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Heavy metal status of different land uses in Soil of Satna District, Madhya Pradesh, India

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Abstract
Heavy metals, such as iron, magnesium, zinc, chromium and lead are major environmental pollutants, particularly in areas with high anthropogenic pressure. Heavy metal accumulation in soils is of great concern in agricultural production due to the adverse effects on food safety and marketability, crop growth due to phytotoxicity, and environmental health of soil organisms. The influence of plants and their metabolic activities affects the geological and biological redistribution of heavy metals through pollution of the air, water and soil. This review focuses on status of heavy metals on different land uses. Concentration of five HMs in surface soils of all land-uses followed the descending order of Industrial area > Agriculture area > Public places > Residential area > Hospital area. Among the land-uses, the Industrial area site measured the highest concentration of Fe, Mg, Zn, Cr and Pb in soil.

Keywords: Satna District, heavy metal, soil, iron, magnesium, zinc, chromium

1. Introduction

The contamination of soil with heavy metals (HM, which is sometimes referred to as metalloid in scientific literature) is one of the most serious concerns brought up in the discussion on food security and food safety in developing countries such as India. There are a number of heavy metals that, when found in the environment at various high concentrations, have been observed to pose a threat to the health of both humans and wildlife (Martin 1997 and Uba *et al*., 2009) [1-2]. There is a rise in the concentration of hazardous metals in agricultural soils as a consequence of the excessive use of a variety of herbicides in an effort to improve crop yields. According to Shetty and Rajkumar (2009) [3], elements such as metals, organic wastes, and several other organic and inorganic compounds might be considered pollutants. This article (Okunola *et al*., 2011) [4] provides a summary of the effects that heavy metals derived from food have on human health, as well as the method by which plants absorb, convert, and accumulate heavy metals in their bodies. It is possible for certain heavy metals to remain in the environment for an incredibly long time. It is difficult for them to be broken down by biological processes, and as a result, their accumulation might reach dangerous levels (Khan *et al*., 2009) [5]. Metals have a high level of toxicity, which means that they can be hazardous to both human health and the environment. In the most recent decades, there has been a significant amount of attention paid to the issue of heavy metals polluting soil (Rafiei *et al*., 2010) [6]. Despite the fact that certain metals are naturally present in soils at low amounts, the concentrations of these metals have been increased as a result of human activity. Therefore, it is of the utmost importance to conduct an assessment of the pollution in the soil and to adopt the appropriate remediation procedures (Romic *et al*., 2007) [7]. Among the human activities that can result in heavy metal contamination of the soil are mining, industries, road traffic, waste disposal, and agricultural use of fertilizers and chemicals (Karbassi *et al*., 2016) [8]. Heavy metal contamination can also be caused by agriculture. In contrast, the most significant natural mechanisms that contribute to the contamination of the soil with metals include volcanoes, fires in forests, and the chemical makeup of the parent materials (Lado *et al*., 2008) [9]. According to Karbassi *et al*. (2014) [10], there are a number of research that have been conducted in a variety of nations for the purpose of interpolation and the calculation of the geographical distribution of heavy metals concentrations in soil.

The elements that are classified as heavy metals are as follows: lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), iron (Fe), zinc (Zn), chromium (Cr), iron (Fe), arsenic (As), silver (Ag), and the elements that belong to the platinum group. Dispersed forms of heavy metals are the most common type of heavy metal found in rock formations.

There has been a rise in the anthropogenic input of heavy metals in the biosphere as a result of industrialization and urbanization alike. The soil and aquatic ecosystems are the places where heavy metals are most readily available, while the atmosphere, in the form of particulate matter or vapours, contains only a trace amount of these metals. As a result of the fact that many heavy metals are regarded to be necessary for plant growth, the toxicity of heavy metals in plants varies depending on the type of plant, the individual metal, the concentration, the chemical form, as well as the soil composition and pH. Some of these heavy metals, such as copper and zinc, either operate as cofactors and activators of enzyme processes, such as when enzymes and substrate metal complexes are formed (Mildvan, 1970) [11], or they exert a catalytic property, such as a prosthetic group in metalloproteins. In the process of nucleic acid metabolism, these vital trace metal elements participate in redox processes, electron transport, and structural functions through their participation. Some of the heavy metals, such as cadmium, mercury, and arsenic, are extremely toxic to enzymes that are sensitive to metals, which leads to the inhibition of growth and ultimately the death of organisms. Fertilizers, both inorganic and organic, are the most significant contributors of heavy metals to agricultural soil. Liming, sewage sludge, irrigation waters, and pesticides are further sources of heavy metals in agricultural soils. Fertilizers are substances that are applied to soil in order to increase the development and yield of plants. Other substances, in particular fungicides, inorganic fertilizers, and phosphate fertilizers, include varying amounts of cadmium, chromium, nickel, lead, and zinc, depending on the sources from which they are derived. The presence of cadmium in plants is a cause for concern due to the fact that it can be found in extremely high concentrations in the leaves, which can be swallowed by either animals or humans. According to Yanqun *et al*. (2005) [12], cadmium enrichment can also be caused by the use of limes, manure, and sewage sludge. It is possible for dangerously high amounts of some metals to accumulate in agricultural soil, despite the fact that the levels of heavy metals in agricultural soil are quite low. This is because of the repetitive application of phosphate fertilizer and the lengthy persistence time for metals.

2. Materials and Methods

Satna is located between 81°15’ east longitude and 24°42’ north latitude and is situated on the Vindhyan plateau at the height of 318 m above MSL. There are many river, viz., Satna, Tamas, Beehar, Asrawal and Simrawal, and most of the land has been irrigated by these rivers. The land becomes fertile due this irrigation facilities. There are a hills of Kaimore and Panna. In Satna district many minerals are found, due to this many industries are running. There are two big cement factory Satna and Maihar. This study designed to determine the status heavy metal in different land uses soils of Satna district Madhya Pradesh. The study area was delineated into 25 sites were selected. Represented soil samples were collected with wooden tools to avoid any contamination of the soils. Three to five pits were dug for each sample. From each pit sample was collected at a depth 0-15 cm. A composite sample of about 1kg was taken through mixing of represented soil sample. All composite samples were dried, ground with wooden mottle and passed through 2 mm sieve. After sieving all the samples were packed in the labeled polythene bags for laboratory investigations. Soil tests were done for heavy metal (Fe, Mg, Zn, Cr and Pb) at soil testing laboratory, Department of Chemistry, A.K.S. University Satna (M.P.) by using following respective methods: The extractable heavy (Fe, Mg, Zn, Cr and Pb) contents of the soil were determined in atomic absorption spectrophotometry Model, Z2300, by taking 1:2 DTPA (0.005M; pH 7.3).

3. Results and Discussion

There has been a widespread pollution of soil with heavy metals (HMs) as a result of increasing industrialization and agricultural practices, which has become a significant environmental concern on a global scale (Chaoua *et al.* 2019 and Sandeep *et al.* 2019) [13-14]. HMs are notable for their extraordinary stability, as evidenced by their half-lives that are more than twenty years (Hadia-e-Fatima, 2018 and Kapoor & Singh, 2021) [15-16]. The introduction of pollutants and heavy metals into the environment is mostly determined by the specific mobility of various metals in the environment. The extraction of minerals and the various handling processes associated with it have an impact on the introduction of these pollutants and HMs. Heavy metal contamination has become a significant issue that requires an effective remedy to limit its impacts. This is because the spread of industry and the unsettling influence of the organic cycle have both contributed to the problem. Heavy metals are generally big metals that do not biodegrade and accumulate in the environment. They constitute a threat to human and environmental health by, for example, contaminating soil and water (Priya and Nagan, 2015) [17]. Heavy metals are responsible for the accumulation of heavy metals. These elements accumulate in the body tissue of a living organic organism through a process that is known as bioaccumulation. Additionally, they travel from a lower to a higher trophic level with an increased concentration, which is a phenomenon that is known as bio magnification. There is a decrease in the number of organisms that live in the soil as a result of the undesirable impacts of heavy metals (Devi and Kumar, 2020) [18].

Heavy metals such as iron (Fe), magnesium (Mg), zinc (Zn), chromium (Cr), and lead (Pb) are among the heavy metals that were investigated in this particular study. Table presents the findings of the analysis performed on the parameters mentioned above.

The statistical characteristics of Fe, Mg, Zn, Cr and Pb measured in five different land use soils of Satna district are reported in Table 1. The overall mean concentration of five HMs was found to be decreased in the order of Zn (56.68 mg/kg) > Fe (50.56 mg/kg) > Pb (48.04 mg/kg) > Cr (47.72 mg/kg) > Mg (2.59 mg/kg) accounting the metals, respectively.

Table 1: Heavy metals concentration (mg/kg) in different land-use Satna district

Land uses (No of samples), (N=5)	Statistical parameter	Iron (Fe)	Magnesium (Mg)	Zinc (Zn)	Chromium (Cr)	Lead (Pb)	$\sum_5$HM
Industrial area	Min.	42.46	2.28	64.67	51.63	26.91	187.95
	Max.	61.58	4.35	80.90	59.16	63.21	269.2
	Mean	49.91	3.32	75.11	54.71	45.07	228.12
	SD	7.85	0.76	6.38	3.20	14.56	32.75
Hospital area	Min.	35.30	1.96	37.89	29.31	39.46	143.92
	Max.	45.69	3.51	51.72	44.00	64.06	208.98
	Mean	40.03	2.62	44.86	36.05	52.55	176.11
	SD	4.59	0.63	5.72	6.38	11.65	28.97
Agriculture area	Min.	49.81	2.06	37.20	50.19	24.08	163.34
	Max.	53.00	2.68	67.53	64.66	65.68	253.55
	Mean	51.49	2.42	56.46	56.57	50.26	217.2
	SD	1.47	0.25	12.22	5.87	16.50	36.31
Residential area	Min.	47.87	2.15	38.21	49.13	32.60	169.96
	Max.	52.44	2.52	66.23	61.06	39.19	221.44
	Mean	50.02	2.28	55.82	55.43	34.82	198.37
	SD	1.90	0.14	11.47	4.91	2.60	21.02
Public places	Min.	56.32	2.09	41.09	34.04	50.53	184.07
	Max.	65.97	2.55	60.56	37.73	66.02	232.83
	Mean	61.35	2.32	51.16	35.86	57.49	208.18
	SD	4.25	0.16	9.12	1.50	7.25	22.28
Mean of all land-uses		50.56	2.59	56.68	47.72	48.04	205.59

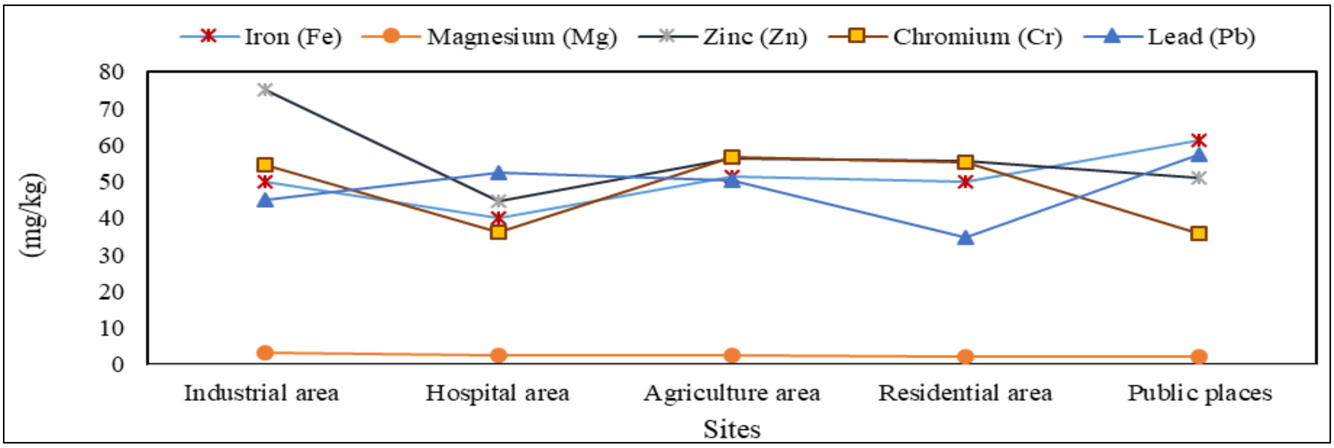

Fig 1: Graph average Heavy metals concentration (mg/kg) in different land-use Satna district.

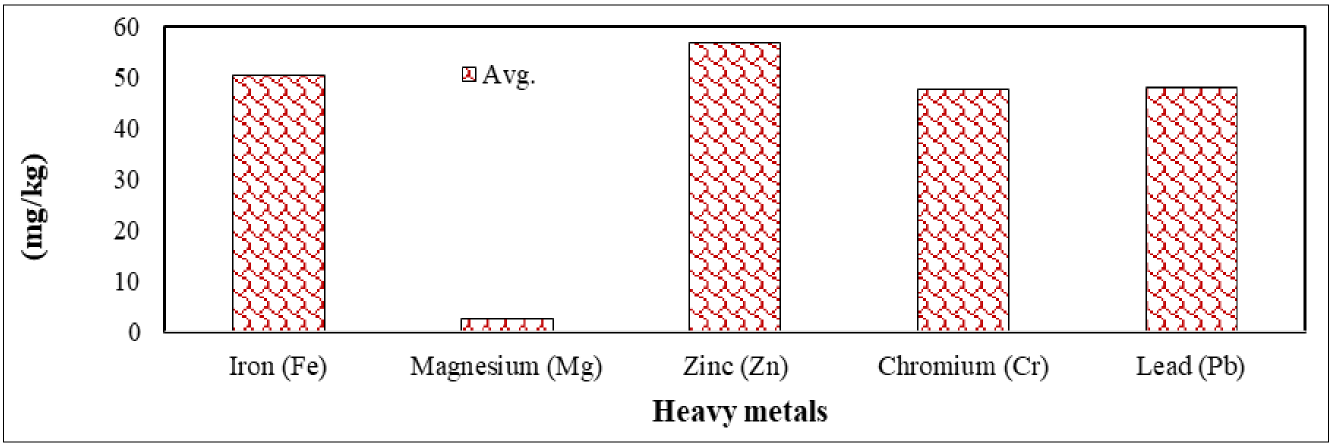

Fig 2: Graph analysis in mean of all land-uses in Satna district.

Dwivedi (2016) [19] examined Maihar City's soil characteristics. Iron increased independently from 8.9 to 73.0 mg/kg. All of the examples had iron levels below the recommended threshold of 380 mg/kg. The Mn concentrations reported here were higher than the concentrations observed in agricultural soils of Panipat and Varanasi (Bharti *et al.* 2013 and Singh *et al.* 2015) [20-21]. In comparison to earlier investigations, the Zn concentrations observed here were greater (Chaudhary *et al.* 2016 and Tian *et al.* 2017) [22-23].

The agricultural soils in this study had a mean content of Cr that was higher than the concentrations in East China and India (Bhagure & Mirgane, 2011; Chen *et al.* 2019 and Rani *et al.* 2021) [24-26]. Other potential sources of lead include various industries close to national highways, such as the paint, battery, metallurgical, and automotive sectors (Debnath *et al*. 2019) [27].

The statistical data of HMs in soil (Table 1) showed the highest mean concentration of $\sum_5$ HM at Industrial area land-use followed by Agriculture area, Public places, Residential area and Hospital area. Accordingly, the $\sum_5$ HM concentration ranged from 187.95 to 269.2 mg/kg (mean 228.12 mg/kg), 163.34 to 253.55 mg/kg (mean 217.2 mg/kg), 184.07 to 232.83 mg/kg (mean 208.18 mg/kg), 169.96 to 221.44 mg/kg (mean 198.37 mg/kg) and 143.92 to 208.98 mg/kg (mean 176.11 mg/kg) in Industrial area, Agriculture area, Public places, Residential area and Hospital area land uses respectively. The selected land-uses measured their HMs concentration (mg/kg) in the soil in the following descending average order as:

- **Industrial area:** Zn>Cr > Fe > Pb > Mg
- **Hospital area:** Pb > Zn > Fe > Cr > Mg
- **Agriculture area:** Cr > Zn> Fe > Pb > Mg
- **Residential area:** Zn > Cr > Fe > Pb > Mg
- **Public places:** Fe > Pb > Zn > Cr > Mg

4. Conclusion

Concluded the concentration of five HMs in surface soils of all land-uses followed the descending order of Industrial area > Agriculture area > Public places > Residential area > Hospital area. Among the land-uses, the Industrial area site measured the highest concentration of Fe, Mg, Zn, Cr and Pb in soil. Additionally, by enhancing metal uptake and corroding common contaminants, the utilization of the current microbial community can aid in increasing the absorptive capacity of roots. By accelerating plant development and overexpressing genes that regulate metal uptake and transport, genetically modified plants may improve phytoremediation.

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