. He developed the LD_{50} test because the use of death as a "target" allows for comparisons between chemicals that poison the body in very different ways. Since Trevan's early work, other scientists have developed different approaches for more direct, faster methods of determining the LD_{50}.

Acute Toxicity - something that damages organisms immediately upon exposure. Focus on the fast kill part! Acute toxicity is often seen with pH swings, phenol, cyanides, or solvents. In bioassay tests, this is the die off of test organisms. With wastewater bacteria, acute toxicity usually comes with an immediate loss of nitrification and deflocculation. As soon as the acute toxic compound washes out or the biomass adapts, the system starts to recover.

Chronic Toxicity - a slower, accumulating toxic effect. Often, we see metals that buildup in biomass as a source of chronic toxicity. You will not see the sharp change in biomass with chronic toxicity. Instead, a loss of treatment efficiency will take hold over time. In bioassay tests, chronic toxicity manifests itself as low reproduction or failure to see weight gain.

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