Journal of Advances and Scholarly Researches in Allied Education
Vol. 16, Issue No. 2, February-2019, ISSN 2230-7540

A Study on the Factors Affecting Soil Toxicology

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***Abstract** – The physico-chemical properties of a compound that are considered important include its molecular structure, solubility, ionization and vapour pressure. All these characteristics affect the toxicological and pharmacological properties of the compound. The nature of chemical reaction is determined by the functional groups of the substance and its toxicity is a response of organisms consequent upon reaction between the compound and certain part of the organism.*

The non-polar (lipophilic) confounds are highly soluble in lipids and other organic solvents. Therefore, they can easily penetrate the membrane's lipoprotein layers and produce their potential effects. However, polar (hydrophilic) compounds are not soluble in lipids; therefore, they cannot cross the membrane barrier to reach the target site. Other properties of chemicals such as rate constant for hydrolysis, photolysis, evaporation, sorption and partition coefficients are also important and affect environmental concentration of toxicants.

Keywords: Factors, Soil, Toxicology

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INTRODUCTION

A toxic substance produces its toxic effects after its interaction with appropriate receptors of the organism. The effect is directly dependent on the concentration of the chemical at the target site and concentration at the target site is related to the amount (dose) of the chemical administered. Paracelsus stated "No substance is a poison by itself It is the dose (the amount of the exposure) that makes a substance a poison and the right dose differentiates a poison and a remedy". This statement became the basis for "dose-response relation ".

The lower doses of the chemical cause mild effects whereas high doses may cause serious and long lasting effects. If the dose is administered through mouth, or applied on the skin, or into the respiratory tract, transport across the membranes may be identical with the dose administered. In environmental exposures, an estimate of the dose can be made from the measurement of environmental and food concentrations as a function of time, and involves the assessment of food intake, rate of inhalation, and the deposition and retention factors.

However, estimation of dose by these methods depends on time taken for transport, absorption, distribution, retention, biotransformation and excretion of the chemical or its metabolites. When the site of action is very near to the site of application, then the time concentration estimate may be quite reliable.

But when the site of action is located away, as the liver cells, then estimates of dose may not be reliable. The presence of a chemical in low or high concentration in the blood indicates absorption. However, the blood concentration of a toxic chemical depends on several other factors such as rate of absorption, distribution, tissue storage, metabolic transformation and excretion.

Certain toxic substances are nonselective in their mode of action i.e., they exert their adverse effect on a large number of organ tissues of the body of an organism. As such, they may be effective in low concentrations. On the other hand, a selective chemical adversely affects only one type of tissue. For example, snake poison either affects blood tissue (haemotoxic) or nerve cells (neurotoxic). The affected and unaffected cells and tissues may be in the same or different organisms. In the latter case, the chemical is called species- specific in its selective toxicity.

Selective toxicity results from biological diversity and variations in the response of living cells and tissues to different chemicals. There appear to be involved two important mechanisms for the selective action of a chemical. These are presence or absence of specific receptor or target sites and the factors that may be responsible for the distribution and change in the concentration of the chemical at specific sites. This results from processes such as selective absorption, translocation, biotransformation and excretion.

In nature, sometimes organisms are exposed not only to one chemical, but to two or three chemicals at the same time. These chemicals may interact with each other and such chemical interactions may have great toxicological significance. In the laboratory, organisms may be exposed to chemical mixtures containing two or more chemicals. These chemicals often interact and affect the toxicity of each constituent. The combined effect of two chemicals may be equal to the sum of the effect of each chemical when given alone. This type of effect is called additive.

For example, effect of combination of two organophosphorus pesticides on AcheE activity. The combined effect of two chemicals may be more than the sum, and then this type of interaction is called synergistic. For example, effect of ethanol and carbon tetrachloride on liver, or effect of cigarette smoking and asbestos exposure on the lung tissue, or the effect of malathion and EPN when given simultaneously to test animals are far more toxic than the sum of their toxicities when given separately.

FACTORS AFFECTING SOIL TOXICOLOGY

A term used to express this condition is sensitization or potentiation, which means that when two chemicals are acting on the same or different organs or systems, one chemical is made more effective in the presence of other. A third type of interaction between two chemicals is called antagonistic. In such cases the combined effect of two chemicals may be less than the sum.

In other words, there is no potentiation of activity between similarly acting chemicals, rather one chemical may antagonise the toxicity of another and we observe negative simulation or antagonism. For example, chelation of heavy metals by dimercapol. Thus, according to Sprague's interpretation, the toxicity or effects of chemical mixtures are described as simply additive, more than additive (synergistic) or less than additive (antagonistic). In other words, the interaction of one chemical with another may have no effect on their toxicity, or increase their toxicity, or decrease their toxicity.

Aquatic animals are naturally exposed to chemicals and wastes present in water, sediment and food items. Water soluble toxicants are more readily available to organisms than water insoluble chemicals that may be tightly absorbed, or otherwise bound to suspended particles or organic matter. Water soluble chemicals may enter an organism through integument, mouth or gills. Chemicals concentrated in food items may be ingested and absorbed through the alimentary canal.

Adsorbed chemicals may also enter the body through the general body surface and gills as they gradually dissociate from particles to water in immediate contact with these areas. The chemical produces more rapid and immediate effect when given by intravenous route (injection). Besides the routes mentioned above a toxicant may also gain access to the body of an organism by inhalation or by intra-peritoneal, intra-musculer and subcutaneous injections.

Toxic effects can be produced in the natural environment or in the laboratory by short-term (acute) or long-term (chronic) exposure to toxic chemicals. Exposures of intermediate duration are called subchronic esposures. In routine bioassay, organisms are exposed for 24, 48, 96 hrs or for more days depending upon the type of chemical, organism and test conditions.

The concentration of the chemical required to kil 50% test organisms is called LC 50 or LD 50 and expressed as 24 hr- LC 50, 48 hr-LC 50 or 96 hr-LC 50. For example, 96 hr-LC 50 is the concentration of a chemical that is lethal to 50% of the test organisms in 96 hr. Obviously, the safe concentration, which permits successful reproduction, growth and all other normal life processes in the organisms natural environment is usually much lower that LC 50.

The LC 50 values of toxicants decrease with increase in duration of exposure. The LC 50 value obtained for long-term exposure is much less than those determined for short-term exposure. A variety of exposure systems are used in the laboratories. The choice of the system depends upon the test organisms and facilities available.

In the Static System, a toxicant is mixed in the water and the organisms are exposed to the toxicant in still water. In Re-circulatory System, toxicant is re-circulated through certain pumps. In Renewal System, a toxicant solution is renewed after certain interval, say 24 hrs or more. In Flow through System, the toxicant solution flows into and out of the test chamber continuously or intermittently.

Toxicity of a chemical is generally evaluated against a particular organism or a group of organisms. The toxicity of a chemical varies according to the size, life history stage, age, sex and health and nutritional status of the organism. Acclimation of the organisms to laboratory conditions prior to bioassay also plays an important role. The same species or organisms collected from different habitats may exhibit variations in their limits of tolerance to the chemicals. Certain individuals of a species may be susceptible to a chemical while others may be resistant.

Therefore, it is often suggested that to have a reasonably clear picture of the toxicity of a chemical, it must be tested against one plant such as an alga, one or two non-chordates (an insect or a crustacean) and at least one chordate such as a fish.

DISCUSSION

In general, invertebrates are more sensitive to toxicants than the vertebrate species. Not all the species of a group are equally sensitive to toxicants. Among various fish species, the toxicity of a chemical may vary considerably. Generally, trouts and minor carps are more sensitive than catfish and snakeheads.

In most bioassays usually the most sensitive locally important species may be used. For any one series of bioassays, the test species should be obtained from a common source and collected at one time. Test organisms that are nearly uniform in size and belong to the same age group or life history stage are considered ideal. A variety of organisms including algae, protozoa, cladoceran, copepods, annelids, crustaceans, molluscs, aquatic insects, fishes and macrophytes have been used in different bioassays.

But all these organisms are not suitable for all types of bioassays. For a long time it was felt that only fish bioassays were necessary when estimating the probability of harm to aquatic life from industrial wastes. However, fish are not invariably the most sensitive organisms in the aquatic ecosystem.

There are many abiotic and biotic factors of the environment that may modify the toxicity of chemicals. The factors of the environment affecting the toxicity of chemicals have been studied extensively for the aquatic medium and 'aquatic toxiology' is now considered an important branch of science.

Of all the environmental factors of the aquatic medium, the water temperature greatly affects the toxicity of xenobiotic chemicals. An increase in water temperature increases the solubility of many substances, alters the chemical structure of some toxicants and also lowers the dissolved oxygen content of water. However, some pesticides have been reported to be more toxic at higher temperatures while some others show stronger lethal action at low temperatures.

The pH of the medium also affects toxicity of chemicals. The pH of water may have greater effects on the toxicity of chemicals that can ionize under the influence of pH. Generally, an un-dissociated form of a chemical is more toxic to organisms because it can penetrate the cell membrane. The unionized from of ammonia (NH_3) is highly toxic to fish and quite low concentrations, 0.2 to 0.7 mg./l, adversely affect salmonids.

However, the ionized from of ammonia, ammonium ion (NH^+_4) is little or no toxic. An increase of pH by one unit within the usual middle ranges increases the proportion of NH3 by about six folds, hence six folds increase in the toxicity of the chemical. The pH has profound effect on metal [toxicity, as metals ionize under the influence of pH.

The salinity and hardness of water also affect toxicity. Generally, euryhaline organisms are I more resistant in water containing about 30-35% salinity. An appreciable decrease in salinity of water often renders the marine organisms less tolerant. Therefore, some studies concluded that the toxicity of xenobiotics may be increased with an appreciable decrease in the salinity of the surrounding medium.

Several studies indicated that many heavy metals are more toxic to aquatic biota, including fish, in very soft water than hard water. The increase in toxicity of metals with respect to decrease in hardness of water has been attributed to alteration in fish gill permeability caused by the calcium content of water.

The suspended and dissolved solids, which affect conductivity of water, also affect the toxicity of chemicals. They may partly detoxify some of the xenobiotic chemicals such as metals as a result of sorption or binding. The addition of suspension of clay affects the toxicity of an insecticide, endrin to fathead minnous, while the addition of soil suspension to endrin solution moderates its toxicity.

CONCLUSION

The DO and BOD content of water also affect the toxicity of chemicals. The sewage and other organic matter discharged to a water body are degraded by oxygen requiring microbes. The amount of DO consumed by the microorganisms is biochemical oxygen demand (BOD). If the BOD value is more, the water contains less amount of DO. Freshwater can dissolve 14.6 mg/1 of oxygen at O-C, which gradually decreases to 9.1 mg/1 at 20°C and further decreases to 7.5 mg/1 at 30°C.

It is, therefore, obvious that rise in water temperature decreases its DO content. Since oxygen is essentially required for respiration, any physiological change affecting the rate of oxygen flow to the blood of the respiratory organ (gills), will obviously affect the concentration of toxicant at the gill surface and thus the overall toxicity of the chemical.

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