www.envsciarch.com

ENVIRONMENTAL SCIENCE ARCHIVES
ISSN: 2583-5092
Volume V Issue 1, 2026

Received: 2026/02/06
Accepted: 2026/03/28
Published: 2026/04/04

RESEARCH PAPER

OPEN ACCESS

A Study on Groundwater Resources of Mendhar Town of Jammu and Kashmir, India with Respect to Heavy Metal Content

Javed Manzoor[1]* and Rani Mughal[2]

[1]Department of Environmental Science, Government Degree College Surankote, J&K India
[2]Principal, Government Degree College Surankote, J&K India
*Correspondence for materials should be addressed to JM (email: javedevs@gmail.com)

Abstract

Ground water is a significant natural resource used for many purposes. Present study was carried out to evaluate the concentration of some specific heavy metals in the groundwater of Mendhar town, Jammu and Kashmir, India. Groundwater samples were obtained from ten distinct locations within the Mendhar town and subsequently designated as GW1, GW2, GW3, GW4, GW5, GW6, GW7, GW8, GW9, and GW10. The value of temperature, pH, TSS, electric conductivity, and hardness was found to vary throughout the samples collected. The concentrations of heavy metal ions in ground water samples were found to be in the range of 0.29 mg/l to 10.47 mg/l for iron, <0.5 mg/l to 2.1 mg/l for manganese, <0.05 mg/l for nickel and lead, <0.003 mg/l for cadmium, and from 0.001 mg/l to 0.041 mg/l for arsenic. The fluorides concentrations were found to be in the range of 0.34 ppm to 1.89 ppm. The findings were compared with the National Drinking Water Quality Standards (NDWQS) to assess the present state of the water in the town. The result of the study indicates that the groundwater of Mendhar town requires some degree of treatment before consumption in order to prevent negative effects on human health.

Keywords: Groundwater; Mendhar; Heavy metals; Parameters; Samples

Introduction

Ground water is a valuable natural resource used for a variety of purposes. It accounts for around 20% of the world's fresh water supplies and is the most significant source of drinkable water globally (Khanam et al., 2014). Due to its purification in the soil column through ion exchange, filtration, and anaerobic decomposition, it has long been regarded as the purest form of water when compared to surface water and is utilized abundantly throughout the world in rural and semi-urban areas (WHO, 1984; Saha et al., 2008). Groundwater's suitability for multiple uses is determined by its inherent quality, which takes into account sources from the atmosphere, soil, and the weathering process, as well as through human-induced processes. Precipitation, climate change, and natural hazards all contribute to atmospheric inputs, whereas water contact with soil and rock causes weathering and erosion of crustal elements (Babu et al., 2007). Anthropogenic overburden caused by population pressure, unplanned development, unrestrained exploration policies, and dumping contaminated water in inappropriate locations increases the entry of dangerous substances into ground water (Pandey and Tiwari 2008). Ground water consists of high levels of dissolved inorganic and organic chemicals, which can be detrimental to human health.

Water is considered polluted when it gets contaminated by anthropogenic substances and it either no longer supports human usage, such as drinking purposes, or when its ability to support its constituent biotic populations changes dramatically. Heavy metal contamination in groundwater is a big issue around the world. Heavy metals occur naturally in the environment, however during the recent decades, its concentration levels in groundwater, rivers, and soil systems have increased due to anthropogenic pressure such as chemical factories, mining, fertilizers, emissions from automobiles, and farm runoff (APHA, 1998; BIS, 2012). Heavy metal contamination of groundwater resources has become a severe concern in most of the developing countries since heavy metals are harmful to human health and ecological systems such as rivers, soil, and groundwater (Bhardwaj et al., 2012; Jaishankar et al., 2014; Manzoor and Iqbal, 2020). Thus, before drinking any water, it is necessary to measure the concentration of heavy metal ions in the water. In Mendhar town, subterranean water is one of the sources of water used for a variety of purposes such as drinking, washing, and bathing. The quality of ground water in Mendhar town is continuously degrading day by day due to leaching of different chemicals into water through different anthropogenic activities, thereby serving as a source for the spread of various water borne diseases like cholera, tuberculosis, typhoid, diarrhea etc. Water samples were obtained at random from some selected hand pumps and bore wells that are often utilized by the public for a variety of purposes so as to ascertain its quality.

Material and methods

Study area

Mendhar is a town of Poonch District of Jammu and Kashmir, India, and lies in the Pir Panjal range of the Western Himalayas, at an elevation of 977 meters above sea level. Geographically Mendhar town is located within 33° 37′ 0" N latitude and 74° 8 0" E longitude.

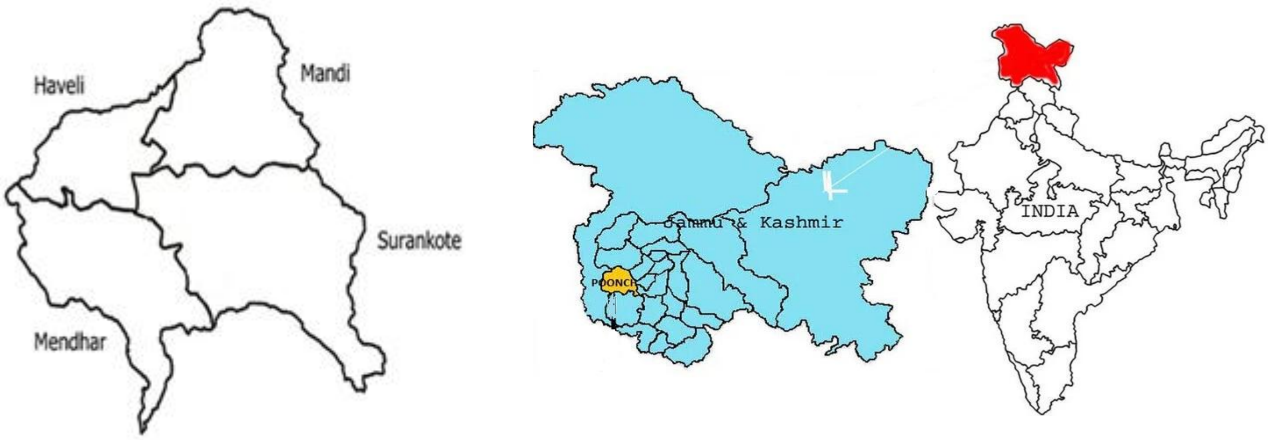

Fig. 1. Map of study area

The region has a subtropical to temperate climate, with summer temperatures ranging from 20 °C to 39 °C and winter temperatures from 3 °C to 19 °C. The terrain is steep, mountainous, undulating, with a few plain valleys and is drained by small rivulets and nallahs. The average annual rainfall in the area is 929.2mm.

Sample collection and physicochemical analysis

The study includes a preliminary survey, monitoring, and testing of ground water to determine some physicochemical parameters and heavy metal concentrations. Ten number of samples at a random were obtained during April 2024 from those hand pumps and bore wells that were frequently used by public for meeting various domestic water needs and have been designated as GW1, GW2, GW3, GW4, GW5, GW6, GW7, GW8, GW9, and GW10 respectively. Temperature, pH, TSS, and electrical conductivity were measured on-the-spot using a thermometer, digital pH meter, portable TSS meter and digital conductivity meter. The hardness of groundwater samples was measured using the EDTA technique.

Heavy Metal Analysis

Atomic absorption spectrophotometry (AA-6200) was used to determine the quantity of heavy metals (Fe, Mn, Ni, Pb, Cd, and As) in groundwater. The analytical data quality was assured through meticulous standardization, procedural blank measurements, and duplicate samples. The calibration was performed with a standard stock solution (1000 ppm), and the requisite standards were created according to the hollow cathode lamp set (Table 1). For heavy metals estimation (Fe, Mn, Ni, Pb and Cd), air and acetylene gas cylinders were used as oxidant and fuel, respectively, with the exception of arsenic, which was treated with nitrous oxide and air and acetylene gas cylinders. The collected ground water samples were filtered through Whatman filter paper number 41 and acidified with nitric acid to keep the pH under 2 for heavy metal analysis. Before analysis, groundwater samples were digested for 30 minutes with laboratory grade concentrated HNO_3.

The concentration of fluoride ions in ground water samples was determined using a spectrophotometer. The device was calibrated with 10 ml of distilled water and 2 ml of prepared Arsenic-free fluoride reagent solution, which was taken in a cuboid and timed for 1 minute. Following calibration, the sample was tested for the estimate of fluoride levels in groundwater samples using a mixture of 10 ml sample and 2 ml reagent in a cuboid for spectrophotometry.

Table 1. Standard solutions for the detection of heavy metals (ppm)

Metal	Standards used (in ppm)
Zinc (Zn)	0.4, 0.8, 1.6, 2.0
Iron (Fe)	2, 4, 6, 8,10
Manganese (Mn)	1, 2, 3, 4
Nickel (Ni)	1, 2, 3, 4
Cadmium (Cd)	0.2, 0.4, 0.8, 1.2, 1.6, 2.0
Arsenic (As)	30, 60, 90, 120, 150

Results and Discussion

Water's appropriateness is based on its intrinsic quality, which makes it a crucial resource for sustainable development. The chemical quality of groundwater is substantially determined by the rock structures, physiography, soil environment, recharge, and drafting conditions in which it occurs. Physico-chemical tests (temperature, pH, TSS, hardness, and electric conductivity) along with the evaluations of some specific heavy metal contaminations (Fe, Mn, Ni, Pb, Cd, As, and F) were carried out to determine the quality and purity of Ground water of Mendhar town (Table 3).

The findings of different metrics are displayed below after being compared with the WHO and ISI standards for groundwater.

Temperature

The average temperature in the ground water samples was found to be 27.54°C, with a range of 25.6°C to 28.4°C. The temperature in GW4 was the highest at 28.4°C, while the temperature in G6 was the lowest at 25.6°C. The average temperature of every water sample was found to be within the permissible range.

pH

The pH is an important water quality parameter. The ground water samples under investigation were found to have pH values between 6.30 and 6.91. GW5 has the most acidic pH value of 6.30 falling nearer to the lower level of guideline value.

Total suspended solids

Total suspended solids in the ground water samples tested ranged from 1.23 to 3.43 mg/l. The highest value of total suspended solid was recorded to be 3.43mg/l in GW8, while the lowest value was found to be1.23mg/l in GW2.

Electrical conductivity

It is a measure of water's ability to conduct or transfer current, as well as a tool for evaluating water quality. It is determined by the concentration and degree of ionization of the various solids involved. The electrical conductivity (EC) of ground water samples was found to be in the range of 215 µS/cm to 478 µS/cm. The highest conductivity (478 µS/cm) was observed at GW4, while the lowest (215 µS/cm) was recorded at GW2. The mineralization of rocks in the aquifers may be responsible for the rise in electric conductivity at some places.

Total hardness

Total hardness of water quality refers to the effects of dissolved minerals in terms of calcium and magnesium. It also assesses the appropriateness of water for various applications. The total hardness of ground water samples was found to be in the range of 189.4 mg/l and 221.3 mg/l. The maximum hardness (221.3 mg/l) was obtained at GW7, while the minimum (189.4 mg/l) was observed at GW2. The increased hardness of water in the collected samples could be attributed to the presence of calcium and magnesium minerals in the aquifers, as well as a decrease in water volume.

Estimation of Heavy metals in ground water

Iron

Iron is a crucial element in the biological system because it couples with ligands to form blood. The iron concentration in ground water was found to range of 0.29 mg/l to 10.47 mg/l. The lowest concentration value was observed in GW2 at 0.29mg/l, while the greatest concentration value was observed in GW4 at 10.47mg/l. Iron in groundwater can be quite damaging for a variety of residential applications. BIS advised that the desirable-permissible limit for iron in drinking water should be between 0.3 mg/l and 1.0 mg/l. Changes in the color of groundwater indicate the presence of iron, and larger concentrations result in an astringent, bitter, inky taste of the water. The NDWQS guideline for iron in drinking water is <0.3 mg/l. With the exception of GW2, all examined samples had higher iron concentration. The high quantity of iron may be due to the entry of iron into drinking water via drinking water pipes. Furthermore, iron is frequently found in water in soluble forms in anaerobic circumstances. In these conditions, iron that is normally insoluble becomes soluble, resulting in its presence in water. Temperature, precipitation, and other environmental conditions all influence iron's solubility and mobility in water.

Manganese

Manganese concentrations in ground water were found to range from <0.5 to 2.1 mg/l. The lowest value observed was <0.5 mg/l in GW2, whereas the highest value observed was 2.1 mg/l in GW7. Manganese levels in drinking water should be less than 0.2mg/l, as per NDWQS guidelines. Mn concentrations in GW1, GW4, GW7, GW9, and GW10 exceeded the NDWQS guideline values. Manganese is used in the fabrication of iron, and manganese can build a coating on water pipes that can shed out as black deposits (WHO, 2011), which could be one of the primary reasons for manganese's entry into groundwater.

Table 2. Physico-chemical analysis of ground water of Mendhar town of J&K, India

S.No	Sample Code	Location Name	Physico-chemical parameters				
			Temperature (°C)	**pH**	**TSS** (mg/L)	**Electric Conductivity** (µS/cm)	**Hardness** (mg/L)
1	GW1	Jaba	27.4	6.67	2.17	232	201.3
2	GW2	Hakim morh	27.6	6.82	1.23	215	189.4
3	GW3	Sangala chowk	25.9	6.60	3.27	377	212.8
4	GW4	Dachal	28.4	6.91	2.13	478	217.6
5	GW5	Dharana chowk	28.1	6.32	3.20	412	206.3
6	GW6	Bus stand	25.6	6.59	2.47	298	209.3
7	GW7	Saria market	26.9	6.80	2.89	222	221.3
8	GW8	Yadghar chowk	25.8	6.51	3.43	392	198.5
9	GW9	College	27.3	6.65	3.28	452	201.4
10	GW10	Bhera stand	28.1	6.30	2.56	398	212.8

Nickel, Lead, and Cadmium

Nickel, lead, and cadmium concentrations in all water samples studied were determined to be very low and nearly same in all samples, placing them inside the permitted range set by NDWQS. Furthermore, consuming water with a high Pb concentration (>0.01 mg/L) can lead to major problems such as insomnia, arthritis, renal failure, vertigo, paralysis, and brain damage. Excess Ni in the human body may result in cancer (Stasinos and Zabetakis, 2013; Zheng et al., 2001). Excessive Cd in water is toxic and can induce renal dysfunction, lung illness, kidney damage, osteomalacia, glucosuria, emphysema, aminoaciduria, respiratory tract difficulties, stomach and small intestine damage, and cancer.

Arsenic

Arsenic is widely spread in the environment due to both natural and anthropogenic causes (Hundal, 2009). The arsenic concentrations in all of the samples analyzed ranged from 0.001 mg/l to 0.041 mg/l. The concentration of arsenic exceeded the permissible limit in GW4, GW6, GW8, and GW10. It is one among the inorganic ions found in natural water, which causes a variety of health issues. Excess arsenic in drinking water can have major consequences for human health if consumed without treatment, including cancer, skin cancer, neurological disorders, pulmonary disease, hypertension, and cardiovascular disease (Tsuji and Karagatzides, 2001).

Fluorides

In the present investigation, fluoride values ranged from 0.34 ppm to 1.89 ppm. Fluoride concentrations were highest (1.89 mg/l) at GW4 and lowest (0.51 mg/l) at GW1.Fluoride concentrations have increased at some places as a result of people's excessive use of chemical fertilizers, which seep into ground water following rainfall (Table 4).

Table 3. Status of heavy metal contamination in the ground water of Mendhar Town

Sample No	Location Name	Concentration of heavy metals					
		Iron (mg/L)	**Manganese** (mg/L)	**Nickel** (mg/L)	**Lead** (mg/L)	**Cadmium** (mg/L)	**Arsenic** (mg/L)
GW1	Jaba	3.28	0.34	<0.05	<0.01	<0.003	0.001
GW2	Hakim morh	0.46	<0.05	<0.05	<0.01	<0.003	0.010
GW3	Sangala chowk	6.06	0.15	<0.05	<0.01	<0.003	0.012
GW4	Dachal	10.47	1.91	<0.05	<0.01	<0.003	0.021
GW5	Dharana chowk	3.73	<0.05	<0.05	<0.01	<0.003	0.011
GW6	Bus stand	2.1	0.13	<0.05	<0.01	<0.003	0.041
GW7	Saria market	0.47	2.1	<0.05	<0.01	<0.003	0.007
GW8	Yadghar chowk	0.29	<0.05	<0.05	<0.01	<0.003	0.032
GW9	College	2.35	1.66	<0.05	<0.01	<0.003	0.012
GW10	Bhera stand	2.81	1.23	<0.05	<0.01	<0.003	0.021

Table 4. Status of Fluoride in Ground water of Mendhar town

Sample code	Location Name	Fluoride (ppm)
GW1	Jaba	0.51
GW2	Hakim morh	0.86
GW3	Sangala chowk	1.35
GW4	Dachal	1.89
GW5	Dharana chowk	1.23
GW6	Bus stand	1.40
GW7	Saria market	0.72
GW8	Yadghar chowk	0.76
GW9	College	0.34
GW10	Bhera stand	0.87

Conclusion

Temperature, pH, TSS and electric conductivity are found to be within the National Drinking Water Quality Standards (NDWQS) standards however the total hardness was found to be above the prescribed limit at certain locations. With the exception of GW8, all of the sites with heavy metal analysis showed iron concentrations above the recommended level. The concentrations of manganese and arsenic were also found to be above the prescribed limit at GW1, GW4, GW7, GW9, and GW10 and at GW4, GW6, GW8, and GW10 respectively. Nickel, lead, and cadmium were found to be within the acceptable limits in almost all the samples studied. Fluoride concentration was also found to be higher than the permissible limit in GW3, GW4, GW5 and GW6 respectively. Thus, the concentrations of analyzed heavy metals i.e. iron, manganese, arsenic, and fluorides in ground water of Mendhar town were found to be higher than the limit set by National Drinking Water Quality Standards (NDWQS), indicating that drinking such water may be harmful to human health. As a result, it is strongly advised to avoid using water that has not been treated and purified.

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Author Contributions
JM and RM conceived the concept, wrote and approved the manuscript.

Acknowledgements
Not applicable.

Funding
Not applicable.

Availability of data and materials
Not applicable.

Competing interest
The authors declare no competing interests.

Ethics approval
Not applicable.

Citation: Manzoor J and Mughal R (2026) A Study on Groundwater Resources of Mendhar Town of Jammu and Kashmir, India with Respect to Heavy Metal Content. Environmental Science Archives 5(1): 223-228.