STM JOURNALS

Journal of
Water Pollution &
Purification Research

ISSN: 2394-7306
Volume 11, Issue 2, 2024
May–August
DOI (Journal): 10.37591/JoWPPR

https://journals.stmjournals.com/jowppr

Research JoWPPR

Qualitative and Quantitative Assessment of Water Resources at Moradabad District (UP), India

Vipin Kumar[1], Meenu Talwar[2,]*, Manmohan Kumar[3], Pamposh Kumar[4], Mukul Das[5]

Abstract

Moradabad district houses several medium and small-scale industrial units: such as alloy manufacturing, chrome plating, electroplating, and metal extraction from e-waste. The city is known for its export of brass handicrafts to various countries across the world including North America and Europe and is popularly known as Peetal Nagri (Brass City). Heavy metals like lead, copper, arsenic and iron used in alloy manufacturing and nickel and chromium used in plating of metal articles form a part of the industrial effluent, which is disposed directly into rivers or soil without any treatment. In the present study, surface water and groundwater quality of Moradabad district has been assessed with respect to heavy metal concentration followed by a public interaction program on water-related health problems that were further communicated to them to create awareness in the masses. Few studies are available on the quality of water bodies of Moradabad district covering the entire district. Further, water quality awareness amongst the local population has not been the focus of any of the previous studies. Out of 64 water samples collected, about 50% had iron content higher than the permissible limit of 300 ppb. The highest level of iron: 6294 ppb has been found at Fazalpur site of Moradabad district. Apart from iron, the level of lead, chromium, copper, and arsenic was also found to be higher than the permissible limit. In view of this alarming situation, it is essential to address this problem and suggest viable solutions so that safe drinking water is available to the local population of Moradabad district, and this will only be possible if all stakeholders join hands to meet these challenges.

Keywords: Water quality, heavy metals, permissible limit, ICP-MS, ICP-OES, field survey

***Author for Correspondence**
Meenu Talwar
E-mail: meenu@shriraminstitute.org

[1]Junior Research Fellow, Shriram Institute for Industrial Research, University Road, Delhi, India
[2]Assistant Director, Shriram Institute for Industrial Research, University Road, Delhi, India
[3]Deputy Director, Shriram Institute for Industrial Research, University Road, Delhi, India
[4]Scientist F, Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi, India
[5]Director, Shriram Institute for Industrial Research, University Road, Delhi, India

Received Date: August 31, 2024
Accepted Date: September 11, 2024
Published Date: October 08, 2024

Citation: Vipin Kumar, Meenu Talwar, Manmohan Kumar, Pamposh Kumar, Mukul Das. Qualitative and Quantitative Assessment of Water Resources at Moradabad District (UP), India. Journal of Water Pollution & Purification Research. 2024; 11(2): 1–9p.

INTRODUCTION

Heavy metals are high-atomic-weight elements with a density five times greater than that of water [1]. Their use in several industries has led to a wide distribution of heavy metals in the environment, especially in water bodies. The disposal of industrial effluents into water bodies without adequate treatment is a major cause of environmental pollution [2]. The toxicity of heavy metals to ecosystems and humans has been well studied [3, 4].

The risk of exposure to contaminated water is a major public health concern. Owing to the degree of toxicity of mercury, cadmium, arsenic, lead, chromium, and copper, they were selected for the study. These metals are naturally found in trace amounts in the Earth's crust (geogenic). However, their amounts are increased by human activities (injudicious disposal of industrial and agricultural waste), which compromise the water distribution system. Minamata disease is one of the most popular examples of the severe effects of improper disposal of industrial waste on human well-being.

There are several examples of how industrial waste disposal without proper treatment has led to public health emergencies. The Kodaikanal mercury poisoning case in India was a result of improper disposal by a thermometer manufacturing unit [5]. Love canal exposure, in which chemical waste leaches into the residential society following a heavy downpour in the area, is another example of improper disposal of industrial waste and its consequences on human health. Apart from industrial sources of pollution, it has also been noted that chemical treatment of water may also increase the corrosivity that can lead to the leaching of heavy metals from plumbing systems, as seen in the Flint lead outbreak in the USA [6]. While industrial waste has been a crucial source of water pollution, some areas have also been found to have a geogenic source of heavy metal contamination of ground and surface water. In Bangladesh, the high concentration of arsenic in groundwater is a natural geological source. Contamination of groundwater by arsenic in Bangladesh is one of the largest poisonings of a population in history, causing widespread cases of Blackfoot disease. Studies suggest that the geogenic concentration of arsenic is high in some parts of India such as Western Uttar Pradesh, Bihar, and West Bengal [7]. States such as Uttar Pradesh and West Bengal also have high-density industrial areas, which make them more vulnerable to water quality deterioration. The districts of Uttar Pradesh, such as Kanpur and Moradabad, are known for their metal industries and chemical production for tanning industries. Moradabad is popularly known worldwide as the “brass city” of India and is also a major metal extraction site.

Moradabad is well-known for its metal handicraft industry. It has eight blocks and approximately 1794 villages. Handicraft manufacturing and exports are ancestral occupations in Moradabad. Waste from this industry is dumped either in soil or in water without any prior treatment. This is a major source of heavy metal pollution in soil and water bodies. Recently, a new practice for the recovery of metals from electronic waste was introduced in Moradabad on the banks of the Ramganga River (Daswan Ghat). This is another source of heavy metal contamination in water bodies. Given the above, it becomes apparent that it is very important to create a knowledge base on the health of water bodies, especially pertaining to the heavy metal content of water sources.

Prior studies have also examined the water quality of the Moradabad district but in a limited manner. These findings are described here as a reference. Trace metals were estimated in water collected from 13 sites of the Gangan River in and around Moradabad, using an ICP-AES instrument [8]. The Gangan River was found to be excessively contaminated with copper (433–595 ppb) and iron (9840–15850 ppb). Residents near rivers are prone to exposure to these heavy metals, which can cause severe health problems. Metal toxicity in underground drinking water in Moradabad has been studied [9]. Groundwater samples were collected from five Moradabad sites and nine trace metals Pb (Cd, Mn, Mg, Fe, Cr, Co, Ni, and Cu) were analyzed by ICP-AES using Varian Liberty II ICP-OES. Groundwater was found to be severely invariably contaminated by manganese (206–266 ppb) and iron (1020-3852 ppb) at all sites. Physicochemical parameters of water quality were analyzed in and around Moradabad to understand the level of water pollution in the Gangan River [10]. It was observed that the chemical oxygen demand was extremely high, ranging from 40 to 268 ppm, which is far beyond the permissible limit of 10 ppm. These results indicate that river water is severely contaminated by chemical pollutants. Animesh et al. studied the effect of brass and steel industrial waste on the Ramganga River [11, 12]. Metals such as Cu, Ni, Zn, Cr, and Fe are part of industrial waste and are generally dumped into lakes and rivers nearby. Cr and Ni are more toxic than Cu, Zn, and Fe, but together in a ratio of (1:1:1:1:1) their toxicity increased by seven to eight times. Thus, several studies are available on the water quality of Moradabad, but a complete picture of the entire district has not been covered in any of these studies.

In the present study, the authors have taken the initiative to assess the water quality of the Moradabad district using two methods: first, by interacting with the local population and taking feedback from them using a questionnaire, and second, by collecting water samples from various potential sites and evaluating their heavy metal content using instrumental techniques. This paper describes the methodology followed for the selection of sites, interaction with the local population, sample collection and analysis, results obtained in the form of local opinion, and quantitative analysis of water samples.

MATERIALS AND METHODS

Study Area

The Moradabad district of Uttar Pradesh, India, is situated on the east side of the Ganga River and lies between 28°21´ and 28°16´ north latitude and 78°4´ and 79° east longitude. The area has slopes from north to south and east to west which results in water logging in the area of Choudharpur village [13]. The district covers an area of 3718 km^2 and has a population of about 47.72 Lakhs (census 2011). There are eight blocks in Moradabad district (Figure 1), with 960 panchayats and 1794 villages. Of these villages, 108 representative villages were selected based on the exposure of water bodies to anthropogenic activities to undertake field surveys and water sample collection.

Ramganga and its tributaries, such as Gangan, Delha, and Rajheda, serve as major drainage systems in Moradabad district. The Majhola and Lakri Fazalpur industrial areas are situated on the bank of the Gangan River, and the effluent from the industries is discharged directly into the river. Similarly, metal industries and e-waste processing units are situated on the banks of Ramganga near Daswan Ghat. Hredeopur village disposed of solid and liquid waste into the river, causing the water quality to deteriorate enormously.

Qualitative analysis was carried out by conducting a field survey covering all eight blocks of Moradabad district. In total, 108 representative villages were selected from these blocks and visited for interaction with the local population and to obtain public feedback on water quality. The survey was carried out by interacting with the local community and filling up a detailed questionnaire [14] addressing water-related issues. A total of 159 questionnaires were completed after interacting with 549 people in the region.

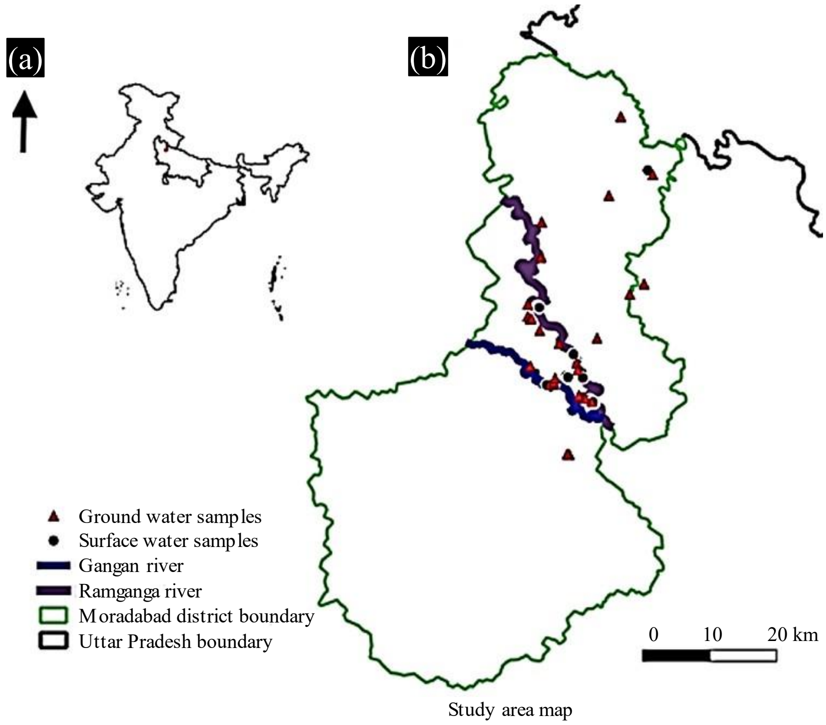


Figure 1. Study area (a) Map of India indicating the location of Moradabad district in the state of Uttar Pradesh (b) Sampling points of Moradabad.

Sampling sites were selected in the riverine zone, where the industrial effluents were dumbed. A total of 64 surface and groundwater samples were collected in pre-cleaned high-density polyethylene (HDPE) bottles as per standard practice. The samples were preserved using nitric acid and maintained at 10 ± 2°C (Bureau of Indian Standard 3025 Part 1, 2003 and APHA – 2012, 21st edition) [15]. Water samples were analyzed in the laboratory for the quantitative estimation of iron using inductively coupled plasma-optical emission spectrometry (ICP-OES), and other metals were assessed using inductively coupled plasma–Mass Spectrometry (ICP-MS).

RESULTS AND DISCUSSION

Field Survey

The assessment of water quality was carried out through interaction and feedback on two major aspects: first, whether any problem exists related to water quality, such as taste, odor, color, and whether the water is colored or colored on storage. The feedback from the representatives of the local population was recorded in the questionnaire, and the information collected from the feedback in questions 6–12 is summarized in Figures 2 and 3. The percentage of people in all districts reporting water-related problems was calculated and plotted in Figure 3.

In this study, 549 local people in 108 villages were interviewed to cover the entire Moradabad district. It was concluded that river water in the Moradabad district is not suitable for drinking purposes because of the intermixing of industrial and domestic effluents [14]. As evident from Figure 3, the two blocks, Dilaari and Bhagatpur Tanda, had the maximum problems related to water quality and were also related to the color change of water during storage. Apart from these two blocks, people of Chajlait complained about water changing color during storage, and the population residing in the Mundapandey block gave feedback that water has odor-, taste-, and color-related problems, which means that the quality of water was not acceptable. Moreover, the color of water becomes yellow to brown upon storage after laboratory experiments clearly indicating the presence of excessive iron as an undesirable contaminant, and iron-loving bacteria were also found in some samples.

About 59% of the local people complained about the problems existing in water quality. According to the local opinion of the people of all the blocks of Moradabad, the water is either colored (yellow) or has some unpleasant odor and taste. In the case of the color of the water, 57% of the people interviewed stated that sometimes the water is yellow from the water source, and sometimes water develops a yellow color on storage. Water contamination was further ascertained by carrying out a quantitative analysis of water samples collected from areas where complaints by the local population were reported regarding poor water quality [14].

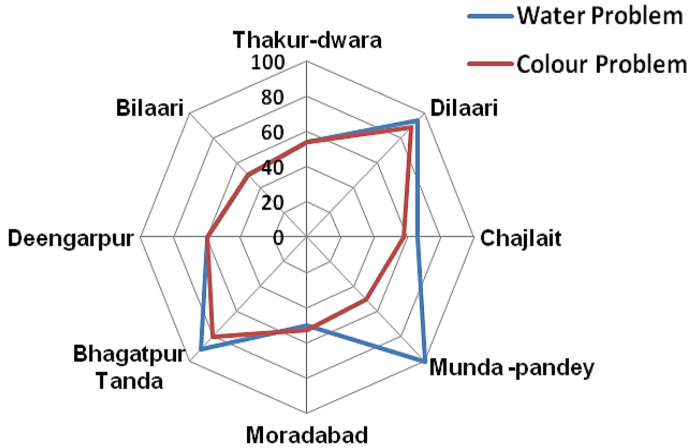


Figure 2. Feedback percent on water quality issues in all eight blocks of Moradabad district.

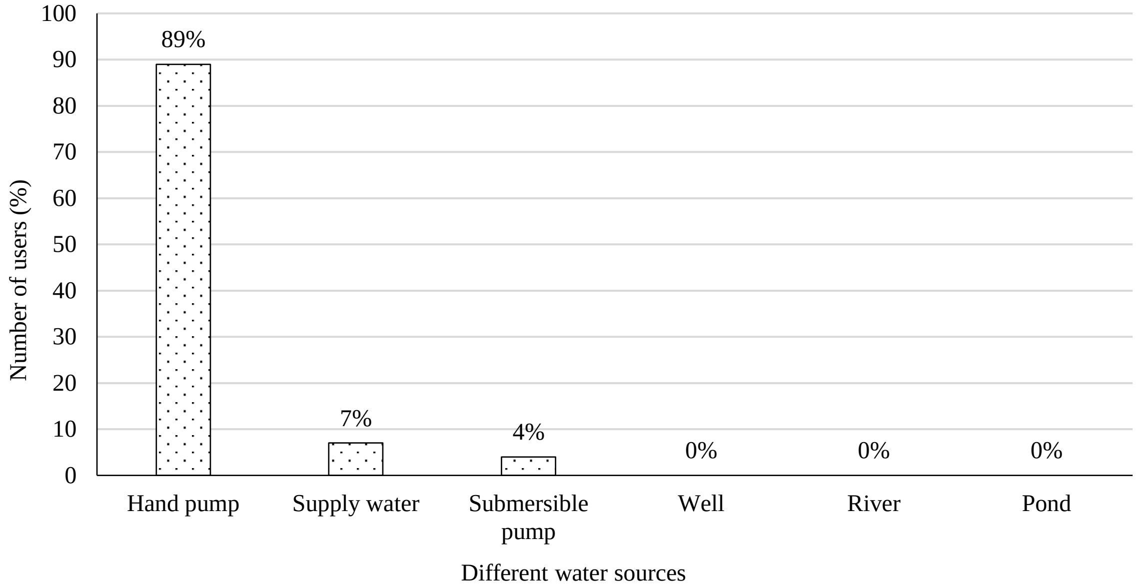
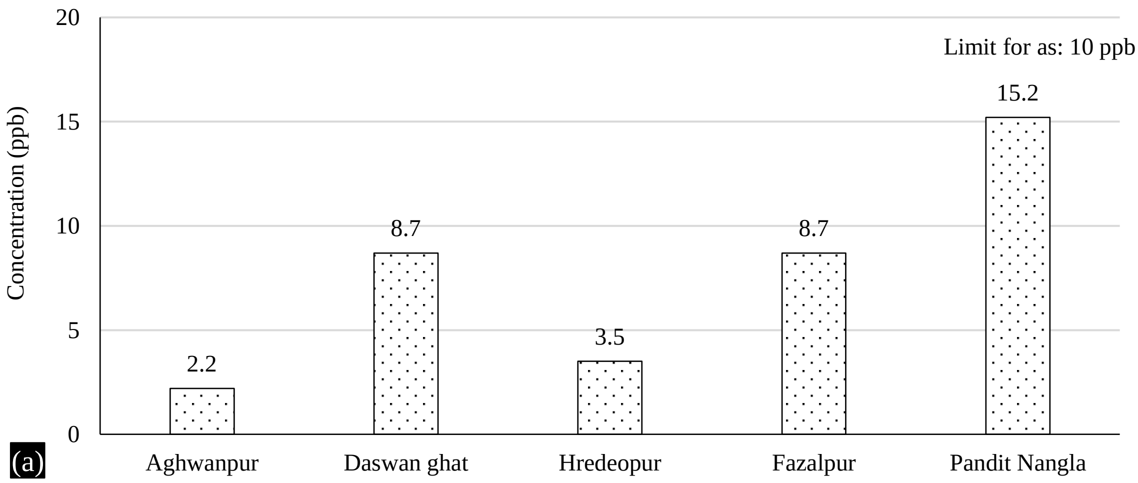


Figure 3. Types of water sources in Moradabad district and their use percentage.

Water Quality Analysis of Surface and Ground Water

In all, 64 water samples were collected from Moradabad district, of which 25 were surface water and 39 were groundwater (hand pumps and submersible pumps). These water samples were analyzed for the concentrations of heavy metals, such as iron, lead, arsenic, chromium, copper, mercury, and cadmium. Mercury and cadmium were absent in all the water samples, except in the case of surface water samples collected from Daswan Ghat, where cadmium was found to be present at a concentration of 2 ppb. The concentrations of heavy metals, such as arsenic, lead, chromium, copper, and iron, were found to be beyond permissible limits (BIS and WHO) in surface and groundwater samples collected from various sites. Based on the analysis, five locations, namely Aghwanpur, Daswan Ghat, Hredeopur, Fazalpur Industrial area, and Pandit Nangla, were found to have higher concentrations of heavy metals in surface water. Regarding groundwater pollution, Daswan Ghat, Hredeopur village, Fazalpur Industrial Area, Mansoori Colony, and Sir Sayyad Nagar were found to be polluted.

In the case of surface water, heavy metals, such as arsenic, lead, chromium, copper, and iron, were found beyond permissible limits, as shown in Figure 4. Thus, the surface water of Moradabad district was found to contain heavy metals, which makes it unsuitable for drinking purposes without testing and remediation.



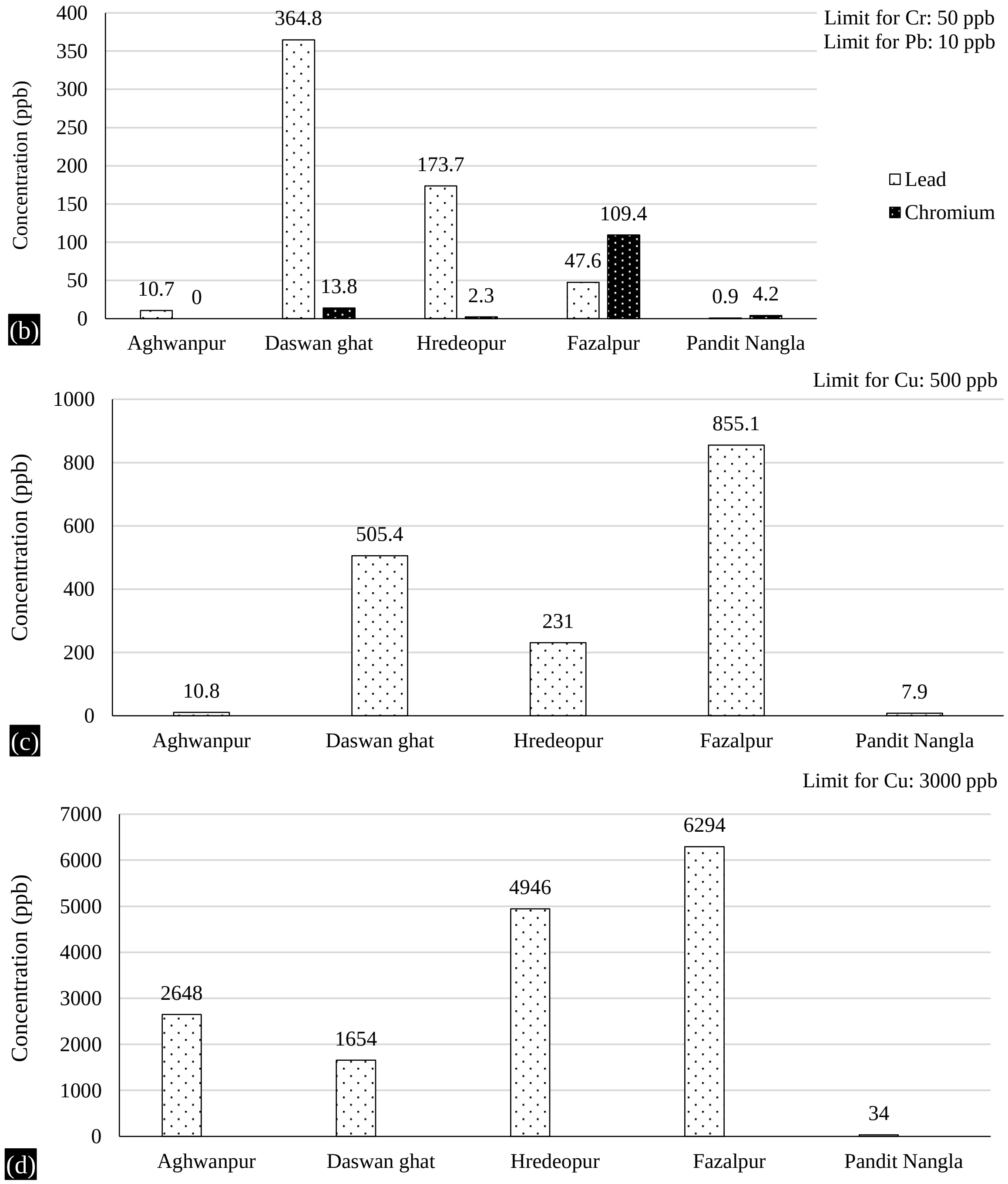
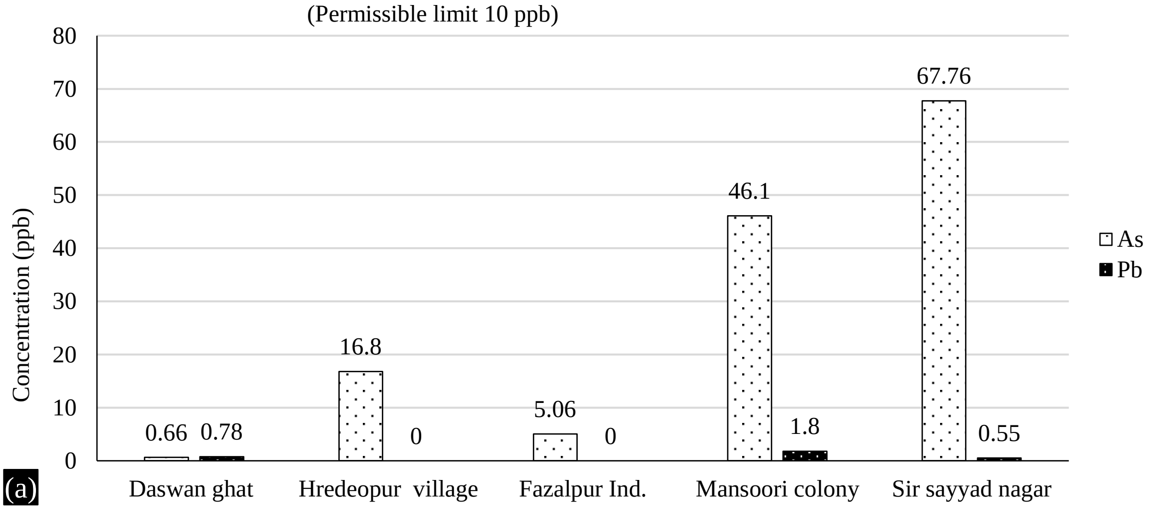


Figure 4. Quantitative estimation of heavy metals in surface water at five different locations:
(a) concentration of arsenic, (b) concentration of lead and chromium,
(c) concentration of copper, (d) concentration of iron.

A total of 39 groundwater samples were collected, and the concentrations of arsenic and iron exceeded the permissible limits, as shown in Figure 5. Hg and Cd were not detected. Lead and copper were found to be quite low at concentration: 0.5–1.8 ppb and 0.6–3.6 ppb respectively. Cr was found to be well within the acceptable limit: Pandit Nangla 7 ppb and Hredeopur 9.3 ppb. Thus, groundwater is mainly contaminated with iron and arsenic, which should be tested before the water can be used for drinking purposes. Since most of the population of Moradabad district is dependent on groundwater to fulfill their daily needs, it becomes necessary to empower them for testing and purification of water prior to its use.



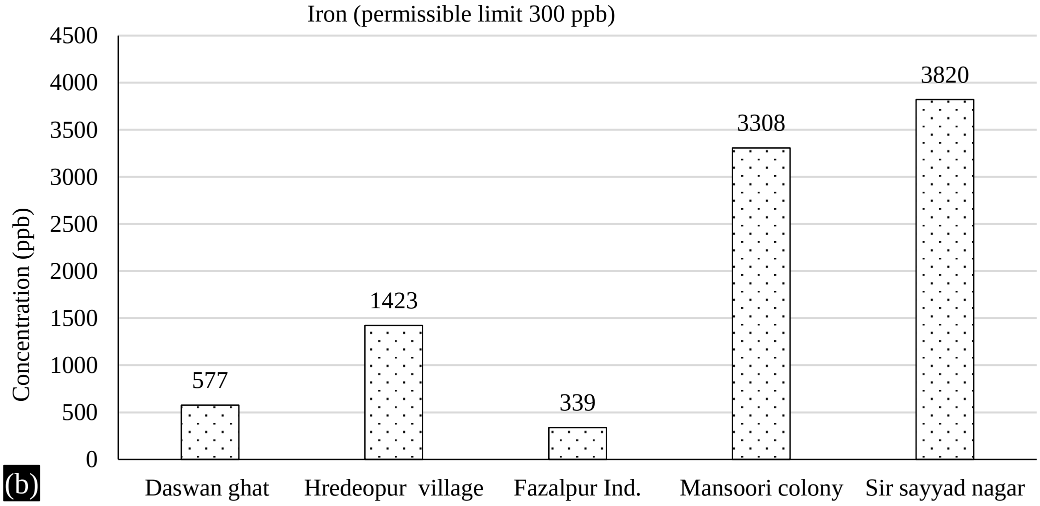


Figure 5. (a) and (b) Iron, arsenic, and lead content of groundwater samples in Moradabad district.

From the data presented here, it is evident that the water available to the local population of the Moradabad district is contaminated with heavy metals, such as iron, lead, arsenic, and chromium. Serious efforts are required to improve the health of ground and surface water bodies.

In the case of arsenic, groundwater at Pandit Nangla, Mansoori, Sir Syyad, and Hredeopur and surface water collected from the Ramganga and Gangan Rivers were found to be contaminated. The presence of arsenic in surface and groundwater samples can mainly be attributed to the processing of electronic waste near riverbanks and the disposal of liquid and solid wastes into the river and soil without any treatment.

The chromium concentration at Daswan Ghat was found to be much higher (109 ppb) than the permissible limit of 50 ppb and was within permissible limits at all other sampling sites. The metal processing and chrome plating industries may be responsible for this phenomenon.

The copper concentrations of surface water samples collected from Fazalpur, Daswan Ghat, and Hredeopur were found to be higher than the permissible limit of 50 ppb. At other sites, the Cu concentration was found to be within the permissible limit. The Pb content ranges from 11 to 365 ppb in surface water samples collected from the Ramganga and Gangan Rivers, which is higher than the permissible limit of 10 ppb. Thus, at several locations, river water is not fit for drinking and is not suitable for irrigation purposes due to high lead contamination.

Table 1. Mean and standard error (±SE) of selected parameters (64 samples were collected in total; 25 surface water and 39 groundwater).

Sample	***Total Cr***	***Cu***	***As***	***Pb***	***Cd***	***Fe***
S.W.	12 ± 6	93 ± 45	8 ± 1	**52 ± 25**	2 ± 0	**1102±317**
G.W.	5 ± 1	4 ± 1	**110 ± 2**	2± 1	BDL	**1068±226**

where,
S.W. = Surface Water (ppb)
G.W. = Ground Water (ppb)
BDL = Below Detection Limit

The iron concentration ranges from 307 to 6294 ppb in the majority of water samples collected from various sites in Moradabad, which is much higher than the permissible limit of 300 ppb. A concentration of 6294 ppb was found in the Gangan River at Fazalpur, and of 4946 ppb was found in the Ramganga River near Hredeopur village, which strongly indicates the disposal of industrial effluents containing iron into the river. In the case of groundwater, the maximum concentration of iron was found in Sir Sayyad Nagar (3820 ppb), Agwanpur (3731 ppb), and Mansoori Colony (3308 ppb). As no reference could be found in the literature on the presence of iron deposits in Moradabad district, this means that iron in ground and surface water may originate from anthropogenic sources.

The explanation for the occurrence of heavy metals in such high quantities in these locations can be found in the fact that Daswan Ghat on the Ramganga riverbank is the site for the burning of electronic waste for metal recovery and the residual waste is being dumped into the river, causing the contamination of water bodies. Hredeopur is situated downstream of the Daswan Hat, where the lead content in water decreases compared to that in Daswan Ghat, but it is still much higher than the permissible limit. This water is used for irrigation purposes by the local population through which lead enters the food chain and threatens the health of people living around it. In the Fazalpur area near Gangan River, chromium is double the permissible limit of 50 ppb due to brass, chrome plating, and metal processing industries nearby.

The locations identified: Daswan Ghat, Fazalpur, and Pandit Nangla are industrial areas involving e-waste processing, metal processing, brassware manufacturing, and chrome plating. Hredeopur is located downstream of these areas and does not have any industry. The water quality in this area is somewhat better than that in Daswan Ghat, Fazalpur, and Pandit Nangla. Aghwanpur is upstream of the areas, and therefore, the presence of arsenic, lead, and copper is much lower in the water stream of this region. An overall view of the health of the water sources in the Moradabad district is given in Table 1. The areas in which the levels of heavy metals exceeded the permissible limits are highlighted in the table. The surface water is highly contaminated with heavy metals. Groundwater mainly contains iron and arsenic contaminants.

CONCLUSION

The population of Moradabad district is mainly dependent on groundwater for drinking purposes and river water for irrigation purposes. As per the public opinion sought via interaction with the local population through questionnaires, all blocks of Moradabad district have water quality-related problems in the form of mal odor, taste, color, and color development during water storage. Fishermen in this area have reported a decline in the population of fish in the Ramganga River.

The injudicious disposal of industrial effluent from the surrounding industries in Moradabad district has led to contamination of rivers and groundwater in the region. Previous studies and the current findings indicate the presence of geogenic arsenic contamination. Since Moradabad is already vulnerable to arsenic, industrial effluent further increases arsenic contamination in the area. The highest contamination found was of iron in the water bodies, which can be the result of anthropogenic contamination because no evidence of geogenic sources could be found in the literature.

This study highlights the need for further research in this area to provide a solution to this problem. A part of the path forward can include framing appropriate policies to prevent further contamination of water bodies in the form of strict norms of industrial waste disposal, setting up of water health clinics, and setting up of water ATMs in Moradabad district, especially in the identified hot spots, to make safe drinking water available for the local population. The authors would also like to mention that arsenic and lead poisoning lead to the development of skin cancer and neurological disorders, and this aspect should be further studied in the population of Moradabad.

Acknowledgments

The authors acknowledge the financial assistance received from the Department of Science and Technology, Government. of India, and the management of the Shriram Institute for Industrial Research for their support in carrying out this study. The authors also acknowledge Ms. Sonali Chauhan, Research Fellow at the Centre for Urban Ecology and Sustainability (CUES), Delhi, for her help in preparing the map of Moradabad district presented in this paper. Manuscript number: SRI-MS # 20240831- 01.

REFERENCES

1. Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. Heavy metal toxicity and the environment. Mol Clin Environ Toxicol. 2012;3:133-64.
2. Colten CE, Skinner PN. The road to Love Canal: managing industrial waste before EPA. Austin (TX): University of Texas Press; 2010.
3. Carolin CF, Kumar PS, Saravanan A, Joshiba GJ, Naushad M. Efficient techniques for the removal of toxic heavy metals from aquatic environment: A review. J Environ Chem Eng. 2017;5:2782-99. DOI: 10.1016/j.jece.2017.05.029.
4. Gall JE, Boyd RS, Rajakaruna N. Transfer of heavy metals through terrestrial food webs: A review. Environ Monit Assess. 2015;187:201. DOI: 10.1007/s10661-015-4436-3, PubMed: 25800370.
5. Lin HO. Mercury pollution in Kodaikanal caused by a thermometer factory spill in 2001. Biol South India. 2015;A6–A11.
6. Bellinger DC. Lead contamination in Flint—An abject failure to protect public health. N Engl J Med. 2016;374:1101-3. DOI: 10.1056/NEJMp1601013, PubMed: 26863114.
7. Banerjee DM, Mukherjee A, Acharya S, Chatterjee D, Mahanta C, Saha D, et al. Contemporary groundwater pollution studies in India: A review. Proc Indian Natl Sci Acad. 2012;78(3):333-42.
8. Sinha DK, Kumar N. Monitoring of trace metals in Gagan river water at Moradabad. Indian J Environ Prot. 2006;26:516.
9. Rastogi GK, Sinha DK. Metal toxicity in underground drinking water at Moradabad, Uttar Pradesh, India. Int J Chem Sci. 2008;6(2):1074–80
10. Sinha DK, Navneet K. Level of Gagan river water pollution in and around Moradabad. Pollut Res. 2008;27:743-6.
11. Agarwal A, Saxena M. Assessment of toxic effect of brass and steel industries waste on Labeo rohita in nearby river. Int J Environ Eng Manag. 2011;2:107-10.
12. Alam M, Pathak JK. Rapid assessment of water quality index of Ramganga River, Western Uttar Pradesh (India) using a computer programme. Nat Sci. 2010;8:1-8.
13. Sharma M, Tobschall H, Singh I. Environmental impact assessment in the Moradabad industrial area (rivers Ramganga-Ganga interfluve), Ganga Plain, India. Environ Geol. 2003;43:957-67. DOI: 10.1007/s00254-002-0718-5.
14. Kumar V, Bharti PK, Talwar M, Tyagi AK, Kumar P. Studies on high iron content in water resources of Moradabad district (UP), India. Water Sci. 2017;31:44-51. DOI: 10.1016/j.wsj.2017.02.003.
15. Indian Standard. 3025 (Part 1) sampling: Methods of sampling and test (physical and chemical) for water and wastewater. New Delhi: Bureau of Indian Standards; 1987.