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Investigation Of Heavy Metal Contamination In Soil Proximal To Municipal Solid Waste Dumping Station, Hisar, Haryana

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Abstract

Heavy metals are non-biodegradable pollutants, they pose a serious hazard to human health. The quantity of heavy metals in dumping site increases as different sources of these metals are disposed of with municipal solid waste. A study of the effect of municipal solid waste on heavy metal contaminations in soil proximal to dumping station located in village Dhandoor, of district Hisar, Haryana, was carried out. The soil samples were collected from dumping site in pre-monsoon and post-monsoon. The concentrations of Iron, Copper, Zinc, Chromium, Lead and Cadmium were analyzed by Atomic Absorption Spectrometer. The concentrations of heavy metals in each sampling area were higher in post-monsoon season and in both the seasons the mean concentrations of heavy metals followed the order: Fe > Cu > Zn > Cr > Pb > Cd. This study shows that the heavy metal contaminations in soil is strongly affected by municipal solid waste.

Keywords *Soil Chemistry, Municipal Solid Waste, Soil Health, Heavy Metal Contamination, Soil Pollution, Soil Quality, Environmental Pollution.*

INTRODUCTION

Municipal solid waste, commonly referred to as "trash" or "garbage" is an indispensable result of humanoid action. Due to limiting funding for garbage removal and a shortage of skilled labor, open dump sites are common in developing countries. When garbage is dumped directly on to the surface of the soil, several toxins, especially heavy metals, can easily seep through and contaminate the soil over time and affecting the area's vegetation abundance [1]. India is becoming more and more urbanized and industrialized, which has increased the quantity of municipal solid waste in the town. The high population growth and economic potential of cities are projected to cause a large increase in the amount of solid garbage in the future [2]. By 2031, it is anticipated that the amount of garbage would have increased from 64-73 million tonnes at present to aprox.126 million tonnes [3]. One of the India's biggest environmental issues is the management and dumping of municipal solid garbage. The rate of solid waste generation in India rises exponentially with the growth rate of the urban population, which grows at an annual rate of 4% [4]. Major component of municipal solid waste is plastic, which have negative impact on soil's biological, physical and chemical performance [5]. Municipal solid waste is a major cause of pollution, endangering human health, the environment and sustainable development [6]. Open solid trash disposal sites are a significant cause of pollution. There is a major environmental risk associated with the migration of gas and leachates from disposal site in to the surrounding area and pollute ground water, soil and air [7]. The soil of nearby area of dumping stations becomes contaminated with heavy metal due to drainage and rainwater leaching, which also increases the quantity of organic matter in the soil [8]. Through solid waste if certain highly toxic chemicals like cyanide, mercury and polychlorinated biphenyls etc. if released untreated they can lead to death [9]. The disposal of garbage in soil significantly increases the pH and metal concentration in soil and water, because of the leachates penetrated from the solid and liquid waste [10]. Open solid waste dumping site have a negative impact on the water and soil quality, and they may provide a health risk to humans through the food chain [11]. Municipal solid waste consists of semi solids, solids and liquid discard out from industrial area, markets or houses. Dumping of municipal solid waste cause ecological risks to the local ecosystem by contaminating the soil with heavy metal atom [12]. Because of the heavy metal leachate from municipal solid waste there is carcinogenic risk to both children and human [13]. Harmful effect will result from heavy metal deposition in soil around municipal solid waste dumping sites. Toxic elements from municipal solid waste leached in to water, cultivated crops, plants and then through the food chain they become harmful to humans

[14]. Crop and plant growth is negatively impacted by industrial waste. Heavy metals in soil disrupt the food chain and have a negative impact on human health [15]. People who live nearby municipal solid waste dumping station may be at risk for health problems due to the anthropogenic operations at the municipal solid waste dumping station. Which have also had an impact on the area's soil. It is advised that municipal solid waste dumping station be situated away from housing areas and in geological settings with non-penetrable materials to stop effluents from seeping in to ground water sources [16]. Solid waste disposal site increases the amount of heavy metal viz. cadmium, cobalt, zinc, copper, nickel and lead etc. in the soil and destroy the quality of nearby soil [17]. The main purpose of this study is to investigate the influence of municipal solid waste on soil's quality by analyzing the heavy metal content in soil surrounding municipal solid waste dumping station of Dhandoor, Hisar district of Haryana. The findings of this study shows that the heavy metal contamination in soil is strongly affected by municipal solid waste. The study also intends to inspire the authorities or researchers to work towards improving the current situation of waste being dumped in the open by providing few recommendations.

METHODS AND MATERIALS

Site description-

The study was conducted at the core dumping site of Hisar city, which is situated in village Dhandoor **(Fig. 1)** near Sirsa on National Highway-9, 8 km away from Hisar. This city is located in south western part of Haryana state with geographical location between $28^0 59'$ and $27^0 46'$ north latitude and $75^0 11'$ and $78^0 18'$ east longitude (**Fig. 2**). The open dumping site, which was constructed in 2010, has a 19 acres disposal area. The population of Hisar city is 379,000 according to municipal corporation of Hisar. The city has 20 ward and 120 locations for the collections of solid garbage. Nagar Nigam Hisar collects and manages the generated municipal solid waste.

Fig. 1 Municipal solid waste dumping station at Dhandoor, Hisar

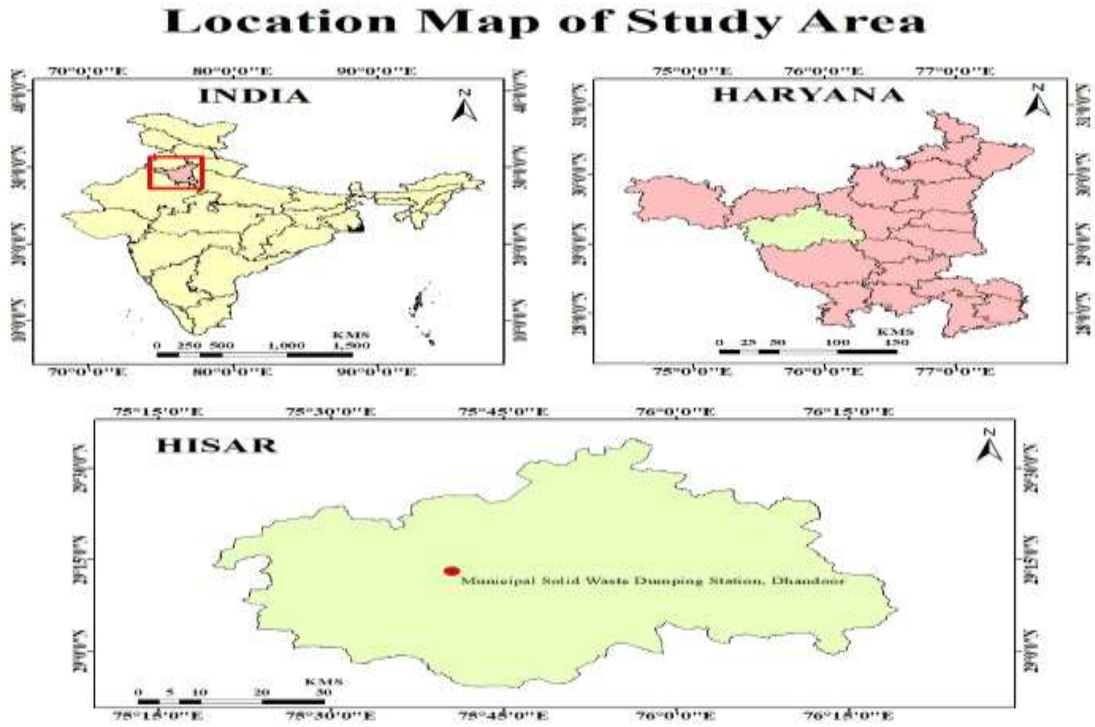

Fig. 2 Location map of study area

Soil sampling-

The samples were collected in the month of April and November, 2023 on the basis of periodic variation which the periods of pre-monsoon (April-May) and post monsoon (October-November). In the month of April (pre-monsoon) and November(post-monsoon) 2023, total 144 soil samples in triplicate from depth 0-15 cm and 15-30 cm at a distance of 5 m, 30 m and 50 m away from the dumping site from all the directions i.e. east, west, north and south were collected. Each of the collected soil samples from the site were transferred in to cloth bags and labeled appropriately with waterproof marker **(Table 1)**. The samples were kept in cool place and dried in at room temperature in tray for 6 days. After this, the soil samples were crumbled using porcelain mortar and pestle and external substances were removed using stainless sieve. For further analysis the sieved samples were preserved in airtight clean Ziploc bag.

Table 1. Label of the sampling areas

Distance from dumping site (meter)	**Depth (in centimeter)**	**Sampling areas**
5 m	0-15 cm	DS1
5 m	15-30 cm	DS2
30 m	0-15 cm	DS3
30 m	15-30 cm	DS4
50 m	0-15 cm	DS5
50 m	15-30 cm	DS6

Soil analysis-

pH values of soil samples were measured by using pH meter in 1:2 soil: water suspension. Samples were digested with aqua regia and then analyzed for heavy metals viz. Iron (Fe), Lead (Pb), Zinc (Zn), Cadmium (Cd), Chromium (Cr) and Copper (Cu) by Atomic Absorption Spectrophotometer (AAS). From each sampling site three samples of soil were collected and means were calculated for each measured parameter.

RESULTS AND DISCUSSION

In 2011, the population of Hisar city was 3,46,879 and the per capita municipal solid waste generation rate was 398 g per day. In 2019, the average daily production of municipal solid waste in Hisar city was approximately 169 metric tonnes per day, with a population of 3,67,472 and a per capita waste generation rate of 0.460 Kg. But in 2023, the population of city was expanded to 3,79,000 and the average daily production of municipal solid waste increased to 180 tonnes per day, with 0.474 Kg per capita [18]. At Present the city has only single dumping site in Dhandoor village where garbage is regularly dumped on open land. There are no leach proof arrangements, gas and leachate collection or treatment systems at the site. Food waste made up 34.82% of the total Garbage, followed by polythene (16.39%), paper (4.02%) and plastic (3.69%) [19]. To analyze the contamination in the soil around dumpsite a comparison is made between the data obtained during pre-monsoon and post-monsoon. In order to detect the levels of contamination of the soils near dumpsites, data gained were compared with, world-soil average value given by Kabata-Pendia [20] and the concentrations of world health organization/food and agriculture organization (WHO/FAO) standard [16].

pH value of studied site-

The pH is a better indicator of chemical nature of soil as it affects the accessibility of nutrients from soil to plants. The low values of pH in the soil rises the mobility of heavy metals such as chromium, copper, cadmium, nickel, lead and zinc [21]. The optimal range for pH value of the soil is 6 to 8.5 for plant growth [22]. The pH value of sampling area varies, from 8 to 8.85 during pre-monsoon and from 8.42 to 9.16 during post-monsoon seasons as shown in **Table 2**. The soil around dumping station was alkaline in nature. The samples have higher pH value in post-monsoon season than that of pre-monsoon season.

Table 2. pH value of soil in sampling areas

Sampling areas	**Mean pH Value**	
	Pre-Monsoon	Post-Monsoon
DS1	8.04	9.08
DS2	8.02	9.13
DS3	8	8.42
DS4	8.1	9.1
DS5	8.71	8.89
DS6	8.85	9.16

Heavy Metal Concentrations in the studied site-

Table 3 shows the mean of heavy metal concentrations in soil of all sampling areas during pre-monsoon and post-monsoon seasons.

From the result of concentration, it is noted that the mean concentrations of all the metals in each sampling area in post-monsoon season is greater than that of pre-monsoon season. It is evident from the result of concentrations that metals in all sampling areas of both the seasons (pre- monsoon and post-monsoon) followed the order: Fe > Cu > Zn > Cr > Pb > Cd. It means, in both the seasons (pre-monsoon and post-monsoon) across all types of sampling areas, Fe has the highest mean concentrations and Cd has the lowest mean concentrations.

Table 3. Mean concentrations of Iron (Fe), Lead (Pb), Chromium (Cr), Cadmium (Cd), Zinc (Zn) and Copper (Cu) in sampling areas

Sampling areas	**Mean Iron Concentrations (mg/kg)**	**Mean Lead Concentrations (mg/kg)**	**Mean Chromium Concentrations (mg/kg)**	**Mean Cadmium Concentrations (mg/kg)**	**Mean Zinc Concentrations (mg/kg)**	**Mean Copper Concentrations (mg/kg)**

	Pre-Monsoon	Post-Monsoon	Pre-Monsoon	Post-Monsoon	Pre-Monsoon	Post-Monsoon	Pre-Monsoon	Post-Monsoon	Pre-Monsoon	Post-Monsoon	Pre-Monsoon	Post-Monsoon
DS1	7895	6900	22.43	23.78	21.38	25.66	< 1	< 1	41.04	42.4	43.09	48.3
DS2	14322	7100	55.6	56.95	54.55	65.46	< 1	< 1	101.74	103.1	106.83	119.7
DS3	7845	12300	22.78	24.13	21.73	26.08	< 1	< 1	41.68	43	43.77	49
DS4	8244	17400	31.04	32.39	29.99	35.99	< 1	< 1	56.8	58.2	59.64	66.8
DS5	10346	15200	63.4	64.75	62.35	74.82	< 1	< 1	116.02	117.4	121.82	136.4
DS6	9341	12300	57.6	58.95	56.55	67.86	< 1	< 1	105.4	106.8	110.67	124
WHO/ FAO*	-		85		-		0.8		50		36	
World-Soil Average **	-		27		59.5		0.41		70		38.9	

* World Health Organization/ Food and Agriculture Standard of permissible heavy metal concentrations in soil.
** Calculated average mean for the world scale of unpolluted soil reported by Kabata-Pendias.

The mean concentrations of Fe in sampling areas in pre-monsoon and post-monsoon season were ranged from 7845 to 14322 mg/kg and 6900 to 17400 mg/kg, respectively. Mean Fe concentrations in sampling areas graphically shown in **Fig. 3**.

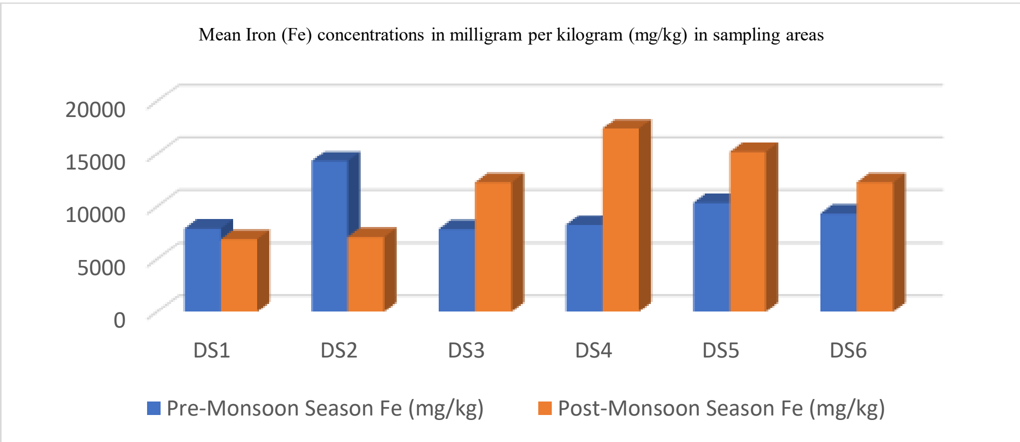

Fig. 3 Mean concentrations of Iron (Fe) in sampling areas in pre-monsoon and post-monsoon season

The mean concentrations of Pb in sampling areas in pre-monsoon and post-monsoon season were varied from 22.43 to 63.4 mg/kg and 23.78 to 64.75 mg/kg, respectively. The observed mean concentrations of Pb were less than the permissible limit of WHO/FAO standard but exceed the calculated world-soil average of 27.00 mg/kg [20]. Plastics, car batteries, coal and insecticides present in the garbage may increase the content of Pb in surrounding soil [23]. The mean concentrations of Cr in sampling areas in pre-monsoon and post-monsoon season were ranged from 21.38 to 62.35 mg/kg and 25.66 to 74.82 mg/kg, respectively. In some sampling areas the observed mean concentrations of Cr were less than the world-soil average but in some areas the observed concentrations exceed the world -soil average 59.50 mg/kg [20].

Observed mean Cd concentrations in each sampling areas in pre-monsoon and post-monsoon season were less than the permissible value of WHO/FAO standard. Although, these concentrations were very less even not detected by AAS and not exceed the calculated world-soil average of 0.41mg/kg [20]. The mean Zn concentrations in sampling areas in pre-monsoon and post-monsoon season were varied from 41.04 to 116.02 mg/kg and 42.4 to 117.4 mg/kg, respectively. The observed concentrations, were higher than the permissible limit of WHO/FAO standard and also exceed the calculated world average of unpolluted soil i.e 70 mg/kg [20]. The mean concentrations of Cu in sampling areas in pre-monsoon and post-monsoon season were ranged from 43.09 to 121.82 mg/kg and 48.3 to 136.4 mg/kg, respectively. The observed values, were greater than the permissible limit of WHO/FAO standard as well as the calculated world average of unpolluted soil (38.9 mg/kg) [20].

Fig. 4 show the mean concentrations of Pb, Cr, Cd, Zn and Cu in sampling areas of pre-monsoon and post-monsoon season in graphical manner. From the data of concentrations, it is noted that the concentrations of Cu, Pb, Cr and Zn in the soils exceeded the calculated average mean for the world scale of unpolluted soil reported by Kabata-Pendias.

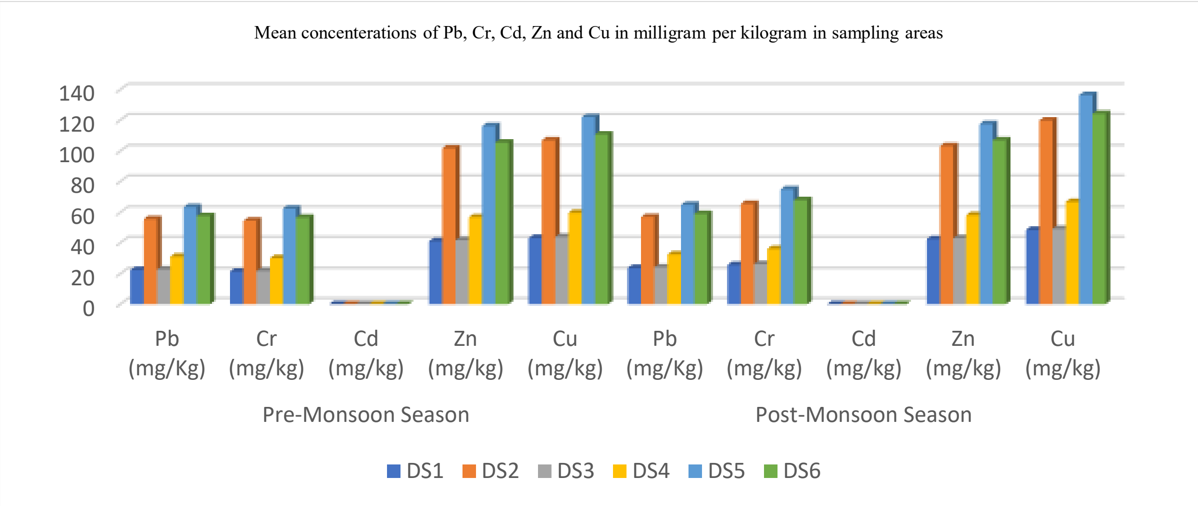

Fig. 4 Mean concentrations of Lead (Pb), Chromium (Cr), Cadmium (Cd), Zinc (Zn) and Copper (Cu) in sampling areas in pre-monsoon and post-monsoon season

CONCLUSIONS

The present study investigated the influence of municipal solid waste on soil quality by determining the heavy metal concentrations viz. Fe, Zn, Cu, Cd, Cr and Pb in soil proximal to municipal solid waste dumping station. The study revealed that the soil of sampling areas was alkaline in nature. The concentrations data of the study showed that the mean concentrations of heavy metals in all sampling areas were higher in post-monsoon season that that of pre-monsoon season. In both the seasons (pre-monsoon and post-monsoon) the mean concentrations of heavy metals in each sampling area followed the order: Fe > Cu > Zn > Cr > Pb > Cd. From the study data it was detected that the mean concentrations of Zn, Cr and Cu in sampling areas were greater than the calculated world average of unpolluted soil and also exceeded the permissible limit of WHO/FAO standard. Mean Cd concentrations in all sampling areas were within the safe limit. But the mean concentrations of Pb in each sampling area were lesser than the permissible limit of WHO/FAO standard but exceeded the calculated world average of unpolluted soil. The study concluded that the soil in proximal to municipal solid waste dumping station is highly contaminated with heavy metals. From the study it is obvious that the heavy metal contamination of soil is strongly affected by waste material or open waste dumping station.

If garbage is not managed appropriately, it can have detrimental consequences on the environment, human health, and aesthetic qualities. For the management of municipal solid waste, careful planning is required. It is advisable that in addition to encouraging waste reduction, recycling and reuse, it is imperative to construct a leach proof control dumping station or there should be gas and leachate collection or treatment system at the dumping station.

STATEMENTS AND DECLARATIONS

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This research does not contain any studies involving human and animal subjects.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

AUTHOR CONTRIBUTIONS

Renu Sharma (Professor in Chemistry) supervised the experiments, reviewed and edited the manuscript. Sarita (PhD Scholar) performed the experiments and wrote the manuscript.

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