



Heavy Metal Enrichment and Soil Quality in Urban Waste Disposal Areas: Case Study of Padegaon, Chh. Sambhajinagar (MS).

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ABSTRACT:

Introduction: Chhatrapati Sambhajinagar (Aurangabad) faces increasing environmental stress due to rapid urbanization and unscientific municipal solid waste (MSW) disposal. The Padegaon dumping site, surrounded by residential settlements, has become a hotspot of pollution. Continuous waste accumulation and improper handling have raised concerns about soil and groundwater quality. This study investigates soil contamination during the 2023 monsoon season with a focus on nutrient imbalance and heavy metal enrichment.

Objectives: The study aims to assess the soil quality in and around the Padegaon dumping site by analyzing both essential nutrients and toxic heavy metals. It seeks to determine contamination levels, compare them with BIS standards, and evaluate their potential risks to agriculture, environment, and public health.

Methods: Five soil samples were collected from different locations near the Padegaon dumping yard using auger sampling at a depth of six inches. Samples were analyzed in a NABL-accredited laboratory for Potassium (K₂O), Copper (Cu), Iron (Fe), Zinc (Zn), Manganese (Mn), Cadmium (Cd), Chromium (Cr), and Lead (Pb). Analytical techniques included ICP-OES with standard FAO and EPA protocols. The results were statistically compared against BIS permissible limits.

Results: The analysis showed elevated potassium levels, far exceeding the BIS safe limit, indicating nutrient imbalance likely from waste deposition or fertilizer runoff. Heavy metals such as cadmium, chromium, and lead also crossed permissible thresholds, highlighting severe anthropogenic contamination. While copper, iron, zinc, and manganese were within safe ranges, their high variability across sites reflected localized pollution hotspots. The contamination pattern revealed heterogeneity linked to unregulated dumping practices.

Conclusions: The study provides strong evidence of heavy metal enrichment and nutrient imbalance in soils around the Padegaon dumping site. Cadmium, chromium, and lead levels represent serious ecological and health hazards due to their toxicity and persistence. Elevated potassium further indicates soil quality degradation. These findings underline the urgent need for scientific waste management, remediation measures, and continuous environmental monitoring to safeguard soil fertility, groundwater quality, and community health.

1. Introduction:

Chhatrapati Sambhaji Nagar, previously known as Aurangabad, is one of Maharashtra's most historically and economically significant cities. It is situated in the

Marathwada region and functions as a central hub for industry, education, tourism, and trade. Named after the Mughal emperor Aurangzeb, the city has grown from a medieval military outpost into a modern urban center



while preserving its cultural and architectural heritage. The population of Aurangabad, which was around 1.2 million during the 2011 census, is estimated to have crossed 1.5 million today. Rapid urbanization, industrial expansion—especially in the Chikalthana and Waluj MIDC industrial areas—and increasing migration from rural to urban zones have significantly contributed to this growth. This demographic boom has, however, placed tremendous pressure on the city’s infrastructure and environment, particularly in the domain of municipal solid waste (MSW) management.

Aurangabad is geographically located at 19.87° N latitude and 75.34° E longitude, and sits at an average elevation of 513 meters above sea level. It experiences a semi-arid tropical climate characterized by scorching summers, moderate to heavy monsoon rains, and mild winters. The city receives an average annual rainfall of about 700 to 800 millimeters, most of which is concentrated between June and September. The hot summer months often record temperatures above 42°C, while winters can see the mercury drop below 10°C. These climatic conditions directly affect the decomposition rate of organic matter in solid waste, influence the generation and mobility of leachate from dumping grounds, and impact the seasonal variation in groundwater and soil chemistry in vulnerable zones.

As Aurangabad’s population and economy have expanded, so too has the volume of waste it generates. The city currently produces approximately 450 to 500 metric tons of solid waste daily. This waste includes biodegradable components such as food and vegetable waste, as well as non-biodegradable and hazardous materials like plastics, metals, e-waste, biomedical waste, and construction debris. Unfortunately, the city’s waste management system has not evolved proportionally to its waste load. Inadequate segregation at source, insufficient public awareness, limited recycling infrastructure, and a lack of sustainable disposal facilities have all led to mounting environmental challenges. Unscientific disposal of solid waste continues to be a major issue, particularly with open dumping practices that disregard modern environmental and health regulations. These systemic failures in MSW handling are most visibly manifest in the form of sprawling and unmanaged dumping sites on the city’s periphery.

2. Materials & Methods:

2.1 Study Area:

One of the most prominent and problematic dumping sites in the region is located at Padegaon, situated in the northeastern part of the city. The Padegaon dumping site has been in operation for several decades and serves as the primary location for the disposal of Aurangabad’s municipal waste. Spanning a vast area, the site was initially located on the outskirts of the city, but due to unplanned urban expansion, residential settlements have now emerged near the dumping yard. Areas such as Bhavsinghpura, Mitmita, Bodhi Nagar, and the Darga area now lie in close proximity to the dumping yard. These neighborhoods suffer from continuous exposure to environmental pollution stemming from the site. Residents frequently report foul odor, increased incidence of respiratory infections, vector-borne diseases, and diminished quality of life. Open burning of waste, illegal dumping, and improper leachate management further compound these problems, creating a health hazard for thousands of families residing nearby.

Despite multiple complaints and growing public pressure, the dumping ground continues to operate without adequate environmental safeguards or a scientific waste processing mechanism. The close interface between waste disposal zones and human settlements in Padegaon illustrates a classic case of urban mismanagement and environmental injustice. Therefore, evaluating the soil and groundwater quality in the vicinity of the Padegaon dumping site is not only relevant for environmental monitoring but also essential for developing sustainable urban waste management strategies. This study, therefore, aims to investigate the levels of essential and toxic elements in the soil around the Padegaon municipal dumping site during the monsoon season, assess the extent of contamination, and evaluate its potential impact on environmental and public health. The findings are expected to offer a data-driven foundation for the formulation of improved waste management strategies and future urban planning policies in Aurangabad.

The following table represents the GPS location of sampling with latitude and longitude.

**Table No. 1. GPS Location of Soil Sampling.**

Sample. No.	Sample Site	LAT	LONG
1	Bhavsinghpura (Satpute)	19.907426	75.287992
2	Padegaon (Kachra Depo Vanvibhag)	19.902609	75.284267
3	Padegaon (Darga Farm)	19.901889	75.28602
4	Bhavsinghpura (Lokhande Sakhrabai)	19.903271	75.288675
5	Bhavsinghpura (Lokhande)	19.901448	75.290516

2.2 Collection and analysis of soil samples:

Five soil samples were taken area around the Padegaon disposal site in Aurangabad, Maharashtra, India. Additionally, Table 1 lists the GPS coordinates for each sampling site. Standard procedures were followed in the collection of the representative soil samples. Using an auger-appropriate digging instrument, samples were taken up to 6 inches from the location. A sample of dirt weighing around 500 grams was taken from each site. The samples were appropriately labeled with the sample date, identification number, and sampling site, and kept in plastic bags.

The samples were delivered to the NABL-accredited lab, where they were examined independently for a number of criteria. Manganese (Mn), Zinc (Zn), Copper (Cu), Iron (Fe) {FAO 2008 PP 59-68, DTPA Extraction technique by ICP-OES}, Lead (pb), Cadmium (cd), Chromium (Cr), Lead (EPA technique No. 3050}, and Potassium (K) {FAO 2007 PP 75-76}.

3. Result & Discussion:

A government-approved and NABL-accredited soil and water testing facility in Aurangabad examined five soil samples in total. Data collected during the analysis period (July 2023) is listed in Table 2.

Table No. 2 Chemical & Heavy Metals Parameters of Soil.

Sample No.	Potassium (Kg/ha)	Copper (mg/kg)	Iron (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)
1	87.25	0.658	0.279	0.063	0.728	0.003	0.29	0.07
2	1976.98	6.02	6.01	0.486	2.73	0.05	0.14	0.19
3	367.46	0.472	0.29	0.104	1.66	0.004	0.2	0.08
4	149.62	0.341	0.15	0.138	3.51	0.004	0.39	0.04
5	166.7	0.521	0.23	0.007	0.69	1.11	0.11	0.18

Table No. 3: Statistical Summary of Padegaon Soil.

Sample No.	Parameter	Min.	Max.	Mean	Std. Dev.	CV (%)	BIS Limit	Status
1.	Potassium (K) (Kg/ha)	87.25	1976.98	549.6	804.82	146.44	280	Exceeds limit
2.	Copper (Cu) (mg/kg)	0.341	6.02	1.6	2.47	154.28	3	Within limit
3.	Iron (Fe)	0.15	6.01	1.39	2.58	185.53	5	



	(mg/kg)							Within limit
4.	Zinc (Zn) (mg/kg)	0.007	0.486	0.16	0.19	118.35	1	Within limit
5.	Manganese (Mn) (mg/kg)	0.69	3.51	1.86	1.24	66.64	2	Within limit
6.	Cadmium (Cd) (mg/kg)	0.003	1.11	0.234	0.49	209.22	0.003	Exceeds limit
7.	Chromium (Cr) (mg/kg)	0.11	0.39	0.226	0.12	50.7	0.05	Exceeds limit
8.	Lead (Pb) (mg/kg)	0.04	0.19	0.112	0.07	61.02	0.1	Exceeds limit

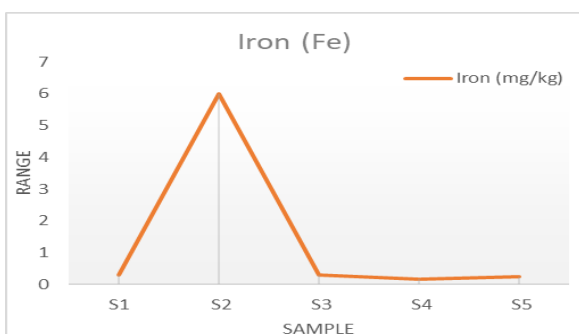
3.1 Detailed Interpretation of Soil Quality (Padegaon Monsoon 2023)

The analysis of soil samples collected during the monsoon of 2023 from various sites around the Padegaon dumping site reveals a complex interplay of macro and microelements, including heavy metals.

3.2 Potassium

Extreme regional diversity is seen in the potassium (K₂O) content, which ranges from 87.25 to 1976.98 kg/ha with a coefficient of variation (CV) of 146.4%. The average potassium concentration is 549.6 Kg/ha, which significantly exceeds the BIS limit of 280 Kg/ha. This high level of potassium suggests either excessive use of potash-based fertilizers or influence from organic solid waste dumping. While potassium is essential for plant growth, overabundance can alter soil osmotic balance and cause nutrient antagonism, impairing uptake of magnesium and calcium.

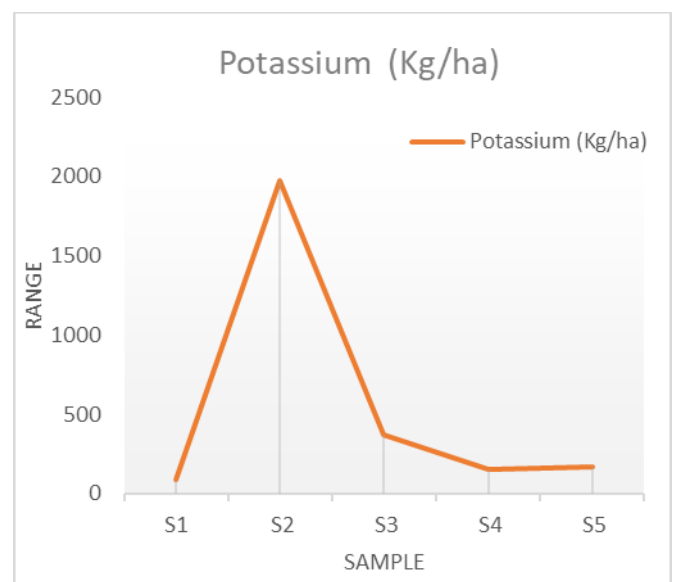
Chart No. 1



3.3 Copper

Copper levels ranged from 0.341 to 6.02 mg/kg, with a mean of 1.60 mg/kg and a CV of 154.28%. Although the average remains within the BIS limit of 3 mg/kg, the elevated value at the solid waste depot site signals potential localized contamination, possibly from electronic or industrial waste. Copper, when exceeding limits, can be phytotoxic and harm microbial biomass, but in this dataset, the statistical significance is low due to only one high outlier, suggesting limited concern at present.

Chart No. 2

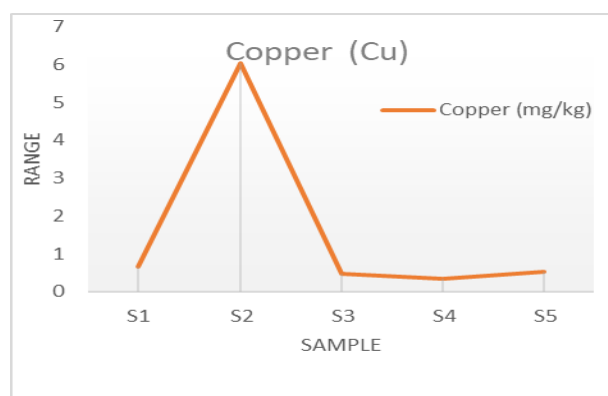




3.4 Iron

Iron concentration fluctuated moderately ($CV = 185.53\%$), with values spanning from 0.15 to 6.01 mg/kg. The mean iron level is 1.39 mg/kg, well within the acceptable BIS limit of 5 mg/kg. This suggests the iron content is largely natural and not significantly impacted by dumping activities. Nonetheless, excessive iron accumulation, if it occurs, could lead to anaerobic soil conditions and reduced microbial diversity.

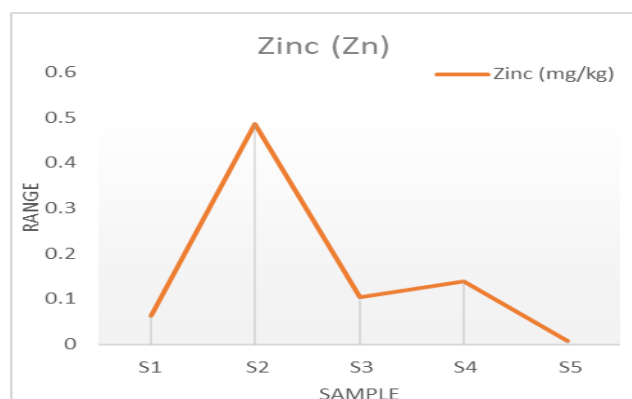
Chart No. 3



3.5 Zinc

In the case of zinc, the mean value of 0.16 mg/kg is substantially below the BIS threshold of 1 mg/kg, suggesting deficiency rather than toxicity. Zinc deficiency can impair plant enzyme functions and lead to stunted growth. Its coefficient of variation is high (118.35%), pointing to site-specific heterogeneity, possibly influenced by the type of waste materials dumped.

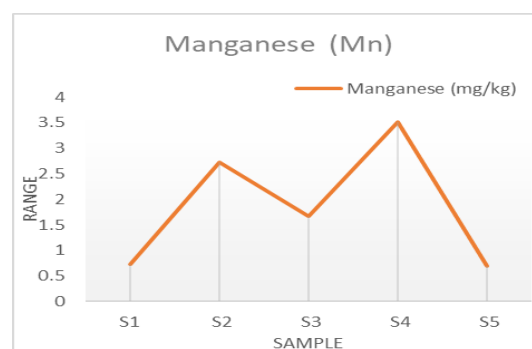
Chart No. 4



3.6 Manganese

Manganese values ranged from 0.69 to 3.51 mg/kg, with an average of 1.86 mg/kg—just below the BIS limit of 2 mg/kg. Although the mean does not breach the standard, the upper extreme hints at significant contamination at certain locations. Manganese is essential in small quantities but becomes neurotoxic at higher concentrations, posing long-term ecological and health risks

Chart No. 5



3.7 Cadmium

The average cadmium level is 0.234 mg/kg, which is dangerously high when compared to the safe BIS limit of 0.003 mg/kg. The extremely high CV of 209.22% reflects substantial variability, and the highest observed value (1.11 mg/kg) indicates hazardous pollution likely from battery waste, plastic residues, or industrial effluents. Cadmium is a notorious carcinogen and nephrotoxin that bioaccumulates in the food chain and degrades soil fertility. Its significance in this study is both statistical and environmental, demanding urgent mitigation.

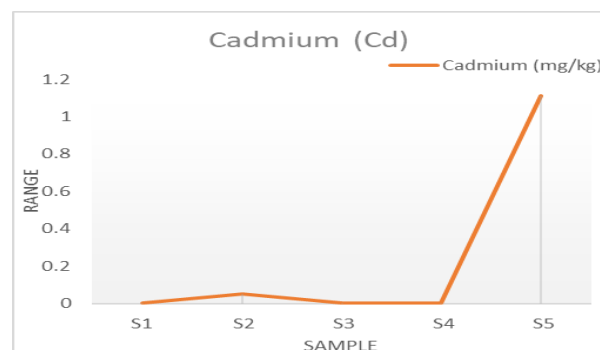


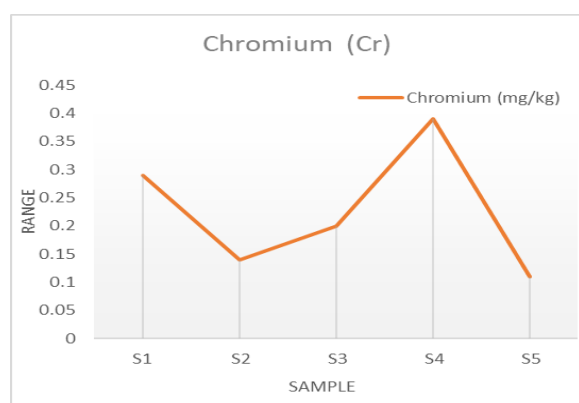
Chart No. 6



3.8 Chromium

Similarly, chromium exceeds the BIS limit of 0.05 mg/kg, with a mean of 0.226 mg/kg. This is of great concern because chromium, especially in its hexavalent form, is a potent mutagen and carcinogen. The variation across sites (CV = 50.7%) is relatively moderate, which implies widespread rather than isolated contamination.

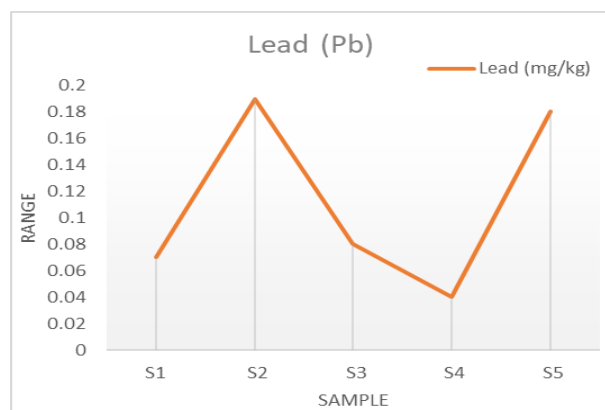
Chart No. 7



3.9 Lead

Lead, another heavy metal of significant concern, also surpasses its BIS threshold of 0.1 mg/kg, recording a mean of 0.112 mg/kg. Although the excess seems marginal, even low levels of lead are harmful due to its cumulative toxicity and impacts on the nervous system, particularly in children. The statistical variation (CV = 61.01%) reinforces the risk of irregular but repeated contamination, possibly from paint, batteries, or vehicle emissions in waste.

Chart No. 8



4. Conclusion

The Padegaon Monsoon Soil 2023 dataset reveals clear evidence of contamination, especially from heavy metals like **cadmium**, **chromium**, and **lead**, all of which exceed permissible BIS limits and pose substantial threats to environmental and human health. Elevated **potassium** levels also reflect possible nutrient imbalance due to waste dumping or fertilizer misuse. Though parameters like copper, iron, and zinc remain within limits, their high variability warrants closer surveillance.

Statistically, high coefficients of variation in most parameters signal heterogeneity across dumping sites, likely due to unregulated and diverse waste input. Environmentally, the contamination of essential agricultural soils with heavy metals could degrade crop quality, reduce yield, impair microbial ecology, and ultimately threaten groundwater quality through leaching.

These findings underscore the urgent need for systematic solid waste management, heavy metal remediation strategies, and routine soil monitoring to protect both agricultural productivity and public health in the region.

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