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# "An Analytic Study on the Impact of Some Heavy Metals on Certain Species of Soil Fauna"

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## Abstract

Due to their toxicity, environmental durability, and bio accumulative characteristics, heavy metals are well-known xenobiotics. In addition to natural sources, increasing industry and urbanisation have polluted the environment with heavy metals, and since the 1940s, their rates of mobilisation and transportation in the environment have considerably increased (Khan et al., 2004). Heavy metals accumulate in the environment and pollute food chains since they are persistent in nature. The microbiological balance of soils is impacted by heavy metal concentrations over threshold levels, which can lower soil fertility (Barbieri, 2016). As a result, heavy metal contamination poses a major threat to the ecosystem (Ali et al., 2013; Hashem et al., 2017). This paper provides a quantitative analysis of the damage caused to the test organisms and its ultimate effect on the soil ecosystem.

*Keyword: - Environmental, Characteristics, Accumulate, Contamination.*

## Introduction

The effects of heavy metals are being assessed by scientists all over the world. As a result, priority research in recent years has focused on the fate of heavy metals in the soil and their impact on no target soil organisms. There is a wide variety of invertebrate species found in soil. Even though the variety of species in the soil can be quite diverse, earthworms and isopods are important regulators of the processes that lead to decomposition (Hendriksen, 1990; Hassall et al., 1987). As a result, a significant area of ecotoxicological research is currently being addressed by a number of academics throughout the world. This research involves evaluating the acute and chronic toxicity of heavy metals that accumulate in terrestrial ecosystems from various sources. Aside from that an early warning risk to terrestrial ecosystems could be assessed using living soil organisms.

**Metals**

Metals and metalloids that have been connected to contamination and possible toxicity are referred to as heavy metals as a group (Duffus, 2002). A metal with a density greater than 5gcm-3 is referred to as a heavy metal (Csuros and Csuros, 2002). Heavy metals are defined as naturally occurring metals with an atomic number larger than 20 and an elemental density greater than 5gcm-3, according to Ali and Khan (2018).

Heavy metals are divided into essential and nonessential categories based on their functions in biological systems. While the heavy metals Cd and Pb are harmful and are viewed as biologically unnecessary, essential heavy metals like Mn, Fe, Cu, and Zn are necessary for living organisms and required in the body in fairly low concentrations (Ramirez, 2013). Heavy metals that are not necessary may be hazardous even at very low amounts. Almost every heavy metal has the potential to be hazardous to biota, depending on the exposure time and amount. For various kinds of organisms, there may be different lists of important heavy metals.

**Environmental concerns related to heavy metals**

Public worry about the potential build-up of heavy metal in soil as a result of quick industrial expansion is growing. Numerous studies have already shown that there is a pronounced air, soil, and water contamination in locations that are close to industrial operations (Bartolomeo et al., 2004; Landajo et al., 2004; Miro et al., 2004).

Metals cannot be degraded naturally, especially when elemental metallic concentration is taken into consideration, but organic pollutants may undergo biological or chemical processes that result in the conversion of the pollutants to less hazardous components (Amiard et al., 1995). Therefore, despite considerable cleanup efforts, the consequences of metal contamination on local habitats and creatures may be significant and long-lasting (Mahimairaja, 2000). Large amounts of trace metals are immediately released into surface waterways and surrounding land in the majority of the world's nations. This activity has a negative impact on the quality of the air, land, and ground water to the point where it is a major global concern (Dahbi et al., 2003; Babel and Kurniawan, 2003; Farabegoli et al., 2004).

**The main sources of heavy metals**

Due to a variety of geological processes, including chemical reaction and erosion of subsurface geological elements, metals naturally arise in soils (Tuchschimid et al., 1995). In addition to these natural sources, industrial processes can contribute a sizable amount of metals to soil (Wilmoth et al., 1991). Many industrial processes generate wastes and toxins that end up in the soil through many channels, including atmospheric deposition from air, spills, leaks, and direct disposal (Nadal et al., 2008). Thus, the buildup of heavy metals and metalloids in soils may result from emissions from rapidly growing industrial areas, mine tailings, high-metal waste disposal, leaded paint and gasoline, fertiliser application to the land, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, petrochemical spills, and atmospheric deposition (Zhang et al., 2010). An increase in the proportion of heavy metals in the environment that are attributed to humans is the result of global tendencies toward urbanisation and industrialisation on Earth (Nagajyoti et al., 2010).

Lead, mercury, cadmium, copper, nickel, and aluminium are the main heavy metals of concern in terms of their environmental load and health impacts. They cite as sources primarily human-caused-industrial activity (Table 1.1). The most significant source of pollution in the area may be emissions from cement factories, according to several studies. Different researches have found high Pb, Zn, Mn, and Ni concentrations in soil samples around cement facilities (Al-Khashman and Shawabkeh, 2006). Pb was mentioned as the main raw ingredient utilised in the manufacture of batteries. One of the primary sources of environmental metal pollution might come from the textile industry (Deepali and Gangwar, 2010). Cadmium is mostly used in the manufacturing of metals, pigments, and batteries (Wilson, 1988). When certain phosphatic fertilisers are applied, Cd and Pb are unintentionally added to the soil (Raven et al., 1998).

It has been discovered that the soil in and around several metropolitan, congested cities in India, where major industrial waste generation occurs, is contaminated. There were extremely high amounts of Pb, Cr, Ni, Zn, As, and Cd released throughout the south Hyderabad industrial area in Andhra Pradesh, which is home to 300 enterprises that produce edible oils, dyes, metal plating, chemicals, and other products (Govil et al., 2008). Several investigations demonstrated that soil and water samples taken from Titagarh, Durgapur, and Kolkata, industrial areas in West Bengal, were highly contaminated by Pb and Cd (Gupta et al., 2008; Pobi et al., 2017; Saha et al., 2015). Due to industrial emissions, increased traffic density, and haphazard industrial waste disposal, the Durgapur industrial area's soils have significant quantities of Pb and Cd (Pobi et al., 2017). In addition, according to Chakravorty et al. (2014), Pb and Cd levels in fresh water ponds near the metal refinery Tata Metallics in Gokulpur, West Midnapore, were higher than allowed (West Bengal). The primary sources of heavy metals tested in soil are briefly summarised in Table.

**Soil sources of heavy metals tested for (source: CPCB, 2009)**

| Metal | Industry |
|---|---|
| Lead(Pb) | Lead acid batteries, paints, electronic trash, smelting processes, coal-fired power plants, ceramics, and the bangle industry. |
| Cadmium(Cd) | Waste battery recycling, paint sludge disposal, fuel combustion, and zinc smelting |

**Organisms in the soil**

A significant source of biodiversity, soil organisms are crucial to many soil ecosystem activities. Organisms that spend at least a portion of their life cycle in or on the soil are known as soil organisms (Hendriksen, 1990). They can be seen of as the "biological engine of the earth" (Ritz et al., 2004), driving and controlling a lot of the significant processes that take place in the soil. Soil invertebrates are typically categorised into four sizes: microfauna, mesofauna, macrofauna, and megafauna (Swift et al., 1979 ). According to Orgiazzi et al. (2016), macrofauna contains more than 20 taxonomic groups with body sizes ranging from 2 to 20 mm, such as earthworms, centipedes, millipedes, isopods, gastropods, myriapods, some arachnidan, and the majority of insects (Ruppert et al., 1996 ).

Additionally, the top soil layers, as well as the litter layer, are home to earthworms and isopods. These macrofauna are essential for breaking up and moving organic matter throughout the soil profile. They produce biogenic structures (faecal pellets) as they move through the soil profile, which may alter the soil's physical characteristics and the availability of food supplies for other organisms (Lavelle and Spain, 1997). The most significant organisms in many of the soils around the world are earthworms and isopods, which are extremely sensitive to ambient pH, moisture, temperature, etc.

The most well-known and possibly most significant animal that lives in dirt is the earthworm. They actively increase soil permeability, improve water penetration, and facilitate solute transfer (Kooch and Jalivand, 2008). Additionally, they consume organic debris and soil particles that they mix together and consume as surface or subsurface casts. As a result, they contribute significantly to the transitions between different humus forms in accordance with the patterns of forest succession.

## Review Literature

The goal of the current study is to assess the ecotoxicological risk of two significant heavy metals by examining their impacts on non-target soil species, specifically earthworms and isopods. An detailed evaluation of pertinent literature was conducted to support the study's goals, substantiate its methodologies, and evaluate the outcomes. The review discusses heavy metal pollution in India, the dangers of heavy metals to soil, the relationship between heavy metal toxicity and soil properties, the impact of earthworms and isopods on soil biological processes, the toxicity of heavy metals to soil organisms, and the use of earthworms and isopods as models in ecotoxicological research. The reviews are listed in full below.

Many factors contribute to the excessive buildup of heavy metals in soil, including mining operations, sewage irrigation, poor storage of industrial solid waste, atmospheric deposition, and the use of pesticides and fertilisers (Zang, 2011). It has been discovered that the soil in and around several metropolitan, congested cities in India, where major industrial waste generation occurs, is contaminated. According to the CPCB (2000), India produces over 50 million tonnes of municipal solid trash annually from its cities. Heavy metals like Ni, Cr, Pb, Cd, and Zn were found to be present in quite high concentrations in urban sewage that contained industrial effluents. Sewage production in the cities surrounding the Ganga basin is 2637.7 MLD. In addition to home sewage, industry produce roughly 13468MLD of waste water, of which only 60% is treated (Kaur, 2012). The residual sewage, which is discharged into the environment untreated, pollutes it. Around 38254 MLD of sewage water and over 25000 MLD of industrial waste water generated from cities and towns in India are discharged in the numerous open and covered channels (mostly without treatment), which worsens river quality. This is due to urbanisation, insufficient treatment capacity, and disposal of untreated waste.

Water quality close to many cities (CPCB, 2009) There has been a large buildup of heavy metals in the soil of agricultural land near various Indian cities and towns as a result of the use of such waste water-loaded surface water for irrigation (Saha and Panwar, 2013). According to estimates, sewage water in India can irrigate around 1.0 Mha of land each year (Sengupta, 2008)

## The Study of significance

The balance between the increase from net production and the decrease from breakdown determines how much carbon is stored in terrestrial ecosystems (Mellillo et al., 1982; Wolters, 2000). Consequently, the C budget of terrestrial ecosystems depends greatly on the breakdown of litter (Prescott, 2010). In a terrestrial ecosystem, decomposition is caused by detritivore feeding, digesting, and microbial breakdown of detritus (Wood, 1974; Facelli and Picket, 1991). The detritus food chain is crucial to the fertility of the soil.

Isopods and earthworms are the most prevalent terrestrial detrivores in grassland and forest ecosystems, consuming and digesting litter and influencing the biomass and activity of litter-colonizing bacteria (Hassall et al., 1987; Scheu, 1993; Van Wemsen et al., 1993; Zimmer and Topp, 1999). By reducing leaf litter's surface area mechanically into smaller particles, these two microfauna also expand the area available for microbial degradation (David and Handa, 2010). Abd El-Wakeil (2015) also put out the idea that microorganisms and invertebrates that break down organic matter, including earthworms and isopods, work together to decompose leaf litter.

The gentle creatures of the soil ecosystem are earthworms and isopods. The earthworms were referred to by Aristotle as "The Intestine of the Earth." Isopods and earthworms are now referred to as "ecosystem engineers" because of their considerable potential to significantly alter soil structure and important soil processes (Lavelle et al., 1997; Stork and Eggleton, 1992). In addition, they aid in soil bioturbation as ecosystem engineers. By reducing salt build-up, bioturbation preserves an environment that is good for the engineer species (Yari, 1995).

## The Study of Statement

In the end, heavy metals released into the atmosphere from many sources return to the ground and contaminate the soil (Alloway, 2013). Heavy metals accumulate in living things and move from one trophic level to the next in food chains because they are persistent in the environment. The degree of weathering, various physicochemical (soil texture, pH, organic matter content), biological, and climatic factors have an impact on the adsorption, presence, distribution, and eventual concentration of heavy metals in soils (Arunakumara et al., 2013). Therefore, the bioavailability of certain heavy metals in soil varies.

Toxic heavy metals in the environment can reach soil organisms in a variety of ways, including through ingestion and cutaneous absorption. The rate of accumulation and the rate of removal from the body determine how much heavy metal is accumulated in the biota. The physiological systems an organism has developed for the control, homeostasis, and detoxification of the heavy metal determine whether heavy metals are retained in the body of the organism (Ali et al., 2019).

## The Study of design

In the current investigation, isopod and earthworm test animals were used in two different types of bioassays: acute and chronic toxicity bioassays. The test media for both acute and chronic toxicity bioassays was natural grassland soil. To establish acute toxicity, filter paper testing was also conducted. In order to establish the median lethal concentration (LC50) of heavy metals for the test organisms in soil medium and through the filter paper test, acute toxicity bioassays were carried out. Test organisms and soil heavy metal concentrations were measured to calculate BCF. In the lab, sub-lethal dosages of two heavy metals were used in chronic toxicity bioassays to track changes in physiological systems and life cycle markers (growth, reproduction, sexual maturity, moulting intervals). To assess and compare the genotoxicological alterations that these heavy metals generate, a different bioassay was conducted in the lab using sub-lethal dosages of two heavy metals.

## Study of the objectives

The primary goal of the current study was to evaluate the ecotoxicological dangers to soil ecosystems brought on by heavy metal build-up in the soil as a result of rapid industrial expansion. Data on acute toxicity, growth (change in biomass), sexual maturation, moulting intervals, reproduction, metal bio-accumulation, and genotoxicity of two species of non-target soil organisms exposed to sub-lethal concentrations of two heavy metals were used to assess the risk. To accomplish the following goals, laboratory experiments were conducted.

1. Calculation of the median Pb and Cd fatal amounts for two soil fauna.
2. Measuring the level of heavy metals in the test organisms' leaf litter substrate.
3. Measuring BCF levels in test organisms.
4. Determining the harmful effects of Pb and Cd on various physiological parameters (growth, sexual maturation, moulting intervals, and reproduction) of test organisms subjected to sub-lethal doses of these two heavy metals.
5. Determining whether these two heavy metals are genotoxic to the test organisms.

## Research Methodology

### Materials and Procedures

**Test organisms**

The present study was carried out on two species of soil fauna, *Perionyx excavatus* (epigeic earthworm) and *Porcellio laevis* (terrestrial isopod).

**Heavy metals used as test chemicals.**

In the present study two heavy metals namely lead and cadmium in the form of lead nitrate [Pb(NO3)2] and cadmium nitrate [Cd(NO3)2] respectively were used as test chemicals.

### Statistical Analysis

Results were expressed as mean and standard deviation. The data were also analyzed for single factor ANOVA followed by Least Significance Difference (LSD) test between the treatments at 5 % level of probability (SPSS, Version-16.0).

### Results

**Acute toxicity**

**LC50 of Pb and Cd to test organisms in soil medium and filter paper test**

Cadmium with the 96h LC50 value of 1.418 gkg-1 soil was found more toxic to *P. excavatus*, followed by lead (LC50 – 2.975gkg-1). Similar results were found in case of filter paper method where cadmium (LC50 - 0.352 mg/ml) found most toxic to *P. excavatus* followed by lead (LC50 – 2.828 mg/ml).

| Heavymetals | 96hLC$_{50}$ | 95%Confidencelimit |
|---|---|---|
| Lead(Pb) | 2.975 | 1.574– 4.005 |
| Cadmium(Cd) | 1.418 | 0.724– 1.661 |

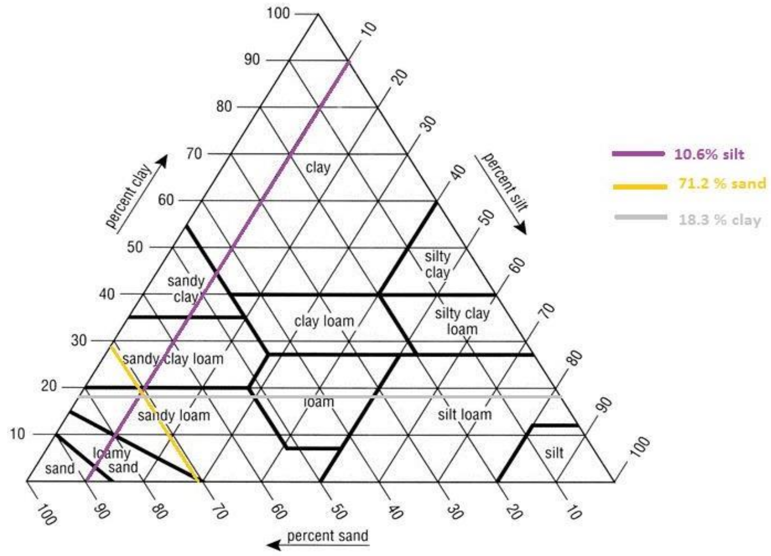
On the otherhand cadmium with the 96h LC50 value of 1.717 gkg-1 soil was found most toxic to *P.laevis*, followed by lead (LC50 – 5.857gkg-1). Similar results were found in case offilter paper method where cadmium (LC50 – 0.707 mg/ml) found severely toxic to *P. laevis*, followed by lead (LC50 – 16.822 mg/ml).

**Test medium's physicochemical characteristics**

Displays the physicochemical characteristics of the test media that were confirmed for their usefulness as media for experiments on earthworms and isopods 10.6% slit, 18.3% clay, and 71.2% sand make up the test material. The grassland soil (test medium) was classified as a sandy loam type based on the soil's texture. The soil medium was discovered to have low organic carbon content and to be slightly acidic in nature.

**Test media physico-chemical characteristics (grassland soil)**

| Parameter<br>Texture (%) | Value for Test Media |
|---|---|
| Sand | 71.2 |
| Slit | 10.6 |
| Clay | 18.3 |
| pH | 6.68±0.06 |
| Organic carbon (g %) | 1.58±0.13 |
| Water holding capacity | 49.07±4.23 |




Triangle representing the soil texture of the habitats of Earthworm and isopoda which were used as test organisms for the acute toxicity of lead (Pb) and cadmium (Cd)levels that are median deadly to *P.excavatus* in the soil medium.

1. Table 4 lists the lead and cadmium 96-hour LC50 values for *P.excavatus* along with their respective confidence intervals.

2. In comparison to lead, cadmium was shown to be more hazardous to *P.excavatus*, with a 96-hour LC50 value of 1.418 $gKg^{-1}$ soil (LC50 – 2.975$gKg^{-1}$).

## Conclusion

The primary goal of the current study was to evaluate the ecotoxicological dangers to soil ecosystems brought on by heavy metal build-up in the soil as a result of rapid industrial expansion. Data on acute toxicity, growth (change in biomass), sexual maturation, moulting intervals, reproduction, metal bio-accumulation, and genotoxicity of two species of non-target soil organisms exposed to sub-lethal concentrations of two heavy metals were used to assess the risk. To accomplish the following goals, laboratory experiments were conducted.

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