

# A Study on Heavy Metals Contamination in Agricultural Soils

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**Abstract – India's capacity to produce enough food to fulfill its population's demands has a major impact on the country's economic progress. Increasing food production was the driving force behind the Green Revolution, which was born out of the necessity to feed a burgeoning population. There is a growing problem with heavy metal poisoning in the environment, and the detrimental effects it is having throughout the world are making people very concerned. Agriculture and metal businesses, together with poor waste management, fertilizers, and pesticides, are polluting our rivers and soils. Heavy metals have also been implicated in a wide spectrum of human ailments. The bioaccumulation, toxicity, and transmission mechanisms of both heavy metals and insecticides, Agriculture soil heavy metal contamination has had significant detrimental effects on human health and the environment. Major attention has thus been focused on the assessment of heavy metals in agricultural land to enhance the environment and ensure the well-being of humans. Food grains have been able to develop and remain viable because to the employment of these agricultural technologies, but they have come at a considerable cost to the environment and human health.**

**Keywords – Heavy Metals, Soils, Fertilizers, Pesticides, Environment and Agricultural, etc.**

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## INTRODUCTION

For many years, human activity has had both detrimental and good effects on the natural environment. Examples include the depletion of natural resources, a lack of a conducive environment, and so on. Human development, both in the short and long term, is a major factor in determining the quality of the resources that matter and energy pass through in the atmosphere, water, and biosphere. Soil, water and air quality are affected by human activities in a wide range of ways. Food security is impacted by population increase and variations in farming techniques and land use [1]. Using metal insecticides has a negative influence on the environment in terms of water, soil, and the entire ecosystem. Air, water, and land have become unsuited for their fundamental functions because of the large range of objects that have been consumed and discarded. Smog, contaminated water, and polluted land are all signs that global expansion is on the rise across the world. Despite recent advances, environmental deterioration, such as air and water pollution, improper disposal of municipal trash including biomedical waste, and noise pollution as a result of rapid urbanization, have increased.

Agriculture and land use patterns have changed as a result of global population expansion. Food security is directly affected by this. In terms of human efforts, agriculture may be the most intimately associated with nature of all. Agriculture, from its inception to its completion, will ensure future generations' access to nutritious food. When crops are plagued by pests, it is imperative to have an efficient pest control approach. Pesticide use in agriculture has skyrocketed in recent decades in response to the world's ever-increasing population. However, excessive pesticide usage and pesticide residue accumulation pose a harm to aquatic environments, making pesticides an important tool for increasing agricultural productivity. According to several studies, pesticides have a harmful impact on a wide range of aquatic and terrestrial organisms. Waterborne microbes, animals, plants, and fish are unaffected by pesticides [2].

## Soil Pollution

In environmental science, anything that contaminates or decreases soil quality is referred to as "soil pollution". Microorganisms and macroorganisms can no longer survive in the polluted soil because the contaminants producing pollution have reduced the quality of the soil. Human actions or

natural processes can both lead to soil contamination and pollution. It's also a result of human activity, however. There are several compounds that can cause soil pollution, including pesticides, herbicides and ammonia as well as petroleum hydrocarbons, lead and mercury.

### Causes of Soil Pollution

There are both natural and man-made sources of soil contamination. However, human activities, such as heavy industry or pesticide usage in agriculture, are responsible for the bulk of soil contamination [1-2].

- Pesticides
- Chlorinated Organic toxins
- Herbicides
- Inorganic Fertilizers
- Industrial Pollution
- Solid Waste
- Urban Activities

### Sources of heavy metal pollution

Since the Earth's origin, these heavy metals have been naturally occurring on the Earth's surface. Heavy metal consumption has skyrocketed, and as a result, both the terrestrial and aquatic environments are seeing an increase in metallic compounds. Anthropogenic activity is the primary cause of pollution, mostly owing to mining, smelting, foundries, and other businesses that are metal-based, leaching of metals from numerous sources such as landfills, waste dumps, excretion, animal and chicken dung, runoffs, autos, and roadwork's [3].

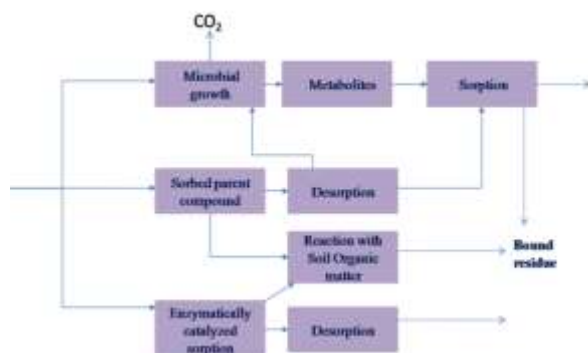


Figure1: Scheme showing the fate of organic chemicals in soils

### Environmental Impacts of Heavy Metals

The earth's crust is naturally rich in heavy metals. Only a few of these organisms are essential to aquatic ecosystems, and they are introduced there

by a variety of human activities. The primary anthropogenic sources of heavy metals in the earth's crust include manufacturing facilities, foundries [4], mining operations, product incineration facilities, and traffic areas. Due to their poisonous nature, non-degradability, and bioaccumulation, heavy metals are a major environmental pollutant. As they accumulate in plants and animals, these metals can be transferred to humans via the food chain. Soil monitoring is the greatest way to discover heavy metal deposition since heavy metals tend to accumulate in the upper layers of the soil [5-6].

### LITERATURE REVIEW

**Kotinagu et al., (2018)**, Fodder samples from the Musi river area in India were tested for organophosphorus pesticide (OPP) residues. A gas chromatography with an electron capture detector and a pulsed flame photometric detector was used to test fodder samples obtained from the six zones of the Musi river region, Hyderabad, India, for the presence of OPP residues. Musi river fodder samples were positive for phorate contamination by gas chromatography. Fodder samples obtained from the Musi river belt contained no traces of dichloroacetate, quinolphos, methyl parathion, profenphos, ethion, phosalone, lambda cyhalotrin [7].

**Nisa et al., (2018)**, Palakkad soils have been found to contain traces of Organochlorinated insecticides (OCIs), which are hydrophobic pesticides that can be bound to labile organic matter present in soils. This study shows that the chemical composition of the soil matrix can be taken into account when assessing the fate and toxicity of OCIs. The interaction of charged particles with binding sites may also have an impact on the fate and transit of these OCIs. Conclusion: In Palakkad soil, proteinaceous elements have an important role in controlling OCI sorption, where lipid hydrophobic phase contributions of aliphatic carbon are substantially smaller. In order to determine the interactions of hydrophobic organic compounds within the Palakkad soil organic matter, a complete examination of the composition of labile organic matter in these soils is required. Aldrin, lindane, and DDT were all prohibited in India along with numerous other OCIs [8].

**David Sylvester (2018)**, in irrigating water, Pb and Fe concentrations exceeded agricultural requirements, according to the study results. Soil heavy metal levels were above agricultural soil guidelines, whereas the mean amounts of Zn and Pb in vegetables exceeded those standards. There is no acceptable degree of heavy metal contamination, no matter how low it may be. As a result, the findings of this study recommend that heavy metals present in soil, irrigation water, and food should be routinely inspected in order to prevent rapid accumulation in the food chain and

hence avoid human health hazards. Thus, environmentalists, administrators and public health professionals should advise the public to avoid eating vegetables cultivated in polluted soils in order to reduce the risk of health complications [9].

**Mustapha et al., (2017)** Pesticide residues have been found in primary and derived agricultural goods, and this presents major health issues for consumers. Twenty-one percent of the samples had pesticide residues over the MRL, whereas seventy-nine percent of the samples had no pesticide residues or had residues below the MRL. Only a small percentage (40%) of the samples containing two to four pesticides was contaminated with more than four pesticide residues. More than half of the pesticides studied were found to have exceeded their maximum contaminant levels (MCLs), including imidacloprid, deltamethrin cypermethrin malathion monocrotophos chlorpyrifos-methyl diazinon and chlorpyrifos-methyl. Pesticide Aldrin was found in one of the apple samples, at concentrations below the MRL. There is a pressing need to create comprehensive intervention techniques to mitigate the possible health risk to consumers from pesticide residues found in regularly consumed fruits and vegetables in Kuwait [10].

**Jayprabha et al., (2016)**, concludes that endosulphan is one of the recognised OCP insecticides to be very hazardous. The Stockholm Convention, held in April 2011, advocated an international ban on the production and use of endosulphan due to its dangers to human health and the environment. According to this article, endosulphan has contaminated rural regions of Kerala's Kasargod district since the 1970s, when the Plantation Corporation of Kerala began aerial spraying the pesticide there. Enough people in this district were exposed to endosulphan before 2000 that more than 3,000 people developed uncommon disorders like mental retardation, cerebral palsy and cancer. Endosulphan has been found in the water and soil in the affected areas, according to numerous official and non-government reports [11].

**Ravindran et al., (2016)**. In soil, the greatest quantities of organophosphorous dicrotophos, chlorpyrifos, profenofos, and ethion were identified, whereas the lowest concentrations were found in the air. Summer and winter were found to have the greatest mean pesticide concentrations. Agribusiness's continued reliance on pesticides has harmed not only crops, but has also disrupted the food chain and ecology, passing on harmful effects to other animals and birds in the vicinity. Pesticides have been linked to a disproportionately high number of adverse health effects and deaths [12].

**Vanderley et al., (2016)**, Pesticide characteristics, which are unique to each molecule, were examined in this research. Adjuvant studies are mostly used to draw conclusions. This study does not take into

account environmental factors, which are prevalent among farmers, as well as their own activities. Understanding the physical-chemical characteristics of agrochemical compounds is the only way to infer their environmental behavior and forecast or mitigate environmental impact. A chemical that is more mobile and persistent has the ability to infiltrate and leach into ground, surface, and subsurface water more easily than one that is more stable. Molecules that have a high bioaccumulation potential and decay slowly in the environment become more harmful to the ecosystem. Pesticides must be handled correctly in order to guarantee a safe application, as well as an awareness of their physical and chemical qualities. Rural development can be aided by research on this issue without compromising the environment, though [13].

**Halimatunsadiyah et al., (2016)**, focuses on pesticide use in managing pests among lowland farmers cultivating leafy and fruit crops to learn about their pest management strategies. Some lowland vegetable products in Malaysia are of equal importance as highland ones owing to Malaysia's extensive distribution network. However, the lack of knowledge about pesticide safety among farmers was unavoidable, given the market's preference for goods with high intrinsic quality. A survey was undertaken among 85 lowland vegetable producers in order to gather information about their pest management strategies. Pesticide use by farmers on vegetable crops was found to still be based on a calendar spraying schedule. Farmers often begin harvesting their vegetable crops within a few days following their latest pesticide application. To give current information on the food safety risk posed by pesticide residues, it is critical that farmers in vegetable operations conduct intensive monitoring of current pesticide usage [14].

**Roy's (2016)**, Pesticide exposure has a variety of negative effects on the farmers in the research region, according to the findings. Sprayers had a higher relative risk than non-sprayers. In general, pesticide toxicity and the preventative measures that should be taken before, during, and after pesticide application are not well understood by the general public. Farmers have been linked to a slew of chronic and acute health risks. Since self-reported symptoms are used to estimate the frequency of this condition, the actual numbers may be lower. Farmers need to be educated on the need of wearing personal protective equipment (PPE) when applying pesticides. In order to put pesticide usage restrictions into action, both governmental and nonprofit organizations must take proactive measures. IPM (inadequate protection measures) and the usage of protective gear when handling pesticides are urgently needed now. It's also a good idea to hire pesticide-adverse effects educators to help spread the word. Farmers should be aware of the advantages of employing

bio pesticides, and bio pesticides should be readily available to farmers [15].

## OBJECTIVES OF THE STUDY

- To analyze and measuring the presence of various heavy and toxic metals on agricultural soil, water and vegetable.
- To evaluate the risk induced by the contaminants in soil samples.
- To analyze the physicochemical character and parameters in agricultural soil.

## RESEARCH METHODOLOGY

Pollution is measured by soil and water, and the agro-ecosystem is made up of intricate interactions involving soil, water, biota, and the atmosphere. The evaluations of these materials are crucial. Random assessments will be conducted in this field study to collect data on various aspects of pollutant concentrations, features, and economic conditions, among other things.

### Sample/ Participants

In this study, eight sampling stations will be chosen for the examination of soil samples from the Kanpur district's agricultural sector. An open well will be used to gather water samples. A soil sample will be taken from a piece of agricultural land. All of the samples will be prepared for the many criteria that will be investigated, such as physiochemical analysis, hazardous elements analysis, and pesticide residues analysis, and preserved in cool conditions for transport and laboratory examination.

## DATA COLLECTION TECHNIQUES

### Water sample

The water samples will be tested for a variety of physicochemical properties. Standard procedures will be used to measure physicochemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Phosphate, and Nitrate (APHA 2012). The metal ions Na and K in the water sample will be determined using a flame photometer (Model Systronic 128). The chloride content of water samples will be determined using the silver nitrate method. The turbid metric approach will be used to determine sulphate.

### Soil sample

Soil samples will be gathered from industrially and agriculturally active areas for this study. Soil samples will be taken using a plastic spatula from the roadside and from farms, and then transferred to zip lock polythene bags/glass bottles, where they will be sealed and easily transported to the laboratory. Soil

samples will be stored in a deep freezer at -5 °C in the laboratory.

### Water quality index

Eleven essential water quality physico-chemical parameters will be used for the calculation of the water quality index in the current study. The drinking water quality standard recommended by the World Health Organization (WHO), Bureau of Indian Standards (BIS), and Indian Council for Medical Research will be used to construct the water quality index (ICMR). The water body's WQ will be calculated using the weighed arithmetic index approach (Brown et al 1972). There will be a supplementary quality rating or sub index (qn) calculated.

### Procedure

Water and soil samples will be taken from the chosen locations throughout the pre-monsoon, monsoon, and post-monsoon seasons. Unless the bottle contains a stabilizer or dechlorinating agent, sample collecting bottles will be rinsed two or three times during the period. Samples will be taken in pre-cleaned polythene bottles with a 1 litre capacity. Four samples are taken at 1km intervals around each place, and composite samples will be utilized to analyze various parameters according to CPCB recommendations. For physicochemical parameter and heavy metal analysis in soil, the following procedure was utilized.

## RESULT ANALYSES

### Heavy metals analysis

ICP-MS is a technique for analyzing trace metals that combines a high-temperature ICP source of argon gas with a mass spectrometer. The atoms in the sample are converted into ions using the ICP source. The mass spectrometer detects these ions after they have been alienated. ICP-MS is an analytical technology that aids in the analysis of trace elements. It has a detection limit of 10<sup>-9</sup> g/l (10<sup>-9</sup>) level. When compared to atomic absorption and optical emission spectroscopy techniques, such as ICP atomic emission spectroscopy, it offers a higher detection capacity, sensitivity, precision, and speed (ICP-AES). The polythene container will be cleaned with 1:1 HNO<sub>3</sub> and then double distilled water for metal analysis.

### Analysis of variation among location years and between seasons

In kanpur, ANOVA test showed significantly high pH (>8) values in the selected locations Panathdy (pH 8.8) and Tatyaganj (pH 8.3) (F= 16.747, p=0.00). The level of COD was very high in the sample site Tatyaganj (33.3 mg/l) (F=26.431), TH (F=3.928), Ca (F= 3.669), Mg (F=2.436),

Cl(F=3.110), Na ( F=6.247),NO<sub>3</sub>( F=3.010). The other five parameters were significantly not varying. Among the years pH was significantly varied from years ( F= 5.141) ( p = .000) , Ca concentration was significantly varied from the station (F=3.168) (p= 0.045).The physiochemical parameter such as Cl(F=23.310) (p=.000),Na (F=9.403) (p=.000),SO<sub>4</sub> ( F=25.411)(p=0.00), K (F= 9.570) (p=0.00), PO<sub>4</sub> (F=32.432)(p=.00). However, there is no significant variation was observed in the physico-chemical parameters (p>0.05) such as EC, TDS, TH, COD, Mg and NO<sub>3</sub> based on the years.

**Table 1: Mean concentration and standard deviation of water sample collected during monsoon of the year 2019**

Sample station	pH	EC	TDS	COD	TH	Ca hardness	Mg hardness	Cl
Mandana	8.12±0.1	214±16	142.7±3.2	5.2±0.2	79.67±17.6	43±21	36.7±7	51.83±2.7
Chaubeapur	7.89±0.2	180.3±8.1	127.7±5.5	12.5±1.2	77.5±4.4	55.5±3.3	22±2	15.63±3.3
Dhamni nivada	7.6±0.2	174.3±21.1	118.7±5.1	31.73±1.6	88±7	54±7.2	34±12.8	38.89±2.6
Maanpur	7.22±0.1	255.7±7.5	164±10.3	14.43±0.5	87.33±3	62±9.2	25.3±0	45.60±6.2
Tatyaganj	7.53±0.2	173.7±0.5	120.3±1.6	13.97±0.2	81.33±4.1	22±2	59.3±5	31.33±3.2
Barajpur	7.7±0.4	182.7±7.5	122±4.4	22±2.7	52.67±9.1	32.33±2.5	20.3±10.5	39.07±3.1
Shivrajpur	7.65±0.2	252.7±18.6	159.7±6	7.32±0.5	110.67±9	76.33±18.5	34.3±19.8	34.13±3.5
Uttaripura	7.7±0.1	184.7±8.7	135.3±3.5	23.67±1.7	86±2	52±5.3	34±5.3	29.4±2.1

**ANOVA among location years and between seasons**

Analysis of variation in soil quality parameters, based on location seven parameters such as pH, EC, Org C , B, Mg, Mn, Zn were significantly varied (p<0.05). The pH was high at Uttaripura (7.8) (F=15.832) and org C was maximum at Mandana region (6.31%) (F=18.685) (p=0.00). Physico-chemical parameter like Na, K, P, S, Ca, Cu and Fe were significantly not varied. Based on the year the parameter are significantly varied from 2019-2020 to 2020-2021. pH, EC, Org C, B, Mg, Zn and Mn were significantly varied. Other parameter (Na, K, P, S, Ca, Cu and Fe) were not significantly varied. In seasons 12 out of 14, parameters analysed showed significant variation in concentration (p<0.05).

**Table 2: ANOVA analyses among location years and between seasons**

Sample station	pH	EC	Org C%	Na	K	P	S	B	Ca
Mandana	7.16±0.1	949.3±3	6.2±0.1	488±3.5	355±9.1	45.1±0.9	22±0.3	0.25±0.01	2482±24.2
Chaubeapur	7.03±0.1	413.3±7.6	5.3±0.1	636±3.8	327±4.6	5.19±0.2	22±1	0.18±0.01	384.95±15.4
Dhamni nivada	7.2±0.03	518.3±5.5	1.8±0.1	367±5.3	235±1.2	23.2±1.3	12±0.7	0.18±0.01	684±11.5
Maanpur	6.9±0.1	716.7±7.6	5.5±0.1	720.3±8.5	534±10.3	53.9±1.6	19.6±1.4	0.23±0.01	1034±10.3
Tatyaganj	6.8±0.1	906±10.6	2.8±0.1	717±6.4	612±8.8	22±1.6	16.7±0.8	0.17±0.01	1971±25.1
Barajpur	6.97±0.03	621.3±9	4.8±0.1	564±9.1	381±5.7	32.19±2	20.6±0.8	0.18±0.1	529.43±7.2
Shivrajpur	6.32±0.1	854.3±8.7	5.8±0.1	686±7.3	492±5	41.35±0.8	15.5±1.0	0.19±0.01	960.53±2.6
Uttaripura	7.8±0.1	442.7±8.3	1.1±0.02	395±5.1	221±9.5	3.02±0.1	11.7±0.8	0.18±0.01	2245.8±62.5

**Surface soil**

In the present study, Al is the major metal component detected in the soil. Only eight metals namely, Lithium, Aluminium, Cr, Cobalt, Ni, Silver, Cadmium and Lead. The mean concentration of Lithium (Li), Aluminum (Al), Cr (Cr), Cobalt (Co), Silver (Ag), Cadmium (Cd) and Lead (Pb) were in the range 0.15-5.58µg/kg, 309 -1017µg/kg, 4.56 - 13.64µg/kg, 0.013- 0.87µg/kg, 2.05to10.53µg/kg, 0.12-2.65 µg/kg, 0.03- 1.29µg/kg and 0.99 - 7.93µg/kg respectively.

**Table 3: Trace metals concentration in groundwater during the period 2019-2020**

S. No	Sample site/limit	Li µg/l	Al µg/l	Cr µg/l	Co µg/l	Ni µg/l	Ag µg/l	Cd µg/l	Pb µg/l
	WHO limit	-	200	5	50	20	-	3	10
	BIS	-	-	50	-	-	-	10	50
1	Mandana	0.17	1.41	6.19	0.006	1.21	0.023	BDL	0.012
2	Chaubeapur	0.1	2	16.92	0.008	2.10	0.004	0.006	BDL
3	Dhamni nivada	0.14	0.42	5.08	0.007	0.78	0.046	BDL	0.0013
4	Maanpur	0.12	0.63	17.2	0.004	0.11	0.0012	BDL	0
5	Tatyaganj	0.14	2.23	5.72	0.08	0.017	0	BDL	BDL
6	Barajpur	0.12	1.48	6.77	0.04	0.7	0.0013	BDL	0.004
7	Shivrajpur	0.12	6.34	21.5	0.33	0.11	0.004	BDL	0.006
8	Uttaripura	0.19	1.41	6.78	0.07	0.207	0.0269	BDL	0.015

**STATISTICAL ANALYSIS**

All of the data from the study's findings will be examined with Microsoft Excel and SPSS software, which will generate graphs and tables. The SPSS 16 version will be used to perform one-way ANOVA and correlation analysis.

**CONCLUSION**

The vast poisoning of the globe with heavy metals, mostly as a result of human activities, is compromising the health of many people. We need to learn more about the harmful effects of heavy metals on our systems and how to get rid of some of the heavy metal toxins we've ingested through heavy metal poisoning diagnoses in the future. Water, soil, and air are three of the earth's most valuable natural resources. Human actions are causing the depletion of these resources. In order to properly manage our natural resources, we need the participation of the general public. Soil physical and chemical parameters, such as pH, EC, C percent, macronutrients and micro nutrients were determined using APHA standard techniques (APHA 2012). This study found seasonal fluctuations in water's physical and chemical features. Oxygen demand, chloride, and nutrition are just a few of the terms used to describe EC, TDS, and TH. Aluminum, Cr, and cobalt concentrations in Cheemeni's groundwater have substantially altered. An analysis of soil chemical

concentrations revealed that pesticides were still being applied on the majority of the region.

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