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Physicochemical and Heavy Metal Assessment of Groundwater and Evaluation of Wastewater Treatment Efficiency

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ABSTRACT: Groundwater quality is an important environmental and public health concern, particularly in regions affected by agricultural activities, industrialization, and inadequate wastewater management. The recent study evaluates the physicochemical characteristics and heavy metal contamination of groundwater and assesses the treatment efficiency of wastewater. Groundwater samples were analyzed for parameters with pH, electrical conductivity, total dissolved solids, hardness, major ions, and selected heavy metals. The pH of groundwater samples ranged from 6.87 to 8.07, while EC, total hardness, and TDS varied from 331.4–3675 µS cm^{-1}, 88–492 mg L^{-1}, and 213–1562 mg L^{-1}, respectively. Cadmium, chromium, nickel, and lead showed no significant contamination, while minor variations were observed for other investigated metals. STP performance was satisfactory, with mean TSS decreasing from 493.58 to 12.98 mg L^{-1}, COD from 783.58 to 27.45 mg L^{-1}, and BOD_5 from 411.53 to 5.28 mg L^{-1}. The corresponding removal efficiencies were 97.4%, 96.5%, and 98.7%, respectively. The findings can support appropriate water-quality management strategies and sustainable utilization of groundwater resources.

1 INTRODUCTION

Water is the necessary natural resources important for the survival of humans, plants, animals and aquatic life. Although an estimated 71% of the Earth's surface is covered by water and only a small proportion is available in the form of freshwater for human consumption and other vital activities (Satpathy et al.,2026). Water is indispensable for drinking, sanitation, agriculture, food production, industrial processes, and ecosystem maintenance (Rahu et al.,2026). Rapid population growth, urbanization, industrialization, agricultural intensification, and climate change have placed increasing pressure on freshwater resources (Batool et al.,2026). In developing countries such as India, the availability of safe and good-quality water remains a major concern, particularly in rural and semi-urban regions. Changes in rainfall patterns, prolonged dry periods, increasing evaporation, and deterioration of surface-water resources have further increased dependence on groundwater (Patel et al.,2026). Groundwater is stored beneath the Earth's surface within the pores, fractures, and interconnected spaces of soil and geological formations (Zhang et al.,2025). It is an important source of water for domestic consumption, irrigation, industrial activities, and ecosystem functioning (Divya et al.,2025). In India, groundwater contributes substantially to drinking-water and agricultural requirements, particularly in areas where surface-water availability is seasonal or insufficient (Tekam et al.,2026). However, excessive groundwater extraction, intensive irrigation, population growth, industrial development, and improper waste disposal have resulted in groundwater depletion and deterioration of water quality (Singh et al., 2026). Groundwater quality is influenced by both natural and anthropogenic processes. Weathering and dissolution of geological formations may introduce constituents such as iron, manganese, arsenic, fluoride, chloride, and sulfate, while agricultural runoff, fertilizers, pesticides, industrial effluents, domestic sewage, septic-system leakage, landfill leachate, and improper waste disposal can further contaminate aquifer

systems (Clune et al., 2016). Haryana, an agriculturally important state of northern India, is highly dependent on groundwater, and increasing irrigation requirements, urbanization, and industrial activities have placed considerable pressure on its groundwater resources. Therefore, regular monitoring of groundwater quality is essential to determine its suitability for drinking and other purposes (Kumar et al.,2024). Wastewater is another major environmental concern because it is continuously generated from domestic, agricultural, commercial, and industrial activities. It may contain suspended solids, organic matter, nutrients, salts, microorganisms, heavy metals, detergents, pharmaceuticals, and other potentially harmful contaminants (Bali et al.,2025). Discharge of untreated wastewater into the environment can contaminate surface water, soil, and groundwater and adversely affect aquatic ecosystems and human health (Dubey et al., 2025). Conventional wastewater treatment includes primary, secondary, tertiary and advanced wastewater treatment. Primary treatment removes coarse and settleable materials through physical processes, while secondary treatment is based on biological processes for reducing biodegradable organic matter. Tertiary treatment is employed to remove nutrients, pathogens, dissolved contaminants, and other pollutants remaining after conventional treatment (Chakraborty et al., 2025). Physicochemical characterization is an important approach for evaluating water quality parameters including pH, electrical conductivity (EC), turbidity, hardness, alkalinity, acidity, chloride, sulfate, nitrate, phosphate, dissolved oxygen (DO), biochemical oxygen demand (BOD), and total dissolved solids (TDS). Chemical oxygen demand (COD) provides valuable information regarding the chemical characteristics and pollution status of water (Shukla et al., 2025). Elevated EC and TDS generally indicate increased concentrations of dissolved ionic constituents, whereas BOD and COD are important indicators of organic pollution in wastewater. Advanced water treatment technologies such as microfiltration, nanofiltration, ultrafiltration, reverse osmosis, and electrodialysis are increasingly used for the removal of suspended particles, dissolved ions, organic compounds, and other contaminants (Sandhan et al., 2026). Thus, systematic assessment of groundwater and wastewater quality is essential for protection of the environment, public health, and sustainable water-resource management. Comparing measured physicochemical parameters with established standards provides a scientific basis for evaluating water suitability and identifying potential pollution (Alafei et al.,2026) (Vinay et al.,2026). In this context, the present study evaluates the physicochemical evaluation of groundwater and wastewater samples collected from selected locations and their comparison with relevant Bureau of Indian Standards (BIS) requirements and applicable water-quality criteria. The study aims to assess the physicochemical characteristics of the investigated samples and evaluate their overall quality and potential pollution status.

2. MATERIALS AND METHODOLOGY

2.1 Area of study

The study was done to assess physicochemical characteristics of groundwater and wastewater from selected locations in northern India. The location chosen for the physicochemical properties of groundwater was Mahendergarh district and its villages; and for wastewater physicochemical properties, the sites chosen were Delhi, Gurugram, Noida, and Meerut.

2.2 Groundwater sampling

A total of 10 groundwater samples were taken from tube wells located in various blocks of Mahendergarh district (Fig.1). The groundwater sources had depths of approximately 180–350 ft. Sampling locations were selected to represent different areas of the district.

Samples were collected using clean, pre-labelled plastic sampling bottles. Before collection, the bottles were thoroughly washed and rinsed with the respective groundwater source to minimize contamination from the sampling containers. Samples were collected using a random sampling approach, and after collection, the samples were carried out to the laboratory under refrigerated conditions and stored at approximately 4–5 °C until analysis. For metal analysis, samples were preserved by acidification with nitric acid to minimize adsorption or precipitation of metals during storage. Prior to instrumental analysis, samples were appropriately filtered and prepared according to the requirements of the analytical method.

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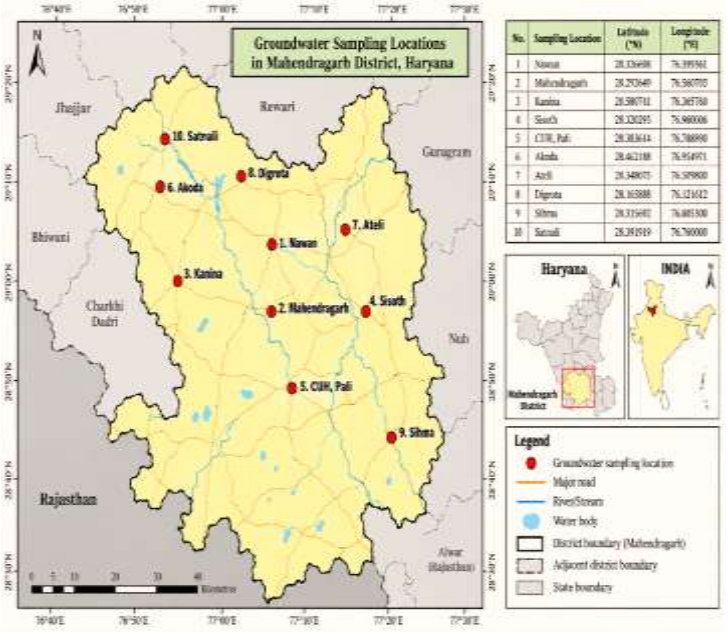


Fig.1 Study area map of Groundwater Samples

2.3 Wastewater sampling

Wastewater samples were collected from selected sewage treatment plants located in Delhi, Gurugram, Rewari & Mahendergarh (Fig.2). Samples were collected from both the inlet and outlet points of the respective treatment plants. A total of 24 wastewater samples were analyzed, containing 12 inlet and 12 outlet samples. Three samples were collected from each selected location. Grab sampling was used for wastewater collection. Samples were collected in clean, labelled containers and transported to the laboratory under refrigerated conditions at approximately 4–5 °C. Appropriate preservation and holding conditions were maintained according to the requirements of the individual analytical parameters.

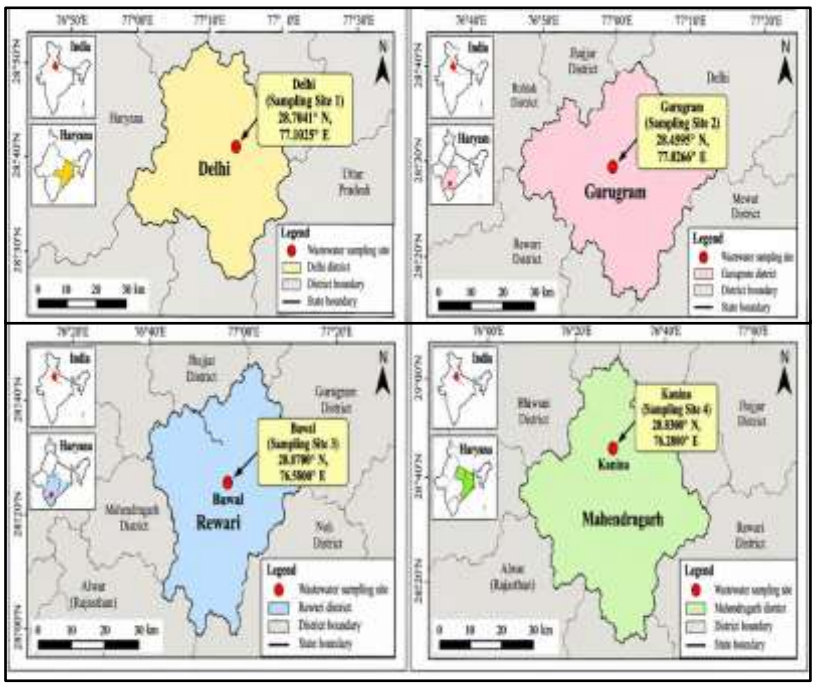


Fig.2 Study area map of wastewater samples

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2.4 Analytical parameters

Groundwater quality assessment in Mahendergarh district requires many different parameters to be analyzed. The included parameters are pH, EC, Turbidity, Total Hardness, Calcium Hardness, Alkalinity, Chloride, TDS, Fluoride, Metals, Wastewater pH, TSS, COD & BOD. The specific standard that illustrates the water parameters range is I.S 10500:2012. After the approval of Food and Agriculture Division Council the Drinking Water Sectional 25 Committee's final draft, the Bureau of Indian Standards (BIS) adopted this standard. The methods and instruments used for the different parameters are summarized in Table 1.

Table 1. Analytical parameters, methods, and applicable standards for groundwater and wastewater characterization

S. No.	Sample type	Parameter	Analytical method	Desirable limit	Permissible limit
1	Groundwater	pH	Digital pH meter	6.5–8.5	No relaxation
2	Groundwater	Electrical conductivity (EC)	Digital conductivity meter	<1500 µS/cm	1500–3000 µS/cm
3	Groundwater	Turbidity	Turbidity meter	1 NTU	5 NTU
4	Groundwater	Total hardness	EDTA titration	200 mg/L	600 mg/L
5	Groundwater	Calcium hardness	EDTA titration	200 mg/L	600 mg/L
6	Groundwater	Alkalinity	Acid titration	200 mg/L	600 mg/L
7	Groundwater	Chloride	Argentometric titration	250 mg/L	1000 mg/L
8	Groundwater	Total dissolved solids (TDS)	Gravimetric method	500 mg/L	2000 mg/L
9	Groundwater	Fluoride	Fluoride ion-selective electrode	1.0 mg/L	1.5 mg/L
10	Groundwater	Cadmium (Cd)	ICP-OES	0.003 mg/L	No relaxation
11	Groundwater	Cobalt (Co)	ICP-OES	—	—
12	Groundwater	Chromium (Cr)	ICP-OES	0.05 mg/L	No relaxation
13	Groundwater	Copper (Cu)	ICP-OES	0.05 mg/L	1.5 mg/L
14	Groundwater	Iron (Fe)	ICP-OES	0.3 mg/L	No relaxation
15	Groundwater	Magnesium (Mg)	ICP-OES	—	100 mg/L
16	Groundwater	Manganese (Mn)	ICP-OES	0.1 mg/L	0.3 mg/L
17	Groundwater	Molybdenum (Mo)	ICP-OES	0.07 mg/L	No relaxation
18	Groundwater	Nickel (Ni)	ICP-OES	0.02 mg/L	No relaxation
19	Groundwater	Lead (Pb)	ICP-OES	0.01 mg/L	No relaxation
20	Groundwater	Zinc (Zn)	ICP-OES	5.0 mg/L	15 mg/L
21	Wastewater	pH	Digital pH meter	5.5	9.0
22	Wastewater	TSS	Gravimetric method	100 mg/L	600 mg/L
23	Wastewater	COD	Dichromate oxidation/FAS titration	250 mg/L	—
24	Wastewater	(BOD_5)	Five-day incubation method	30 mg/L	—

3. RESULTS AND DISCUSSION

3.1 Analysis of Physicochemical Parameters of Groundwater

The physicochemical characteristics of the ten groundwater samples collected from different locations of Mahendergarh district are presented in Tables 3 and 4. The results were analysed with reference to the drinking-water requirements specified in IS 10500:2012. The acceptable and permissible limits were considered where applicable.

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Table 3. Result of parameters of Groundwater Samples

S. No.	Sample	pH	EC	Turbidity	Total Hardness	Calcium Hardness	Alkalinity	Chloride	TDS	Fluoride
1	P1	7.46	2762	1.53	395	81	581	363.2	1558	0.912
2	P2	7.94	349.2	6.35	111	64	104	22.31	211	0.228
3	P3	7.71	1369	1.17	104	41	415	157.1	795	0.351
4	P4	6.89	3675	1.13	492	169	338	918.6	1528	0.691
5	P5	7.34	1942	0.42	144	75	475	246.3	1163	0.498
6	P6	7.41	3352	0.22	469	158	331	698.4	975	0.774
7	P7	8.07	529.8	4.57	138	61	118	51.2	442	0.329
8	P8	7.59	678.5	0.23	221	31	586	475.9	1372	2.91
9	P9	6.99	331.4	4.48	124	71	98	17.25	249	0.205
10	P10	8.06	887.9	0.32	88	33	303	85.14	641	0.461

3.1.1 pH

The values of the pH for the groundwaters sampled were 6.89 to 8.07, with the average being close to 7.55. This implies that all the ten groundwaters were within the BIS acceptable range of 6.5-8.5. The lowest value of the pH was recorded in P4 groundwaters, while the highest value was recorded in P7. This suggests that the groundwaters were mildly alkaline or near neutral and did not show extreme levels of acidity and alkalinity. Changes in groundwater pH can be attributed to carbonate equilibrium, mineral dissolution, interaction of groundwater and rock formation, and local anthropogenic factors.

3.1.2 Electrical conductivity

There was a lot of variation in the electrical conductivity of the groundwater samples. Electrical conductivity ranged between 331.4 and 3675 μS cm^{-1} with an average of about 1588 μS cm^{-1}. Samples P4 had the highest EC, followed by P6 and P1, while sample P9 had the lowest value. The high values of EC recorded at some sites suggest higher concentrations of ions in the water sample. The high value of EC at P4 is also supported by the high value of TDS, chloride, and hardness in it.

3.1.3 Turbidity

The turbidity was between 0.22 and 6.35 NTU, with an average of about 2.06 NTU. The highest value of turbidity occurred in P2 (6.35 NTU), which is above the standard BIS accepted value of 1 NTU, and even the permissible limit of 5 NTU, in the absence of any other source. The high turbidity value of P2 may be due to suspended mineral particles or disturbance at the time of ground water withdrawal.

3.1.4 Total hardness

The total hardness varied from 88 to 492 mg L^{-1} as $CaCO_3$ with an average value of approximately 228 mg L^{-1}. Four values were higher than the acceptable threshold of 200 mg L^{-1} but did not exceed the permissible value of 600 mg L^{-1} (Fig.3). The other six samples had values in the acceptable range. The high hardness can be related to the dissolution of minerals bearing calcium and magnesium during the circulation of groundwater.

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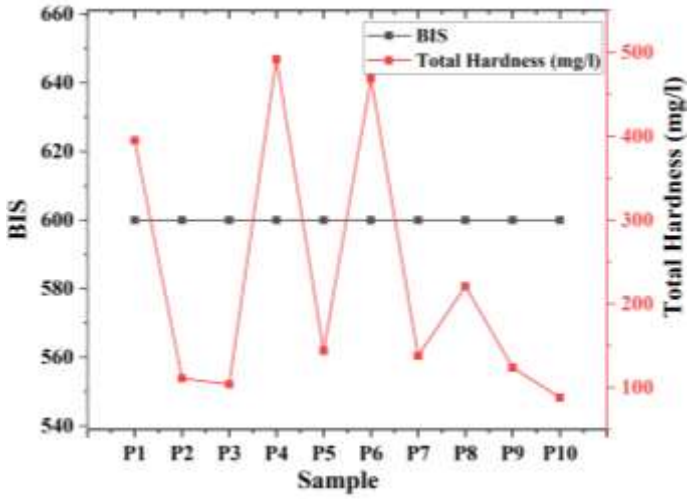


Fig. 3 Total hardness in groundwater samples of Mahendergarh district

3.1.5 Calcium hardness

Calcium levels were found between 31 and 169 mg L^{-1}, with an average level of about 78.3 mg L^{-1}. P4 had the highest level (169 mg L^{-1}), then P6 (158 mg L^{-1}) and P1 (81 mg L^{-1}). Based on BIS permissible values for calcium where the acceptable level is 75 mg L^{-1} and permissible level is 200 mg L^{-1}, P1, P4, and P6 are above the acceptable level but below the permissible level. This high calcium level correlates well with the high level of total hardness at these points. Calcium in groundwater is formed by the dissolution of calcium-containing minerals.

3.1.6 Alkalinity

Alkalinity ranged from 98 to 586 mg/L as $CaCO_3$, with an average of about 333.5 mg/L. The highest alkalinity was recorded at P8 (586 mg/L), followed by P1 (581 mg/L) and P5 (475 mg/L). With respect to the BIS acceptable value of 200 mg/L and permissible value of 600 mg/L, there were six samples (P1, P3, P4, P5, P6, and P8) that exceeded the acceptable value but still stayed below the permissible value (Fig.4). The relatively higher alkalinity indicates the presence of carbonate and bicarbonate ions in the water. The dissolution of carbonates and reactions between the groundwater and the aquifer are possible sources of the alkalinity. Another possible cause for elevated alkalinity is long residence time of the groundwater and its interaction with carbonate bearing materials in the geology.

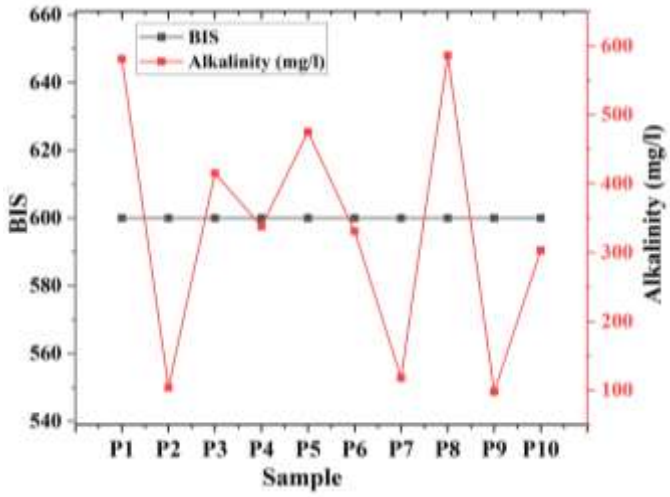


Fig. 4 Alkalinity in groundwater samples of Mahendergarh district

3.1.7 Chloride

Chloride values were between 17.25 and 918.6 mg L^{-1}, with the mean of approximately 304.24 mg L^{-1}. The highest values were observed at P4 (918.6 mg L^{-1}), P6 (698.4 mg L^{-1}), and P8 (475.9 mg L^{-1}) (Fig.5). According to BIS standards, acceptable and permissible limits for chlorides are 250 and 1000 mg L^{-1}, respectively. Consequently, P1, P4, P5, P6, and P8 have surpassed the acceptable level of chlorides, but no samples had more than the permissible level. High levels of chloride could be attributed to increased mineralization and dissolution of chloride-bearing minerals, evaporation, irrigation return flow, or anthropogenic sources.

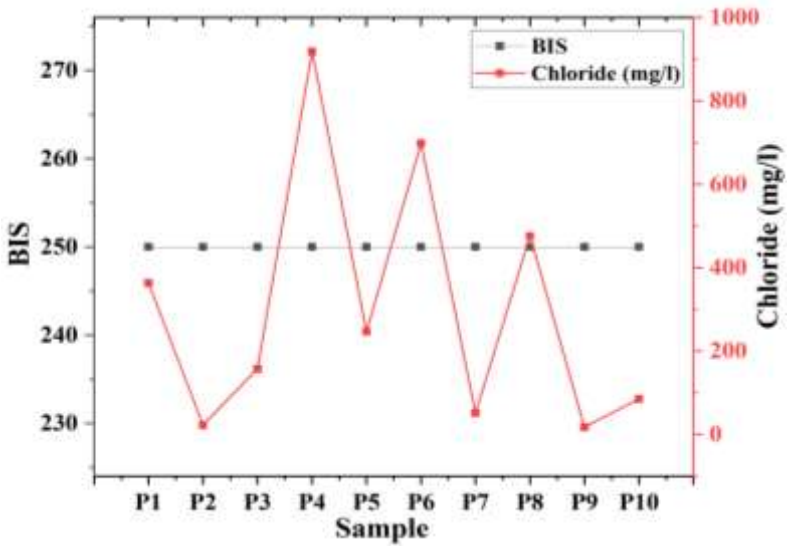


Fig. 5 Chloride concentration in groundwater samples of Mahendergarh district

3.1.8 Total dissolved solids (TDS)

The level of TDS ranged from 213 to 1562 mg L^{-1}, with a mean value of about 894.4 mg L^{-1}. P1 had the highest TDS (1562 mg L^{-1}), followed by P4 (1535 mg L^{-1}), P8 (1368 mg L^{-1}), P5 (1158 mg L^{-1}), and P6 (981 mg L^{-1}). Based on the IS 10500:2012 standard, the observed acceptable and permissible values of TDS are 500 and 2000 mg L^{-1}, respectively. Therefore, five groundwater samples had higher TDS values than the acceptable value but remained below the permissible limit. The high TDS values showed a good correspondence with the EC values.

3.1.9 Fluoride

Fluoride concentrations varied from 0.208 and 2.94 mg L^{-1}, while the average fluoride concentration was found to be 0.739 mg L^{-1}. In general, most of the samples had fluoride concentrations lower than the BIS permissible value of 1.0 mg L^{-1}. However, the fluoride concentration at P8 exceeded the permissible value of 1.5 mg L^{-1}, with a concentration of 2.94 mg L^{-1} (Fig.6). Thus, the elevated fluoride concentration at P8 represents a concern in groundwater quality assessment. Fluoride in groundwater is typically governed by interactions between water and rocks, mineral dissolution, groundwater residence time, and various geochemical processes.

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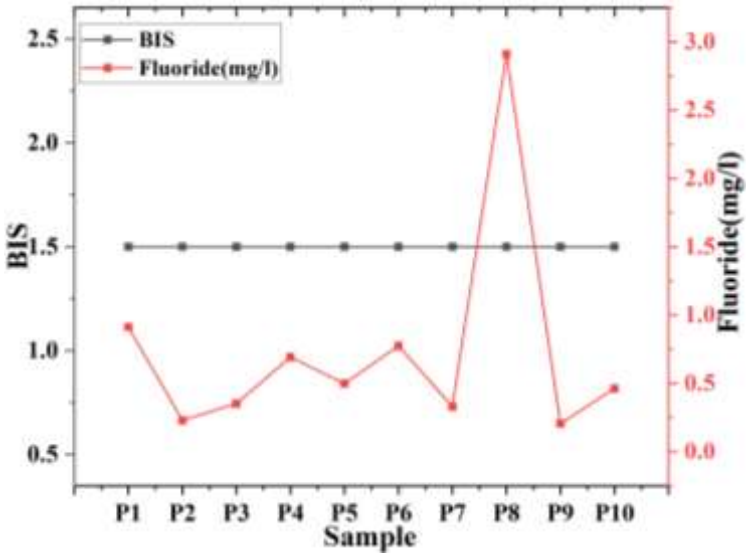


Fig.6 Fluoride concentration in groundwater samples of Mahendergarh district

3.2 Heavy metals features in groundwater

The metal concentrations found in ten groundwater samples are shown in Table 4 below. The metals analyzed were Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, Pb, and Zn.

Table 4. Result of Physiochemical parameters of Groundwater Metals

S. No.	Sample	Ca	Cd	Co	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Pb	Zn
1	P1	28.34	0.0004	0.0011	0.0060	0.0062	0.035	38.62	0.0041	0.0041	0.0062	0.0018	0.0041
2	P2	13.08	0.0003	0.0006	0.0042	0.0052	0.095	4.94	0.0041	0.0011	0.0042	0.0010	0.0111
3	P3	16.18	0.0003	0.0005	0.0163	0.0061	0.020	9.31	0.0011	0.0011	0.0052	0.0010	0.0308
4	P4	112.74	0.0003	0.0007	0.0031	0.0032	0.163	39.31	0.0021	0.0011	0.0051	0.0018	0.0265
5	P5	23.84	0.0003	0.0001	0.0071	0.0173	0.0185	9.61	0.0007	0.0011	0.0042	0.0011	0.142
6	P6	85.91	0.0004	0.0009	0.0082	0.0041	0.0215	33.38	0.0011	0.0041	0.0006	0.0005	0.0275
7	P7	28.31	0.0003	0.0004	0.0041	0.0052	0.158	10.84	0.0112	0.0021	0.0061	0.0010	0.0205
8	P8	29.82	0.0003	0.0006	0.0061	0.0585	0.0245	26.54	0.0011	0.0162	0.0061	0.0008	0.0082
9	P9	29.82	0.0004	0.0002	0.0031	0.0051	0.198	9.47	0.0081	0.0011	0.0052	0.0011	0.0082
10	P10	13.18	0.0003	0.0003	0.0142	0.0061	0.0265	4.72	0.0010	0.0021	0.0031	0.0014	0.0385

3.2.1 Cadmium, cobalt and chromium

The levels of cadmium were exceptionally low at 0.0003 to 0.0004 mg L^{-1}. Cobalt levels were within the range of 0.0001 to 0.0011 mg L^{-1} and chromium levels were between 0.0031 to 0.0163 mg L^{-1}. No significant spatial enrichment was noted with respect to these metals.

3.2.2 Copper

Copper levels were found to range between 0.0032 to 0.0585 mg L^{-1} with the highest levels found at P8. All the other samples contained much lower levels of copper. High levels of copper found at P8 may be related to the geological conditions in that area or due to some form of anthropogenic pollution.

3.2.3 Iron

Iron concentrations varied between 0.020 and 0.198 mg L^{-1}, with the maximum iron concentration noted at location P9. The above values are below the accepted value of 0.3 mg L^{-1}, as per BIS standards for iron. Thus, iron was not a constraint in the drinking water quality in the studied samples. However, differences in iron concentration could be due to mineralogy and oxidation-reduction reactions.

3.2.4 Magnesium

The magnesium concentration was found to vary from 4.72 to 39.31 mg L^{-1} based on the analysis data, with the maximum being recorded at P4. The increased magnesium concentration at P4 could be attributed to the fact that the total hardness in the area is relatively high.

3.2.5 Manganese

Concentrations of manganese were between 0.0007 and 0.0112 mg L^{-1}, with the maximum concentration found at P7.

3.2.6 Molybdenum and nickel

The molybdenum concentrations varied from 0.001 to 0.0162 mg L^{-1}, while those of nickel varied from 0.0031 to 0.0061 mg L^{-1}.

3.2.7 Lead

The lead concentrations were 0.0005-0.0018 mg/L, with the highest concentrations found in P1 and P4 samples. The concentrations were lower than the BIS value of 0.01 mg/L for lead concentration.

3.2.8 Zinc

The concentrations of zinc varied from 0.0041 to 0.142 mg L^{-1}, with the highest concentration being at P5. The concentrations of these metals were low as compared to their drinking water criteria.

3.3 Wastewater quality assessment

Parameters such as pH, TSS, COD, and BOD_5 were investigated for the inlet and outlet water samples taken from selected sewage treatment plants. Details of the parameters are shown in Tables 5 and 6 below.

Table 5. Reading of Inlet wastewater from STP

S. No.	Sample	pH	TSS (mg/L)	COD (mg/L)	BOD (mg/L)
1	IW1	6.82	425	418	206
2	IW2	7.20	468	832	414
3	IW3	7.04	892	1572	826.40
4	IW4	6.93	674	592	324
5	IW5	7.37	728	604	356

6	IW6	7.32	874	1492	774
7	IW7	7.27	283	614	339
8	IW8	7.02	351	842	431
9	IW9	7.42	381	918	464
10	IW10	7.33	202	425	205
11	IW11	7.47	224	485	252
12	IW12	7.31	291	619	341

Table 6. Reading of Outlet wastewater from STP

S. No.	Sample	pH	TSS (mg/L)	COD (mg/L)	BOD (mg/L)
1	OW1	7.65	6.4	21	4.2
2	OW2	8.01	8.3	27.1	6.3
3	OW3	7.73	20.5	47	10.4
4	OW4	7.21	6.5	14.8	1.9
5	OW5	7.69	10.4	16.8	2.0
6	OW6	9.18	27.4	24.8	4.8
7	OW7	7.31	6.8	33	6.2
8	OW8	7.53	7.5	35	6.4
9	OW9	10.18	9.5	43	8.7
10	OW10	7.63	5.3	25.4	5.2
11	OW11	7.75	9.1	45	8.8
12	OW12	7.81	13.6	51	9.5

3.3.1 Inlet wastewater

Inlet Wastewater Characteristics

The inlet wastewater had considerable variability in organic and suspended solids loading. The pH ranged from 6.82 to 7.47, with an average pH value of about 7.21. Therefore, the untreated sewage was generally neutral. TSS had a variability of 202 to 892 mg L^{-1}, with a mean of 482.75 mg L^{-1}. The maximum amount of TSS was detected in IW3; therefore, there was a considerable suspended solid load. COD had variability of 418 to 1572 mg L^{-1}, with a mean of 784.42 mg L^{-1}. The highest COD was noted in IW3, then IW6 and IW9. Variability of COD indicates that there was variability in organic and oxidizable matter in the inflow water into different sewage treatment plants. BOD_5 had a variability of 205 to 826.40 mg L^{-1}, with a mean of 411.03 mg L^{-1}. The maximum BOD_5 amount was found in IW3, then IW6 and IW9. The high value of BOD_5 and COD in inlet water shows the considerable organic load in untreated sewage.

3.3.2 Outlet wastewater

The results after treatment indicated significant changes in wastewater characteristics. The outlet pH was between 7.21 and 10.18 with a mean of about 7.79. All treated samples indicated a near-neutral to slightly alkaline condition except for OW6 (pH 9.18) and especially OW9 (pH 10.18), which had high pH values and need special consideration regarding the discharge standards. For TSS, the range was between 5.3 to 27.4 mg L^{-1} with a mean of about 10.88 mg L^{-1}. The range for COD was 14.8 to 51 mg L^{-1} with a mean of about 33.08 mg L^{-1}, while for BOD_5, the range was between 1.9 to 10.4 mg L^{-1} with a mean

of about 6.13 mg L^{-1}. These significant decreases in TSS, COD and BOD_5 indicate effective removal of suspended and biodegradable/oxidizable organic matter.

3.3.3 Treatment efficiency

The treatment efficiency was determined using:

$$\text{Removal efficiency (\%)} = \frac{C_i - C_o}{C_i} \times 100$$

where C_i represents the inlet amount and C_o represents the outlet amount.

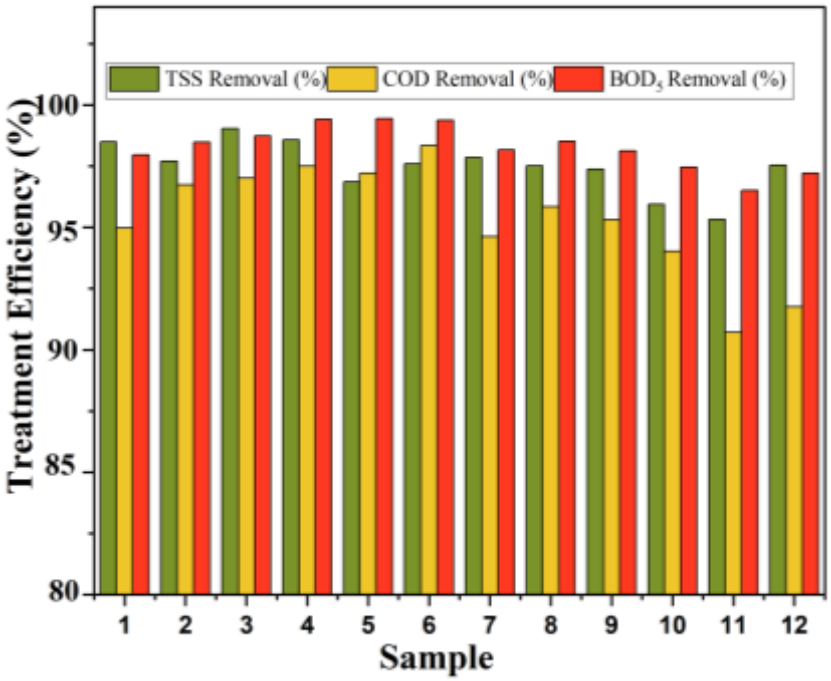


Fig. 7 Treatment efficiency of STP wastewater

The best removal efficiency for COD was obtained for IW6 (98.34%), while the low removal was observed for IW11 (90.72%). As for BOD_5, the removal efficiency was approximately between 96.51–99.44%. The reduction of TSS concentration from an average of 482.75 mg L^{-1} to 10.88 mg L^{-1} indicates good solids separation. Reduction of COD from approximately 784.42 mg L^{-1} to 33.08 mg L^{-1} indicates good reduction of chemically oxidizable organic matter. Reduction of BOD_5 to an average of approximately 6.13 mg L^{-1} indicates good biological treatment.

4 CONCLUSION:

The current study investigated physicochemical properties as well as selected metals of groundwater samples collected from ten tube wells in Mahendergarh district and analyzed the performance of selected sewage treatment plants based on inlet and outlet wastewater samples. The pH of groundwater was between 6.87 and 8.07, and all the samples fell within the acceptable range according to BIS standards. The total hardness surpassed the acceptable level of 200 mg/L at four places, and similarly, chloride and TDS levels were above acceptable levels at five places. However, these parameter levels remained lower than their respective permissible levels in the studied samples. Fluoride was found to be the most significant specific quality concern regarding the groundwater. Even though fluoride was found in most samples at a level lower than 1.0 mg/L, a fluoride level of 2.94 mg/L was reported in sample D8, which was higher than the BIS permissible limit of 1.5 mg/L. Cadmium, chromium, nickel, and lead contamination were not prevalent. Levels of lead contamination were lower than the permissible limit for drinking water. Minor variation was noted in aluminum, copper, iron, manganese, vanadium, and zinc. There was significant efficiency in terms of the wastewater treatment process. The mean value of TSS decreased from approximately 493.58 mg/L in the inlet wastewater

to 12.98 mg/L in the outlet wastewater. Similarly, the mean COD concentration decreased from 783.58 mg/L to 27.45 mg/L, while the mean BOD concentration decreased from 411.53 mg/L to 5.28 mg/L. The corresponding average removal efficiencies were approximately 97.4% for TSS, 96.5% for COD, and 98.7% for BOD, respectively. Overall, it is observed that the water quality in terms of pH and most of the studied trace metals in the investigated area of Mahendergarh is relatively good, although there is the need for the problem of mineralization and fluoridation to be solved. The studied STPs showed highly efficient removals of suspended and organic materials.

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