IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, July 2026
Impact Factor: 8.2

Assessment of Metal Contamination in Industrial Wastewater of Sanganer, Jaipur (Rajasthan, India)

Sunita Shekhawat[1], Utkarsh Kaushik[*2], Priyanka Sharma[1]
Department of Zoology, LORDS University, Alwar, Rajasthan[1]
Department of Zoology, Poddar International College, Mansarovar, Jaipur, Rajasthan, India[2]
sunitashekhawat0212@gmail.com, utkarsh3kk2012@gmail.com, Priyanka.sharma@lordsuni.edu.in
* Corresponding Author: Utkarsh Kaushik

Abstract: *The untreated wastewater discharged from textile dyeing and printing units in the Sanganer industrial area of Jaipur, Rajasthan was identified as a serious environmental issue due to the presence of toxic heavy metals and other pollutants in it. The present study was aimed to evaluate the concentration, distribution and contamination status of some selected heavy metals present in the industrial wastewater samples from various effluent discharge points of Sanganer textile cluster.*

Wastewater samples were collected from representative site of different stages of industrial effluent discharging and analyzed with the help of standard analytical procedure as recommended by Central Pollution Control Board (CPCB), World Health Organization (WHO), Bureau of Indian Standards (BIS). The concentration of major heavy metals such as lead (Pb), chromium (Cr), arsenic (As), iron (Fe), aluminium (Al), manganese (Mn) and nickel (Ni) were determined to assess the level of metal contamination and general wastewater quality.

After initial screening, a sample of the wastewater with the greatest contamination was chosen for further research. The concentrations of Pb, Cr, As, Fe, Al, Mn, and Ni were recorded as 3.26 ± 0.08, 4.28 ± 0.09, 0.45 ± 0.02, 11.4 ± 0.22, 5.7 ± 0.11, 2.4 ± 0.06, and 2.08 ± 0.05 mg/L, respectively. The analysis showed that all the heavy metal levels measured were found to be below the recommended maximum level by the World Health Organisation for wastewater discharge and environmental safety. The highest concentrations of some of the metals investigated were found for Chromium and Lead, which may indicate significant inputs from dyeing/printing of textiles and other related industrial activities.

The results showed that the industrial wastewater produced in Sanganer area was extremely polluted with toxic metals which may have adverse impacts on soil quality, groundwater, aquatic environment and human health if discharged in the environment for a long time. The study highlighted the importance of developing sustainable industrial wastewater management practices in the region, including the adoption of efficient effluent treatment technologies, enforcement of regulations, and the establishment of monitoring programs to help reduce heavy metal contamination.

Keywords: Heavy metals, industrial wastewater, textile effluents, Sanganer industrial area, chromium contamination, lead pollution, environmental monitoring, wastewater characterization

I. INTRODUCTION

The industrialization was not only important for the economy and for social development but also one of the main sources of environmental pollution because of the production and release of industrial wastewater. The textile dyeing and printing industry was identified as one of the industries creating wastewater with high concentrations of dyes, salts, organic compounds and toxic heavy metals among others. In many developing countries, low quality of water and high

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, July 2026
Impact Factor: 8.2

ecological risks were caused by insufficient wastewater treatment facilities and poor environmental management practices.

The town of Sanganer in Jaipur district of Rajasthan, India was famous for its textile dyeing and hand block printing craftsmanship. The industrial cluster consisted of many small and medium scale textile mills which released significant amount of waste water in the dyeing, bleaching, washing and printing processes. While regional common effluent treatment plants were available, some of the effluent was either untreated or partially treated and discharged to surrounding environments and drainage channels in the region, raising significant environmental issues.

The wastewater produced from textile industries was complex mixture of synthetic dyes, suspended solids, dissolved salts, organic matter and heavy metals. Particular attention was focused on heavy metals, including lead (Pb), chromium (Cr), arsenic (As), nickel (Ni), iron (Fe), manganese (Mn) and aluminium (Al), due to their toxicity, persistence in the environment, being non-biodegradable and an ability to build up in living organisms. Exposure to these metals on a chronic basis resulted in impacts to aquatic ecosystems and reduced soil quality, contaminated groundwater resources and human health risks due to bioaccumulation and biomagnification in the food chain.

Heavy metal concentrations have been found to be higher in the wastewater and environmental compartments in textile industrial areas before. In Sanganer industrial area, repeated release of effluents from industries had been correlated with the deterioration of the soil, pollution of surface and ground water resources and negative effect on agricultural lands adjoining the effluent discharge points. The results emphasized the need for an integrated monitoring and evaluation of heavy metal contamination of industrial effluents produced in the area.

Hence, it was decided to undertake the present study for the assessment of concentration, distribution and contamination status of the selected heavy metal in the industrial wastewater samples collected from different sites of the textile industrial area of Sanganer. The study was directed towards the determination of the concentration of lead (Pb), chromium (Cr), arsenic (As), nickel (Ni), iron (Fe), manganese (Mn) and aluminium (Al). In addition, observed concentrations were compared to regulatory values to determine potential environmental impacts. The results of this study would be useful for the conception of environmental monitoring programs, pollution control measures and sustainable wastewater management measures for textile industrial areas.

II. MATERIALS AND METHODS

2.1 Study Area and Sampling Strategy

The study was carried out in the Sanganer industrial area of Jaipur, Rajasthan, India, a well known industrial area of textile dyeing and hand block printing, where a significant amount of industrial wastewater was generated. Water samples were taken from some of the sites as they were representative of various stages of industrial effluent discharge and flow routes. These were the discharge outlets of industries, channels which received untreated or partially treated effluents, and areas which were potentially influenced by industrial effluents downstream.

Representative wastewater samples were collected in the study area initially using a systematic sampling method. But, based on the initial screening and comparative evaluation of the collected samples, one sample which was contaminated with the maximum amount of heavy metals was selected for detailed physicochemical and heavy metal analysis. The selected wastewater sample was used throughout this study.[1]

It is important to note that all samples were collected in pre-cleaned, acid washed polyethylene containers, according to standard procedures advised by the American Public Health Association (APHA). The samples were collected and immediately preserved at 4°C and sent to the laboratory for further physicochemical and heavy metal analysis.

[1] Bureau of Indian Standards (BIS). (2020). *Indian Standard drinking water specification (IS 10500:2012)*. https://bis.gov.in

DOI: 10.48175/IJARSCT-37808

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, July 2026
Impact Factor: 8.2

2.2 Physicochemical Analysis

Some key physicochemical parameters of the wastewater samples were analyzed to determine the overall quality of the wastewater and whether they could be safely discharged into the environment.

The following parameters were investigated:

- pH
- Electrical Conductivity (EC)
- The total quantity of dissolved matter (dissolved solids) present in water.

Standard methods recommended by the American Public Health Association (APHA) were followed for all analyses. The derived values were then compared with the guidelines set by the World Health Organization (WHO) and Bureau of Indian Standards (BIS) for the assessment of environmental quality.

2.3 Heavy Metal Analysis

The concentration of selected heavy metals in the wastewater samples was carried out using the method of Atomic Absorption Spectrophotometry (AAS). [2]

The following metals were analysed:

1. Lead (Pb)
2. Chromium (Cr)
3. Arsenic (As)
4. Nickel (Ni)
5. Iron (Fe)
6. Manganese (Mn)
7. Aluminum (Al)

Standard acid digestion process was performed on the wastewater samples before analysis. Standard solutions of the certified stock solutions of each metal were used to calibrate the instruments. Reagent blanks, calibration verification standards and replicate measurements were added to assure analytical quality control.

The levels of heavy metals were reported in mg/L and compared with the permissible limits set by WHO which are given in mg/L to check the extent of contamination.

III. DATA ANALYSIS

The concentration of heavy metals collected from various sampling sites were analyzed, and compared with the permissible limit prescribed by WHO and BIS. Mean values of all measured parameters and standard error (SE) were presented. Comparative assessment was made to determine the most polluted sampling point and to assess the degree of pollution of the industrial effluents of textile industries in Sanganer industrial area by determining the level of contamination of the heavy metals.[3]

IV. RESULTS AND DISCUSSION

4.1 Heavy Metal Concentration in Industrial Wastewater

Table4.1: Heavy Metal Concentration in the Selected Wastewater Sample from Sanganer, Jaipur and Comparison with WHO Permissible Limits

Heavy Metal	Concentration (mg/L)	WHO Permissible Limit (mg/L)	Status
Pb	3.26 ± 0.08	0.01	Exceeds Limit

[2] World Health Organization (WHO). (2022). *Guidelines for drinking-water quality*. https://www.who.int

[3] Central Pollution Control Board (CPCB). (2021). *Standard guidelines for industrial effluent discharge*. https://cpcb.nic.in

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, July 2026
Impact Factor: 8.2

Cr	4.28 ± 0.09	0.05	Exceeds Limit
As	0.45 ± 0.02	0.01	Exceeds Limit
Fe	11.40 ± 0.22	0.30	Exceeds Limit
Al	5.70 ± 0.11	0.20	Exceeds Limit
Mn	2.40 ± 0.06	0.10	Exceeds Limit
Ni	2.08 ± 0.05	0.02	Exceeds Limit

The concentrations of the selected heavy metals, collected from the Sanganer textile industrial area, Jaipur have been compared with the permissible limits of the World Health Organization (WHO) and are presented in Table 4.1.

The analysis revealed all the heavy metals investigated were present in concentrations much higher than the recommended by the WHO. Lead (Pb) was recorded at 3.26 ± 0.08 mg/L, chromium (Cr) at 4.28 ± 0.09 mg/L, arsenic (As) at 0.45 ± 0.02 mg/L, iron (Fe) at 11.40 ± 0.22 mg/L, aluminum (Al) at 5.70 ± 0.11 mg/L, manganese (Mn) at 2.40 ± 0.06 mg/L, and nickel (Ni) at 2.08 ± 0.05 mg/L.

Of the toxic metals, chromium was present in the highest concentration of the specifically toxic contaminants followed by lead, nickel and arsenic. The concentration of arsenic was far in excess of the limit recommended, showing that it is highly contaminated.

The overall concentration of Fe was highest, followed by Al and Mn. This trend indicated that the sources of metal pollution in the region were likely related to the textile dyeing industry and other industrial activities, including printing and manufacturing.

The outcome of the results showed that the industry's existing effluent treatment was not adequate. Untreated or partially treated wastewater was probably being discharged on a continuous basis into the drainage system. This scenario may have caused significant environmental impacts such as reduction in soil health, surface and groundwater contamination, harm to water systems, and impacts on productivity. These metals have the potential to bioaccumulate over time and to be passed down the food chain to humans, making them a health threat.[4]

4.2 Heavy Metal Concentrations in the Selected Wastewater Sample

Table4.2 : Heavy Metal Concentrations in the Selected Wastewater Sample

Heavy Metal	Concentration (mg/L)
Pb	3.26
Cr	4.28
As	0.45
Fe	11.40
Al	5.70
Mn	2.40
Ni	2.08

Table 4.2 was a summary of the heavy metals that were measured in the same sample of wastewater.

The results of the analysis showed that heavy metals had a high pollution load in the wastewater sample. Industrial activities, particularly the textile dyeing and printing industry, were confirmed to be the main contaminants as they were identified as chromium, iron and lead.

[4] Rao, P. K. (2021). Industrial wastewater management in developing countries. *Water Research, 203*, 117–129. https://doi.org/10.1016/j.watres.2021.117123

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 6, Issue 3, July 2026

Impact Factor: 8.2

The pattern that was observed indicated that untreated industrial effluents were being directly released into the wastewater system. The high levels indicated a failure in the effluent treatment prior to its release to the water bodies or drainage system.[5]

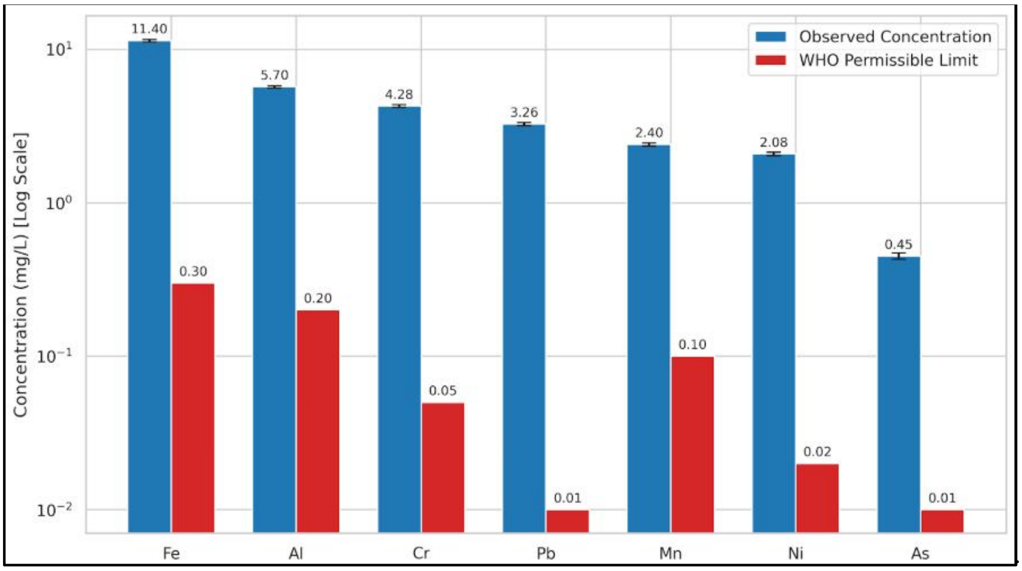

Figure 4.1: Comparison of Heavy Metal Concentrations in the Selected Wastewater Sample with WHO Permissible Limits

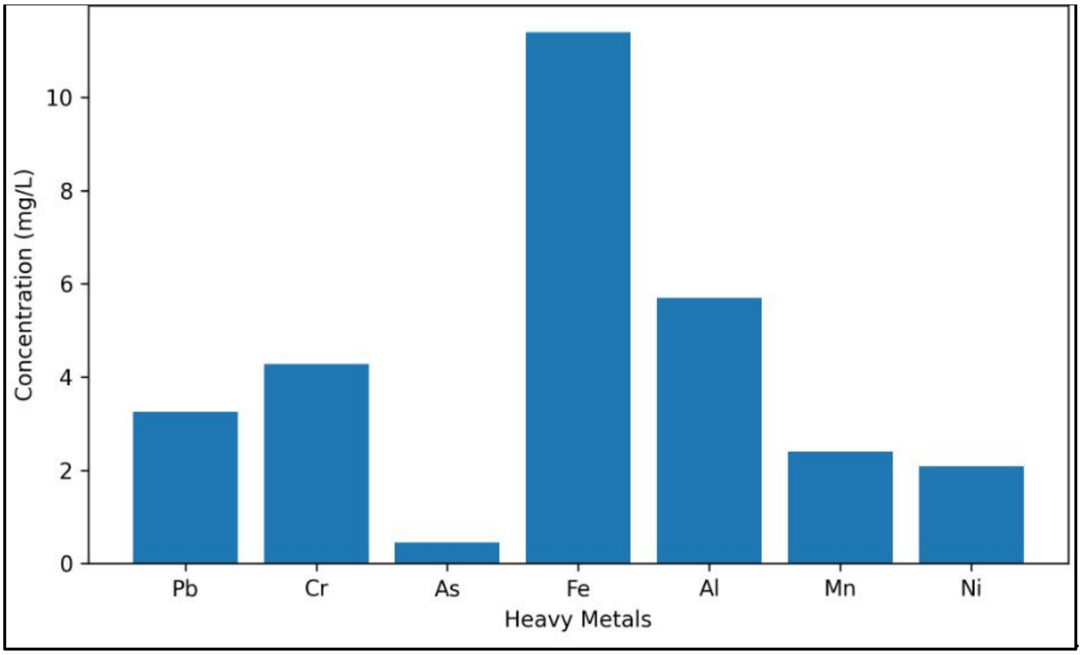

Figure 4.2: Heavy Metal Concentrations in the Selected Wastewater Sample from Sanganer Industrial Area

[5] Anonymous. (2023). Analysis of physicochemical characteristics of textile effluents in Sanganer region. *Materials Today: Proceedings, 95*, 34–42. https://doi.org/10.1016/j.matpr.2023.06.381

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, July 2026
Impact Factor: 8.2

The graphical analysis also revealed that all the metals recorded values above the permissible limits as per WHO guideline. The heavy elements of particular note, where chromium and lead both were found in large quantities, were signs of a strong pressure of industrial pollution in the study area.[6]

4.3 Environmental Effects of Heavy Metal Pollution

4.3.1 Soil and Groundwater Contamination

Waste water samples taken from the Sanganer industrial area contained high concentrations of heavy metals and this was of great concern for polluting the soil and groundwater resources. In the present study, concentrations of chromium (Cr), lead (Pb), arsenic (As) and nickel (Ni) found were much higher than recommended limit set by WHO, which is a clear indication that the textiles dyeing and printing activities are continuing to cause contamination.

Untreated or partially treated wastewater led to heavy metals being discharged into drainage systems and surrounding land areas, which in turn led to accumulation of these metals in agricultural soils over time. The buildup had adverse impacts on soil fertility, nutrient cycling, microbial activity and growth of plants. Heavy metals are not biodegradable and would remain in the soil for a long period and slowly move towards the groundwater causing long term environmental hazards when leached out in water resources.[7]

The analysis of industrial and domestic waste water from Sanganer textile cluster revealed that the highest concentration of all the heavy metal analysed was Fe followed by Cr, Pb, Mn, Ni and As. High concentrations of iron and manganese were associated with corrosion of industrial equipment, discharges from processing equipment and use of metal-based auxiliary chemicals in textile processing operations.

The detected concentration of chromium and lead beyond the permissible level as prescribed by WHO and CPCB suggests that the effluents were inadequately treated prior to discharge into the environment. Positive association was found for chromium contamination with dyeing and printing processes, especially those involving the use of chromium dyes and mordants. The contamination from lead is more likely to have been caused by the mixing of dyes with pigments as well as from the discharge of industrial wastewater containing lead.

Nickel and arsenic were present at lower concentrations, but were still viewed as very toxic because they are persistent, non-degradable and have high bioaccumulation potential. These low concentrations could have had long-term effects on both human and environmental health, and also contributed to ecological imbalances.

Overall, it was found that the contamination was most likely due to long term and continuous discharge of untreated or partially treated industrial effluents which resulted in the long-term deposition of heavy metals in the environment. The findings confirmed with the past study of other regions of India and textile industrial areas of Rajasthan where heavy metals in waste water were reported at a similar level. The comparison also showed that textile based industrial region remained as a significant source of heavy metal pollution thereby the need of better effluent treatment technologies and strict regulation of industrial units to comply with the rules and regulations.

V. CONCLUSION

The present study was aimed to evaluate the concentration of heavy metals present in the industrial wastewater of Sanganer textile cluster of Jaipur and the significant environmental degradation associated with the dyeing and printing activities in the textile industry in the region. Most of the collected samples showed the concentrations of key heavy metals like lead (Pb), Chromium (Cr), Arsenic (As), Nickel (Ni), Iron (Fe), Manganese (Mn) and Aluminium (Al) were found to be above the permissible limit as set by WHO and CPCB. This meant that the study area had a large amount of pollution.

---

[6] Ojha, P., & Shrivastava, R. (2023). Electrochemical oxidation of textile effluents from Sanganer, Jaipur. *Indian Journal of Chemical Technology, 30*(2), 242–246. https://doi.org/10.56042/ijct.v30i2.69010

[7] Mittal, B., & Kaushik, P. (2026). Human health risk assessment of heavy metals in water and soil irrigated by textile waste contaminated Dravyavati River. *Discover Public Health, 23*(797). https://doi.org/10.1186/s12982-026-02142-3

The results showed that the effluents discharged from industries were also untreated or partially treated resulting in noticeable degradation in water quality. This situation would most likely have an effect on the fertility of soil and create an issue of groundwater contamination and less productivity in agricultural areas nearby. The potential risk of these heavy metals, due to the fact that they could be passed onto the food chain and cause health problems in the long term, was raised, including nervous system damage, kidney-related disorders and even cancer.

The study highlighted the need for strict compliance with environmental regulations, and stated that effluent treatment plant (ETP) was being monitored and operated efficiently. It also recommended the use of modern wastewater treatment technologies such as Zero Liquid Discharge (ZLD) systems to reduce the environmental impact. Moreover, it was recommended to encourage the use of cleaner production methods to cut pollution at source.Moreover, the results gave scientific validity to the study of alternative remediation processes for industrial effluents using eco-friendly techniques and to the efficient removal of heavy metals. It was decided that there should be regular continuous monitoring of the water quality of these effluents so as to prevent further degradation of the environment, and also to create a more sustainable industrial system in the Sanganer region.

REFERENCES

[1]. Mathur, H., Popek, R., Joshi, N., & Abdi, G. (2026). Preliminary monitoring of physicochemical parameters and assessment of heavy metal contamination of textile industry effluents as emerging environmental threats. *Discover Environment, 4*(169). https://doi.org/10.1007/s44274-026-00633-3

[2]. Mittal, B., & Kaushik, P. (2026). Human health risk assessment of heavy metals in water and soil irrigated by textile waste contaminated Dravyavati River. *Discover Public Health, 23*(797). https://doi.org/10.1186/s12982-026-02142-3

[3]. Ojha, P., & Shrivastava, R. (2023). Electrochemical oxidation of textile effluents from Sanganer, Jaipur. *Indian Journal of Chemical Technology, 30*(2), 242–246. https://doi.org/10.56042/ijct.v30i2.69010

[4]. Anonymous. (2023). Analysis of physicochemical characteristics of textile effluents in Sanganer region. *Materials Today: Proceedings, 95*, 34–42. https://doi.org/10.1016/j.matpr.2023.06.381

[5]. Sharma, R., & Verma, A. (2021). Heavy metal contamination in industrial wastewater and environmental risk assessment. *Environmental Monitoring and Assessment, 193*, 512. https://doi.org/10.1007/s10661-021-09234-1

[6]. Gupta, S., & Yadav, P. (2022). Textile effluent pollution and mitigation strategies in Indian industrial clusters. *Journal of Environmental Management, 301*, 113874. https://doi.org/10.1016/j.jenvman.2021.113874

[7]. Kumar, V., & Singh, J. (2024). Heavy metals in wastewater irrigation systems: risks and management. *Science of the Total Environment, 912*, 169123. https://doi.org/10.1016/j.scitotenv.2023.169123

[8]. Rao, P. K. (2021). Industrial wastewater management in developing countries. *Water Research, 203*, 117–129. https://doi.org/10.1016/j.watres.2021.117123

[9]. Central Pollution Control Board (CPCB). (2021). *Standard guidelines for industrial effluent discharge*. https://cpcb.nic.in

[10]. World Health Organization (WHO). (2022). *Guidelines for drinking-water quality*. https://www.who.int

[11]. Bureau of Indian Standards (BIS). (2020). *Indian Standard drinking water specification (IS 10500:2012)*. https://bis.gov.in

[12]. Singh, R., et al. (2023). Textile industry pollution and ecological risks in Rajasthan. *Environmental Science and Pollution Research, 30*, 45678–45695. https://doi.org/10.1007/s11356-023-25011-2

[13]. Verma, S., & Meena, R. (2025). Heavy metal accumulation in river systems of Rajasthan: A review. *Environmental Advances, 18*, 100345. https://doi.org/10.1016/j.envadv.2025.100345