

Ground Water Contamination from Solid Waste Near Jhiri Dumpyard Ranchi

Preeti Verma¹ and Neeta Sinha²

¹Research Scholar, Department of chemistry, Ranchi University Ranchi, Jharkhand, India.

²Assistant Professor, Department of chemistry, Ranchi University Ranchi, Jharkhand, India.

E-mail : preetisadarsh@gmail.com, neetasahay@gmail.com.

Manuscript received 16 June 2024, accepted on 15 October 2024

Abstract : Groundwater contamination from solid waste dumpyards poses a significant threat to public health and environmental sustainability. This study investigates the impact of open dumping of Municipal Solid Waste (MSW) on groundwater quality in the vicinity of Jhiri dumpyard in Ranchi, Jharkhand, India. To assess the variations, groundwater samples were collected from the surrounding areas of the dumpsite. Utilizing a comprehensive approach that includes sampling and laboratory analysis the research identifies key contaminants and their concentrations in the groundwater sources around the dumpyard. Results indicated significant contamination due to migration of landfill leachate, with higher contamination levels observed in areas closer to the landfill. Elevated alkalinity, total dissolved solids, and ammonia concentrations were recorded, along with concerning levels of heavy metals such as lead (0.097 mg/L), iron (0.97 mg/L), and manganese (0.36 mg/L), all exceeding the Bureau of Indian Standards (BIS) limits for drinking water. The Water Quality Index (WQI), classified the overall groundwater quality of the region as “poor,” highlighting the severe impact of landfill leachate on groundwater. The study underscores the urgent need for improved waste management practices and the implementation of effective groundwater monitoring systems to safeguard the health of local communities and the environment. Recommendations for mitigating groundwater pollution and enhancing regulatory frameworks are also discussed, aiming to provide a basis for sustainable waste management strategies in Ranchi and similar urban areas.

(Keywords : Groundwater Contamination, Heavy metals, (WQI), Waste Management, Mitigating groundwater pollution.)

Introduction

Groundwater is a crucial resource for drinking water, agriculture, and industrial processes. The improper disposal of solid waste in dumpsites poses a significant threat to groundwater quality. Leachate generated from solid waste can percolate through the soil, carrying harmful contaminants into the groundwater aquifers. Solid waste generation and its management has become a growing environmental and public health problem around the world, especially in developing countries where poverty, increased population growth, unplanned urbanization, industrialization and changing consumer habits produced huge amount of solid waste¹. In most of the developing countries, solid waste is disposed unscientifically in open areas that result in risk to the surrounding environment and human population². Open dumping is the oldest and most prevalent method for disposing of solid waste. Over 90% of the MSW produced in India is inadequately dumped on land. Leachates generated by the MSW in uncontrolled landfills have become a major environmental problem across the globe³.

Areas close to dumping sites are more likely to experience groundwater contamination due to the leachate produced by these sites. This contamination presents a considerable risk to people who rely on local groundwater sources. Once groundwater becomes contaminated, full restoration of its quality is not probably possible in some cases⁴.

The continuous degradation of groundwater quality by anthropogenic activities particularly from dumpsites, will greatly affect its quality. Similarly, physicochemical, bacteriological and heavy metal pollution of groundwater has a direct impact on human health which leads water-borne diseases such as typhoid, cholera and dysentery⁵. Therefore, this research paper aims to explore the sources and mechanisms of groundwater contamination from solid waste near dumpsites, assess its impacts, and propose effective mitigation strategies to address this critical environmental issue.

Study Area

This study area is carried out at Jhiri Ranchi. It is located at Jhiri town which lies

between 23° 30' N (Latitude) and 85° 30' E (Longitude). In the Northern side of the Dump yard, Jaguar Campus is located, the area of southern side is called Shiv Nagar, the eastern side is called Chamar Garha and the western side is known as Anand Nagar. Jhiri village is located in Kanke Tehsil of Ranchi District in Jharkhand. Jhiri dump yard is located at the distance of 16km from District Head Quarter Ranchi. The total geographical area of the village is 258.66 hectares.

Jhiri dump yard is one of the biggest dumpsite in Jharkhand, spread across 41 acres of land, where more than 600 tonnes of garbage are dumped every day since decades.



(Source: Kuldeep Suman and Kirti Avishek Applications of Geospatial Technologies in Solid Waste Management Planning for Ranchi City: Sustainable Development Perspective)

Fig 1: Map showing study area.

SOURCES OF GROUNDWATER CONTAMINATION

Solid waste can be categorized into municipal, industrial, agricultural, and hazardous waste. Each type of waste generates different types of leachate which contains organic and inorganic pollutants, heavy metals, and pathogens. Groundwater contamination can occur from both natural and anthropogenic sources.

Natural Sources

The natural sources of groundwater contamination include seawater, brackish water, surface waters with poor quality, and mineral deposits. These natural sources may become serious sources of contamination when human activities upset the natural environmental balance, such as depletion of aquifers leading to saltwater intrusion, acid mine drainage and leaching of hazardous chemicals as a result of excessive irrigation^{6,7}.

Anthropogenic Sources

Ground water contamination by anthropogenic activities is defined as the addition of undesirable substances to groundwater caused by human activities. This is caused by chemicals, road salt, bacteria, viruses, medications, fertilizers, and fuel. However, groundwater contamination differs from contamination of surface water in that it is invisible and recovery of the resource is difficult at the current level of technology⁸. Groundwater contaminants are usually colourless and odourless. In addition, the negative impacts of contaminated groundwater on human health are chronic and are very difficult to detect⁹. Some of the common sources of ground water contamination due to anthropogenic sources are.

- Hazardous waste sites: Uncontrolled and abandoned hazardous waste sites can lead to groundwater contamination if hazardous materials leak from barrels or other containers.
- Landfills: Pollutants like car battery acid, paint, and household cleaners, can penetrate the landfill and contaminate groundwater.
- Agricultural activities: Chemical fertilizers and pesticides used on crops can seep through the soil and contaminate groundwater.

Material and Methods

The study on groundwater contamination from solid waste near the Jhiri dumpsite in Ranchi involve systematic collection and analysis of groundwater samples from various locations around the dumpsite. Sampling sites were selected within a radius of 1km from the dumpsite to capture potential contamination levels. Water samples were collected from five different bore hole sites into a 1L plastic container each at stipulated time. The bore holes are identified as BH1, BH2, BH3, BH4 and BH5 respectively and same labelling were also used for the plastic containers. The samples were stored in sterilized plastic containers and transported to the laboratory under refrigerated conditions. Standard procedures were followed

for the physicochemical analysis of the samples. An average of 10 samples of each set were collected and analysed from each of the bore hole. The ground water samples were analysed for physical and chemical parameters. The physical parameter includes, pH, total dissolved solid, conductivity, turbidity, conductivity. While the chemical parameters include Heavy metals, iron content, sulphate, nitrate as nitrogen, total hardness (Ca), hardness (Mg) total and phosphate as phosphorous.

The physiochemical parameters of groundwater samples were assessed using standardized analytical techniques. pH was measured using a pH meter. Electrical conductivity was determined using a conductivity meter. For the analysis of heavy metals, such as lead, cadmium and arsenic, samples were subjected to Atomic Absorption Spectrophotometry (AAS), which provides high sensitivity and specificity for trace metal detection and Nitrate levels were measured using UV methods. These methods ensured comprehensive and reliable evaluation of the groundwater quality in the study area.

Results and Discussion

The groundwater analysis from the Jhiri dumpsite in Ranchi, Jharkhand, reveals several key findings. The pH value is within the permissible range of 6.5 to 8.5 in all boreholes. Conductivity levels are low and within permissible limits. However, total hardness is considerably below the standard limit of 200 mg/l, suggesting that the water is moderately hard. The turbidity levels significantly exceed the permissible limit of 1 mg/l, with all boreholes indicating that the water is highly turbid and may contain suspended solids.

Iron concentrations in all boreholes are higher than the permissible limit of 0.3 mg/l, which could affect water taste and colour. It may lead to health issues like gastrointestinal issues

and liver damage. The concentrations of heavy metals such as nickel, manganese, lead, and copper exceed their respective permissible limits in several boreholes, raising concerns about potential toxicity. Increased lead and copper concentration causes cognitive impairment and kidney damage.

In terms of other parameters sulphate, chloride, and nitrate levels are within acceptable limits across all boreholes, indicating no significant presence of these compounds in harmful concentrations. Calcium levels are also within acceptable standards. The presence of other heavy metals like arsenic, cadmium and zinc are within permissible limits. The data of the result

Table - 1
Comparison of Water Quality Parameters Against IS:10500 Standards
for Borehole Samples BH1-BH5

SL. NO	PARAMETERS	UNIT	IS:10500	RESULT				
				BH1	BH2	BH3	BH4	BH5
1	pH	0	6.5 - 8.5	7.13	7.15	7.13	7.06	7.24
2	CONDUCTIVITY	mS/cm	0	0.04	0.04	0.06	0.05	0.06
3	TOTAL HARDNESS	mg/l	200	79	77	77	73	74
4	ALKALINITY	mg/l	200	80	82	84	88	86
5	TDS	mg/l	500	167	170	170	166	167
6	TURBIDITY	mg/l	1	94	100	96	98	97
7	FLOURIDE	mg/l	1	0.28	0.28	0.27	0.31	0.32
8	IRON	mg/l	0.3	9.50	9.40	9.48	9.45	9.47
9	SULPHATE	mg/l	200	30	34	29	35	32
10	NITRATE	mg/l	45	1.69	1.87	1.81	1.77	1.81
11	CHLORIDE	mg/l	250	19	16	17	19	19
12	CADMIUM	mg/l	0.003	0.0011	0.0012	0.0015	0.0017	0.0015
13	ARSENIC	mg/l	0.01	0.003	0.004	0.001	0.001	0.001
14	LEAD	mg/l	0.01	0.046	0.047	0.051	0.045	0.051
15	CALCIUM	mg/l	75	21.9	22.8	21.8	23.9	21.8
16	BORON	mg/l	0.5	0.3	0.1	0.5	0.1	0.1
17	COPPER	mg/l	0.05	0.30	0.38	0.29	0.38	0.35
18	MANGANESE	mg/l	0.1	0.41	0.42	0.48	0.46	0.43
19	NICKEL	mg/l	0.02	0.09	0.07	0.07	0.06	0.06
20	SELENIUM	mg/l	0.01	0.005	0.001	0.001	0.002	0.001
21	ZINC	mg/l	5	2.37	2.29	2.36	2.28	2.40

and discussion have been tabulated in **Table 1** with its graph shown in **Figure 2,3,4,5,6** respectively. The methods used for testing the water samples are pH meter, Conductivity Meter, EDTA titration, Turbidity metric, Spadns method (to measure fluoride concentration) and Atomic

Absorption Spectroscopy (to measure concentration of heavy metals). This data is used to determine the suitability of the water for drinking purposes based on its compliance with the recommended guidelines.

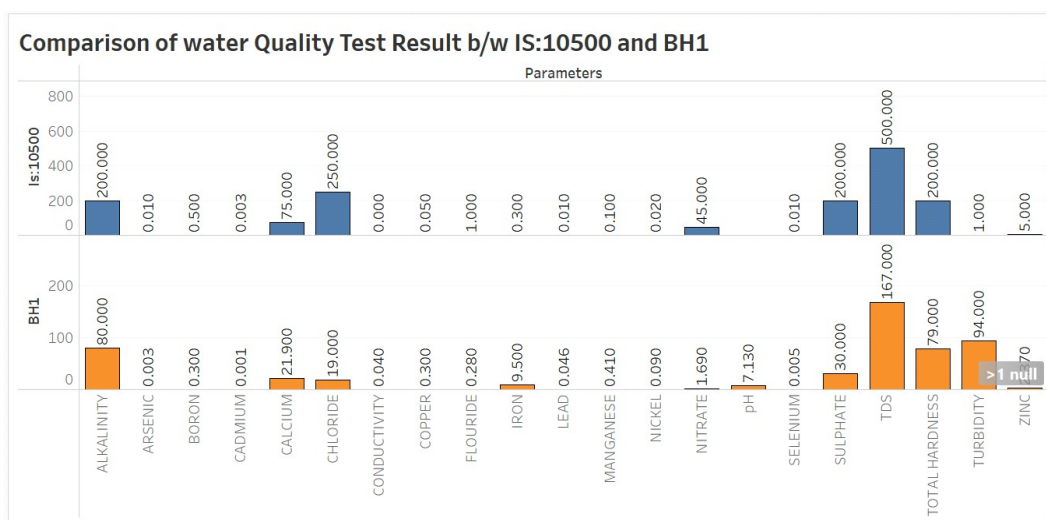


Figure 2: Water Quality Test Results - Jhiri Dumpyard, Ranchi.
Comparison between IS:10500 and BH1

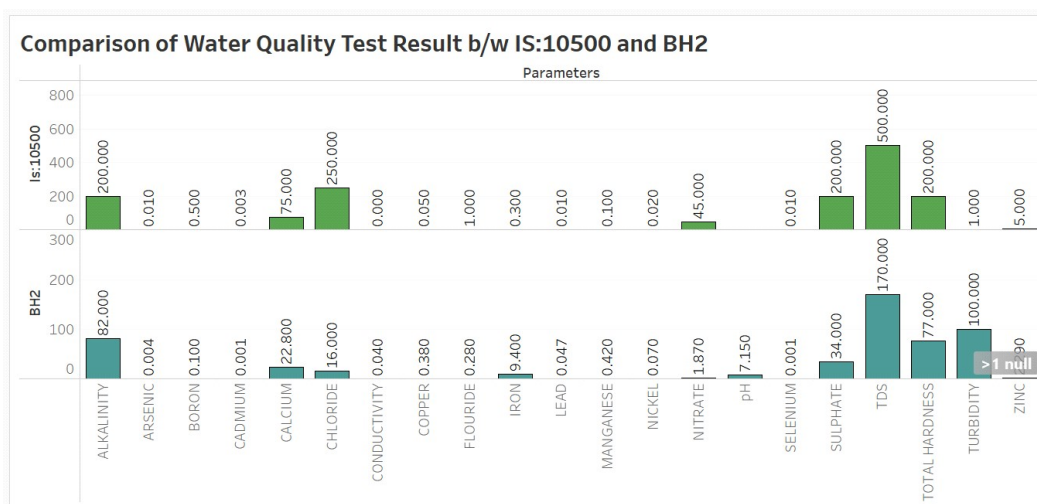


Figure 3: Water Quality Test Results - Jhiri Dumpyard, Ranchi.
Comparison between IS:10500 and BH2

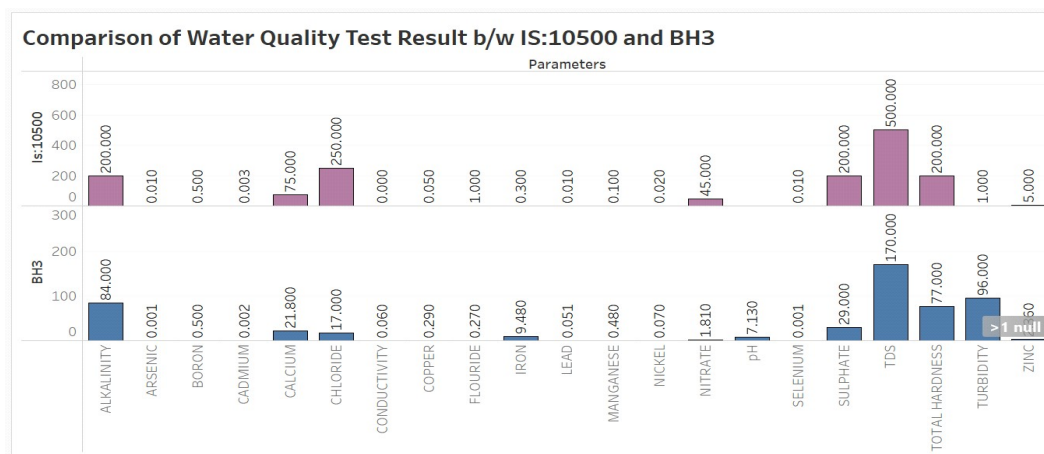


Figure 4: Water Quality Test Results - Jhiri Dumpyard, Ranchi.
Comparison between IS:10500 and BH3

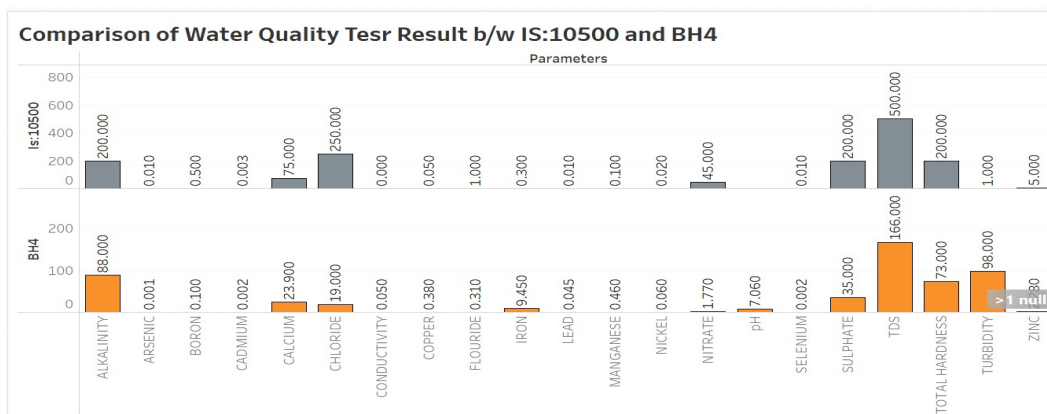


Figure 5: Water Quality Test Results - Jhiri Dumpyard, Ranchi.
Comparison between IS:10500 and BH4

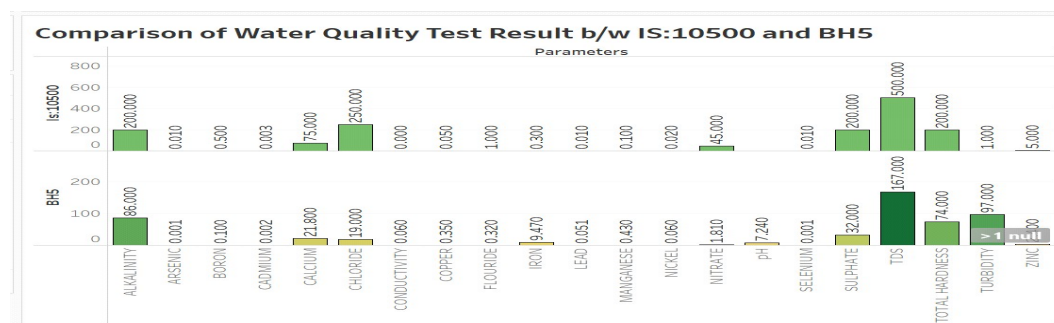


Figure 6: Water Quality Test Results - Jhiri Dumpyard, Ranchi.
Comparison between IS:10500 and BH5

ENVIRONMENTAL IMPACTS AND MITIGATION

Environmental Impacts

Groundwater contamination from solid waste has several environmental impacts.

1. **Water Quality Degradation:** The leachate from the dumpsite is contaminating the groundwater with high levels of chlorides, nitrates, sulphates, ammonium, and heavy metals like cadmium, chromium, copper, iron, nickel, lead, and zinc¹⁰. This makes the groundwater unfit for drinking, domestic use and other purposes.
2. **Ecosystem Damage:** Local flora and fauna are adversely affected by polluted groundwater, disrupting ecosystems and reducing biodiversity.
3. **Soil Contamination:** The dumpsite is generating toxic compounds like carbon monoxide and hydrogen sulphide, which are polluting the soil. This can have long-term negative effects on the soil quality and fertility¹¹.
4. **Surface Water Pollution:** The nearby rivers, lakes, and other surface water bodies, extending the pollution and affecting larger areas.

Mitigation

The groundwater contamination from solid waste, can be mitigated by following strategies.

1. **Biogas Energy:** With the construction of bio-gas plants which can convert organic waste into energy. This can reduce the volume of fresh waste accumulating at the site.
2. **Leachate Management:** Installation of proper leachate collection and treatment systems which can prevent leachate from seeping into the groundwater.
3. **Waste Segregation and Recycling:** Increasing recycling efforts and promotion of waste segregation at the source itself can reduce the amount of waste generation leading to better management of waste.

Conclusion

Groundwater contamination from solid waste at the Jhiri dumpsite in Ranchi, Jharkhand, has serious environmental and public health concern. There is a critical need for effective solid waste management systems near the dumpsite. The contamination of ground water due to leachate generated from the decomposing solid waste at the Jhiri dumpsite contains toxic substances, including heavy metals and organic compounds. Studies have indicated that this leachate is not stabilized, leading to high pollution levels that threaten local

References

1. S. Kanmani, R. Gandhimathi. Investigation of physicochemical characteristics and heavy metal distribution profile in groundwater system around the open dump site, *Applied Water Science*, (2013).
2. S. Miahra, D. Tiwary, A. Ohri, A.K Agnihotri. Impact of municipal solid waste landfill leachate on groundwater quality in Varanasi, India, *Groundwater for Sustainable Development* (2019).
3. S.S. Kale, A.K Kadam, S. Kumar, N.J Pawar. Evaluating pollution potential of leachate from landfill site, from the Pune metropolitan city and its impact on shallow basaltic aquifers, *Environ Monit Assess* 2010.
4. P. Vasanthi, S. Kaliappan, R. Srinivasaraghavan. Impacts of poor solid waste management on groundwater, *Environmental Monitoring and Assessment* (2008).
5. A. N Amadi, M. Ameh, J. Jisa. The impact of dumpsites on groundwater quality in Makurdi metropolis benue state, *Natural and Applied Sciences Journal* (2010).
6. Z. Su, J. Wu, X. He, V. Elumalai. Temporal changes of groundwater quality within the groundwater depression cone and prediction of confined groundwater salinity using Grey Markov model in Yinchuan area of northwest China. *Expo Health* (2020).

7. P. Li, J. Wu, H. Qian. Preliminary assessment of hydraulic connectivity between river water and shallow groundwater and estimation of their transfer rate during dry season in the Shidi River, China. *Environ Earth Sci.* (2016).
8. J.A MacDonald, M.C Kavanaugh. Restoring contaminated groundwater: An achievable goal? *Environ Sci Technol*, (1994).
9. D. Chakraborti, M.M Rahman, A. Mukherjee, M. Alauddin, M. Hassan, R.N. Dutta, S. Pati, S.C. Mukherjee, S. Roy, Q. Quamruzzman, M. Rahman, T. Islam, S. Sorif, Md. Selim, MR Islam, M.M Hossain. Groundwater arsenic contamination in Bangladesh—21 years of research. *J Trace Elem Med Biol*, (2015).
10. Raj Kumar Nagarajan, Subramani Thirumalaisamy, and Elango Lakshumanan, Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India, (2012).
11. The times of India, what a mess! Ranchi reeks of apathy as 19 lakh tonnes of waste swamp jhiri, (2023).
12. Jai Kant Kumar Sharma, Ajai Singh, Development of Leachate Pollution Index of Jhiri Dumpsite; Ranchi, Jharkhand, (2019).
13. Dipankar Chakraborti, Bhaskar Das, Matthew T. Murrill, *Examining India's Groundwater Quality Management*, (2010).