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HAZARDOUS EFFECTS OF SOIL POLLUTION AND ITS PROTECTION

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ABSTRACT

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials or disease causing agents that have adverse effects on humans, plants and animals. There can be many causes of the soil pollution, such as seepage from landfills, discharge of industrial waste into the soil, percolation of contaminated water into the soil, rupture of underground storage tanks, excess application of pesticides, insecticides etc. The most common chemicals causing soil pollution are petroleum hydrocarbons, heavy metals, pesticides and solvents.

Industrial waste is one of the single biggest contributors to soil pollution, hence requires to be tackled urgently. In order to assess soil quality and to select proper soil remediation methods in case of severe pollution, first we have to understand the behaviour of various compounds with in soil and their respective effects on organisms. The compound behaviour in soils consists of the following processes,' Speciation', 'Transport' and' Uptake'. Speciation focuses on adsorption to soil particles and on complexation reactions, such as mechanism and modelling of reaction of heavy metals with dissolved organic matter. In this study, we will be studying dissolution, precipitation, volatilization and condensation and these processes will be elaborated for compounds like heavy metals, volatile organic chemicals, cyanide, nitrogen and phosphate.

To determine the dose-response relationship of heavy metals for plants grown in polluted soils, we will use relevant research methods and measurement techniques.

Basic data is derived from a pot experiment with common grass in which two different soil types are used and treated with different doses of various heavy metal (Cu, Zn) at different pH levels. The techniques applied are plant and soil sampling, chemical analysis of total metal amounts in plant and soil, determination of free metal concentrations, pH measurements, and regression analysis (parameter fitting).This study is mainly concerned with the determination of adsorption behaviour of heavy metals in the soil depending on soil type, pH values and the evaluation of effects of heavy metals on plant growth and metal uptake as a function of total or bio available amount in the soil. In this study, a group of 8-10 students, divided into four groups, performed this experiment for different metals while concentrating on the power type functions, which is dose-response relationship.

KEYWORDS: *Dose-response relationship, pH level, Bioavailability, Regression analysis, Pot experiment.*

I. INTRODUCTION

With increased presence of pollutants in the soil, a growing public debate is emerging on what measures should be taken to eradicate the pollutants. Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials or disease causing agents that have adverse effects on humans, plants and animals.[1, 2] Till date, many studies have investigated the toxicological and environmental effects of soil pollutants that have generated guidelines for quantifying the effects of various soil pollutants

There are many different ways that soil can become polluted, such as:

- Seepage from landfills.
- Discharge of industrial waste into the soil.
- Percolation of contaminated water into the soil.
- Rupture of underground storage tanks.
- Excess application of pesticides, herbicides or fertilizers.
- Solid waste seepage.

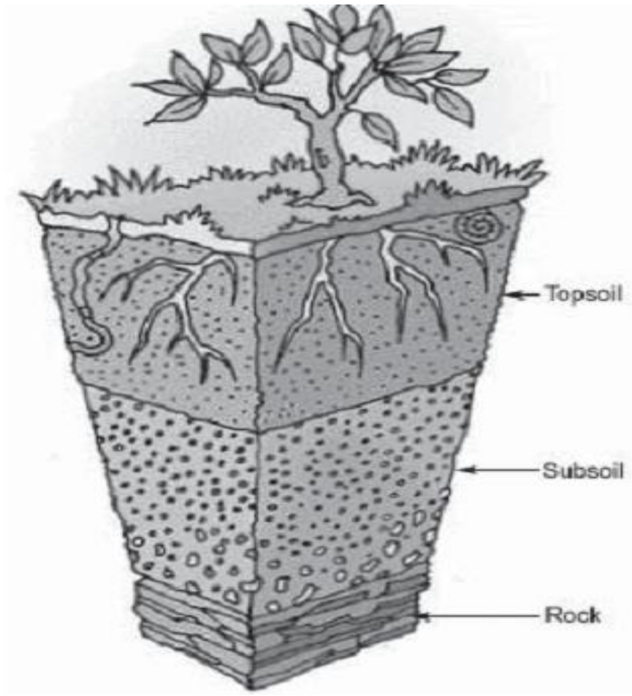


Fig 1 SOIL LAYERS

Fig 1[4] shows the different layers of soil, which get eroded and polluted due to different reasons. The top most layers can get eroded due to deforestation; quarrying and transport of sand can pollute soil; wind can cause erosion and so also can rain[4]. Soil loses its top layer, which reaches ponds, tanks and lakes[4]. This fine soil is called silt. This is a natural process of degradation. Coming to man-made pollution, indiscriminate deforestation makes soil lose its protection from sun, wind and water.[2] When topsoil is lost, the affected area loses precious nutrition that have collected over centuries. Trees and plants would have absorbed these nutrients. When trees are cut, soil nutrients get washed away to collect in water bodies[4,5]

It results in unwanted weeds which, if left unchecked, can cover the water body and suffocate it. Similarly, constant infiltration of salt water from sea can make coastal regions infertile as the ground water in these regions becomes un-potable due to the resultant salinity. Also, effluents and sewage can pollute inner layers of soil. Topsoil acts like a sponge, absorbing and retaining water. When it cannot hold water any longer, the water sinks deeper into the soil, leaving only the toxins in the top layer of the soil.[12]

II. CAUSES AND EFFECT OF SOIL POLLUTION

Soil pollution has a varied range of effects on various aspects of our lives, such as:[3]

- Solids in sewage have the same effect on soil as effluents. Some effluents have cancer-causing properties.
- Sewage waste can carry harmful bacteria that may pollute both water and soil.
- Plastic is non bio-degradable and survives in soil for years. It prevents suitable aeration of soil, which kills useful bacteria and the soil around that region becomes useless.
- In case of an accident, release of chemicals into soil can burn the soil as they are likely to be highly concentrated. Once soil is burnt it is useless for any purpose, not even permitting grass to grow.
- Upon being polluted, soil becomes infertile and barren, which reduces agricultural output and may cause natural hazards like drought, soil erosion etc.
- The wastes absorbed by soil not only degrade the soil but also affect the water table.
- Saturation of soil with pollutants not only affects the soil but also the organism in it.
- When it comes to the environment, the toll taken by contaminated soil is even direr. Soil that has been contaminated should no longer be used to grow food, because the chemicals can leech into the food and harm people who eat it.
- If contaminated soil is used to grow food, the land will usually produce lower yields than it would if it were not contaminated. This, in turn, can cause even more harm because a lack of plants on the soil causes more erosion, spreading the contaminants onto land that might not have been tainted earlier.

II.A. CAUSES AND EFFECT ON SOIL AGRICULTURE

Soil pollutants can have very deleterious effects on agriculture, such as: [3-5]

- Reduced soil fertility.
- Reduced nitrogen fixation.
- Increased erosion.
- Larger loss of soil and nutrients.
- Reduced crop yield.
- Imbalance in soil fauna and flora.
- Deposition of silt in tanks and reservoir.

II.B. INDUSTRIAL EFFECT

Soil pollutants of industrial origin have the capacity of majorly harming the environment, such as: [3-5]

- Dangerous chemicals entering underground water.
- Ecological imbalance.
- Release of polluting gases.
- Release of radioactive rays that may cause health problems.
- Increased salinity.
- Reduced vegetation

II.C. EFFECT ON URBAN AREAS

The urban areas can also be negatively affected in the following ways:[3-5]

- Clogging of drains.
- Inundation of areas.
- Public health problems.
- Pollution of drinking water sources.
- Foul smell and release of gases.
- Waste management problems.

III. CONTROL OF SOIL POLLUTION

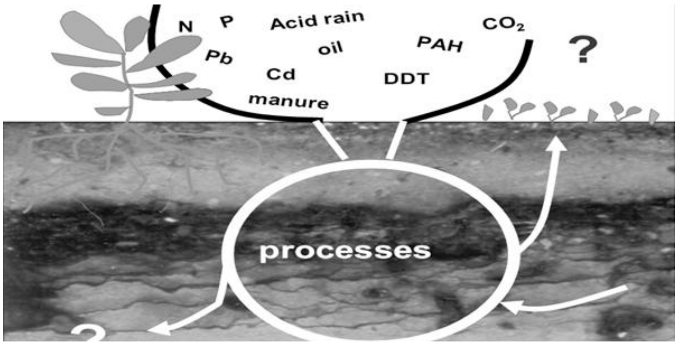


Fig 2 Different types of chemical

Fig. 2 depicts the different types of chemicals responsible for soil pollution. It is necessary to have knowledge of the behaviour of compounds in soil and their effects on various organisms; viz. human beings, plants, soil biota etc, in order to assess soil quality and to select proper soil remediation methods, in cases of severe pollution. The field of application is not limited to soil but includes sediments and solid wastes. Basic knowledge comprises compound behaviour in soils (speciation, transport, and uptake) and effects on soil organisms (bioavailability, uptake, dose-response relationship). Speciation focuses on adsorption to soil particles
and on complexation reactions: mechanism and modelling, especially of heavy metals with (dissolved) organic matter.

IV. EXPERIMENTAL SETUP

This work aims at carrying out experimental soil pollution research, involving relevant research methods and measurement techniques essential for the determination of the dose – response relationship of heavy metals for plants grown in polluted soils. Basic data is derived from a pot experiment with grass, including two different soil types (sand and clay) and their treatment with different heavy metal doses (Cu, Zn) at different pH levels. Techniques applied are plant and soil sampling; chemical analysis of total metal amounts in plant and soil; determination of bioavailability (0.01 M CaCl2-extraction of the soil); determination of free metal concentrations; pH measurement; and regression analysis (parameter fitting).[12]

The work is particularly aimed at ways of handling analysis-equipment and methods of executing standard chemical (soil) analyses. The subjects dealt with in the work concern mainly determination of adsorption behaviour of heavy metals in the soil, depending on soil type and pH as also evaluation of effects of heavy metals on plant growth and metal uptake as a function of total or bio available amount in the soil. The objective is to find the parameters for relevant soil adsorption models and dose–response relationships (power type functions)[18, 21]

For this project, researchers jointly carried out the experiments resulting in a report focussed on experimental and modelling results, such as sampling, soil extractions, and chemical analyses and data evaluation, viz. calculations, regression analysis etc.[13]

V. SPECIATION

V.A. OVERVIEW

Speciation is the origin of new species. Generally, this entails one species changing over time and eventually becoming two species. It consists of the evolution of biological barriers to gene flow (reproductive isolation) between two populations of the same species. As a field of scientific investigation, it links the fields of macroevolution and microevolution, including the fields of genetics, ecology, behavior and biogeography. It is currently one of the most active and exciting areas of evolutionary biology in plants.[6-9]

V.B. WHAT CAUSE SPECIATION?

Speciation or the evolution of reproductive isolation occurs as a by-product of genetic changes that accumulate between two previously interbreeding populations of the same species.[8] For example, let us start with two populations of the same species that do not differ genetically. Initially, an individual from population A is able to successfully breed with an individual from population B. As these populations evolve, each gradually accumulates genetic changes that are different from the other population's genetic changes. In other words, the two populations genetically diverge from each other[9-10]. These changes can be due to different selection pressures because of different environments or because of genetic drift/founder events. At some point in this process, some of these genetic changes cause the two populations to become reproductively isolated from each other. In other words, these genetic changes no longer allow an individual from population A to successfully breed with an individual from population B, thus preventing gene flow between populations.[11] These specific genetic differences, that confer reproductive isolation, are called reproductive isolating mechanisms. There are several different types of reproductive isolating mechanisms, which are classified according to when in the life cycle of the organism isolation occurs. Isolation can occur before fertilization (prezygotic barriers) or after fertilization.[10-11] In this way, plant species become genetically isolated from each other and with the help of the Dose–response relationship of the new form plant we would be able to know its characteristics in different chemicals.[10]

V.C. HOW DOES SPECIATION OCCUR?

There are several different ways in which the evolution of reproductive isolation is thought to occur[14-17]. These can, however, be generalized into a series of events, or steps.[10]

The steps in a speciation event are:

Step 1: gene flow between two populations is interrupted.
(Populations become genetically isolated from each other)
Step 2: genetic differences gradually accumulate between the two populations. (Populations diverge genetically)
Step 3: reproductive isolation evolves as a consequence of this divergence.
(A reproductive isolating mechanism evolves)

The main difference between the different models of speciation is in the first step or how the populations become genetically isolated from each other.[8]

VI. DOSE------------------RESPONSE RELATIONSHIP- OVERVIEW

After collecting observations of the germinating seeds the data is expressed on a graph and a dose-response curve for their chemical is developed. After that data from the investigation of a chemical with those of other teams and other chemicals is compared. In this way dose-response curves are analysed to determine threshold and potency.[19] Dose and response are related and can be represented by a dose-response curve. Data from toxicology testing can be represented by a dose-response curve from which can be used to describe the threshold and potency of chemicals.[19, 20, 22]

VI. DOSE-RESPONSE CURVES

The characteristics of exposure to a chemical and the spectrum of effects caused by the chemical come together in a correlative relationship that toxi-cologists call the dose-response relationship. This relationship is the most fundamental and pervasive concept in toxicology.[19, 20] To understand the potential hazards 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. [22]

Data collected from germination of seeds in the presence of a chemical is used to plot a dose-response curve for the chemical. The dose-response curve so obtained was compared with other such curves got from repeated carrying out of the experiment. Similarly, potency of the chemical got from measuring germination of seeds was compared. In this way, relationships between evidence and explanations were derived.

Paracelus is noted for stating the concept that 'The dose makes the poison.' At extremely low doses, a given substance may be non-toxic and even beneficial (a concept known as hormesis), while at intermediate doses it may be toxic. At high doses, it may be lethal. This again underscores the importance of understanding dose response relationships.[20, 22]

The underlying principles of toxicology rely on an understanding of the causal relationships between exposure and effect. In order to better comprehend how exposure-related effects can be explained the concept of dose-response is important.

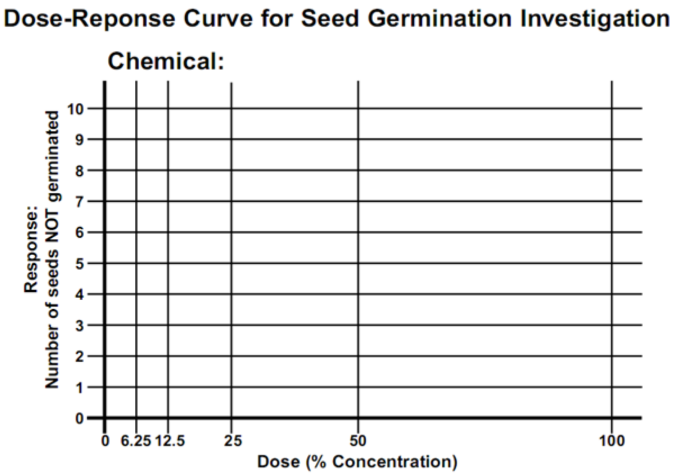


Fig 3 Dose-Response Curve for Seed Germination Investigation

Following are the dose response curves of various chemicals:

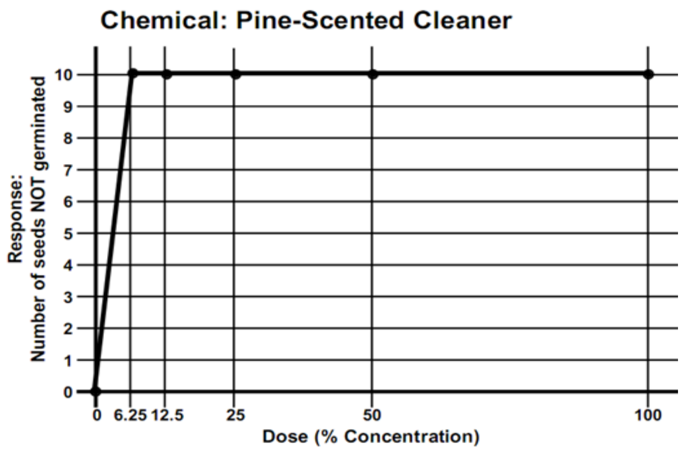


Fig 4 Chemical: Pine- Scented Cleaner

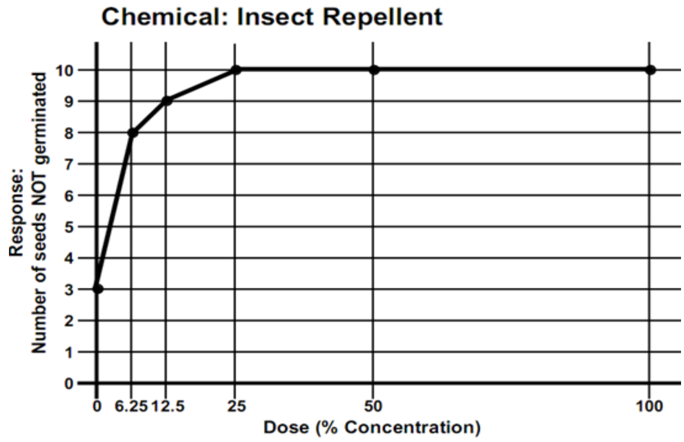


Fig 5 Chemical: Insect Repellent

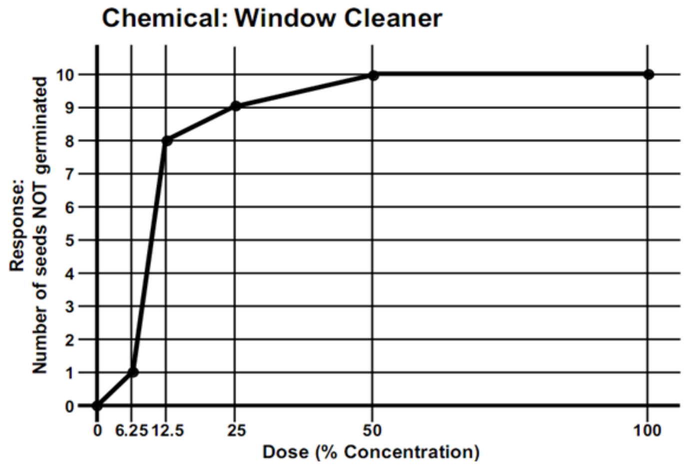
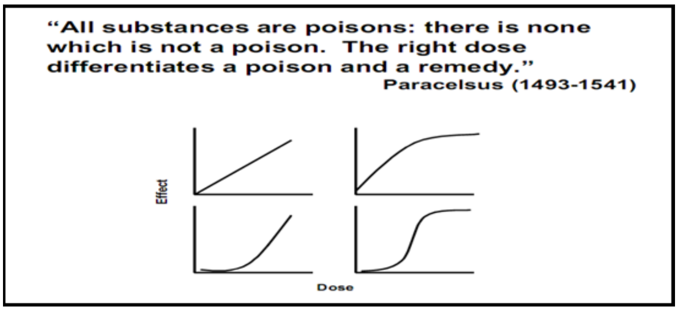


Fig 6 Chemical: Window Cleaner



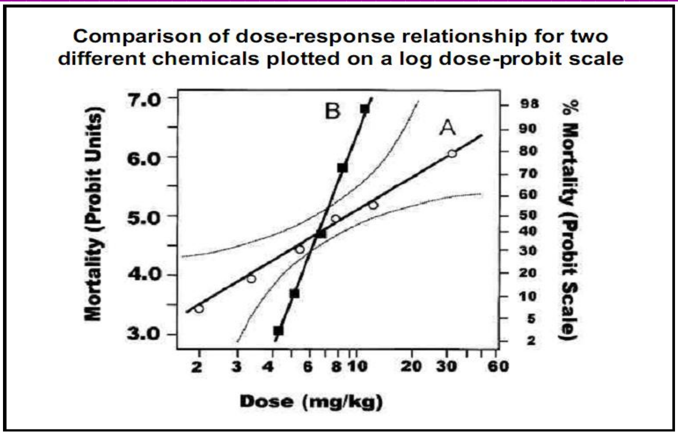


Fig 7 Comparisons

As described above, log-dose data provides a linear plot, which is easier for interpretation and extrapolation. This graph shows two curves on either side of the response line of compound A. These curves are CONFIDENCE INTERVALS for compound A data. CIs are related to standard deviation and tell us how confident we can be that the true population will respond similarly to the experimental (model) population, based on the experimental variability encountered. Note that CIs are tightest closest to the data line nearest the 50% probity response, closest to the mean. This makes sense since we know that response variability increases as we move away from the mean response. The dose-response line for Chemical B is steeper > Chemical A. In this way we can make judgment about which chemical is safer.

VII. CONCLUSION

In this way we will be able to check the increasing soil pollution by:

- Recognizing and describing the impact of soil pollution on the environment.
- Analyzing and describing compound behaviour in soils.
- Explaining and describing essential elements of a soil quality evaluation procedure.
- Applying soil risk assessment to a contaminated soil site.[19]
- Carrying out simple dose–response experiments including sampling, chemical analysis of soil and plant samples, data processing, simple statistical data handling and linear regress.

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