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Groundwater Chemistry in Jind District: Physiochemical Appraisal and Drinking Water Quality Assessment

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Abstract: *It is essential to have access to safe drinking water, particularly in rural regions where groundwater is the primary water source. The physicochemical quality of the groundwater in Jind District, Haryana, India, has been evaluated in this research. Six hundred samples were collected from thirty different places, and the following physiochemical characteristics were measured: pH, total dissolved solids, total hardness, alkalinity, electrical conductivity, calcium, magnesium, sodium, potassium, nitrate, fluoride, and sulfate. The World Health Organization, the Bureau of Indian Standards, the Indian Council of Medical Research, and other regulatory bodies' standards were compared to these results. Most of the necessary criteria were found to be within acceptable levels; however, total hardness, calcium, and magnesium were found to be greater than recommended in certain areas. The Water Quality Index states that the declining quality of the groundwater in certain areas makes it unfit for human consumption. In addition to providing critical information to assist mitigation measures and ensure the provision of sustainable and clean water resources for the population of the Jind district in the state of Haryana, this research highlights the need of regular monitoring.*

Keywords: Physiochemical, groundwater, water quality, jind, water quality index

I. INTRODUCTION

Water is essential to every living thing on Earth's surface. Water is essential to human life for domestic, industrial, and agricultural uses. Sustainable water management is challenged by the overuse of groundwater resources, which has resulted in declining water levels and quality in many areas. Strategies for sustainable water management are required to get over these obstacles. This include promoting water conservation in residential and commercial settings, enforcing groundwater extraction regulations, and effectively using water in agriculture via the use of cutting-edge methods like drip irrigation. Moreover, improving water infrastructure—building reservoirs and fortifying water distribution systems, for example—may facilitate better management of available water supplies. The state of Haryana and many other places throughout the globe have a pressing need to prioritize conservation efforts and efficiently manage water use. This calls for replenishing and protecting the water resources for future generations in addition to managing the ones that exist now. To ensure water security and environmental sustainability, integrated water resource management strategies that take into account groundwater and surface water sources must be implemented. Additionally, it is critical to raise public awareness of the need of sustainable practices and water conservation. Creating a culture that values water conservation and ethical use of resources requires education and community involvement. In summary, water is a valuable natural resource and a national treasure, but with rising demand and environmental concerns, sustainable management is even more important. By means of concerted conservation, regulation, and public engagement initiatives, we can ensure that water resources remain plentiful and easily available to everyone. Since groundwater is vital to the state's economy and so needs scientific monitoring in terms of both quality and quantity, precise evaluation based on acknowledged and legitimate scientific standards is thus required for the sustainable development and management of groundwater resources.

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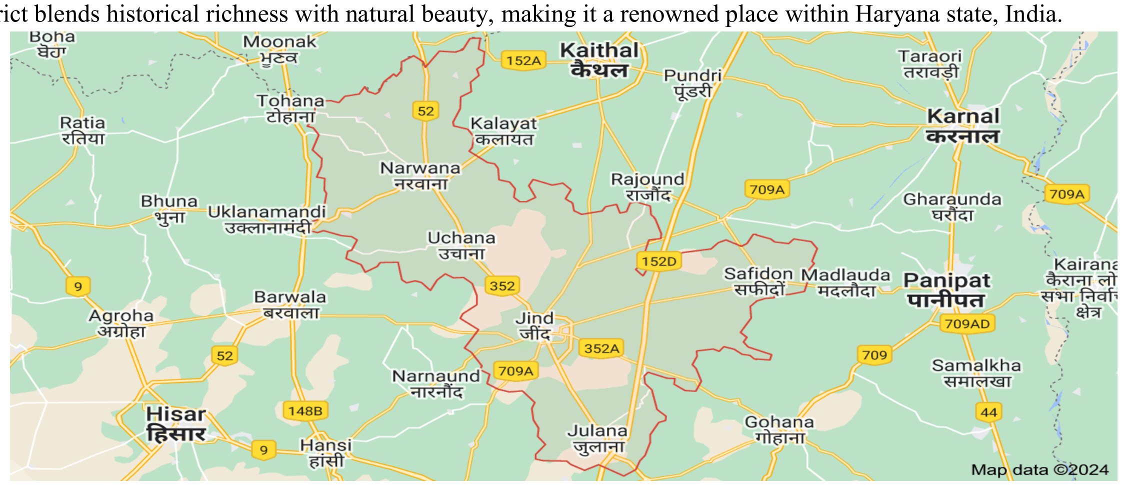
II. GEOGRAPHICAL DESCRIPTION OF AREA OF STUDY

Jind district, located in the northern section of Haryana state, India, possesses historical significance being the largest and oldest district in the area. It falls inside the National Capital Region (NCR), which covers numerous districts around the national capital, New Delhi. Jind is located roughly 134 kilometers from New Delhi, putting it reasonably near to the capital city. Additionally, jind is around 180 kilometers (133 miles) south-west of Chandigarh, which acts as the capital for both Haryana and Punjab. The district has four sub-divisions: Jind, Narwana, Safidon and Uchana. In order to streamline the rural development, these tehsils have been further separated into seven blocks namely Narwana, Uchana, Alewa, Jind, Julana, Pilukhera and Safidon. These 7 blocks encompass 306 settlements of the district with total population of 1334152 according to 2011 census. The neighborhood is noted for its rich historical and cultural legacy, and its closeness to major urban hubs makes it a significant sector within the NCR. The district located in the North of Haryana between 29.03' and 29.51' North latitude & 75.53' and 76.47' East longitude, encompassing a geographical area of 2709 square kilometers.The district's average elevation is 227 meters (744 feet) above sea level. Jind town acts as the administrative capital of Jind district. The district has boundaries with Hisar and Fatehabad to the west and north, and with Kaithal and Karnal. To the east and south, it borders Sonipat, Panipat, and Rohtak districts. Jind district has an average yearly rainfall of 515 mm. Rainfall usually rises from west to east over the area. About 77% of this precipitation occurs during the southwest monsoon.The climate fluctuates substantially throughout the year. In January, the average low temperature is around 6 °C, while in June, the average high temperature is roughly 41 °C.The major language spoken in the region is Hindi, reflecting the cultural and linguistic demography of the area.Overall, Jind district blends historical richness with natural beauty, making it a renowned place within Haryana state, India.



III. SAMPLING PROTOCOL

The samples were gathered throughout a five-month period spanning from January 2024 to may 2024 from diverse places in the area ranging from urban to rural community. The areas where the water samples were obtained are referred to as stations (A1-A30). Each water sample was collected in pre-treated and labeled plastic bottles with a volume of 1.5 liters. The bottles were cleansed with 2% Nitric acid and rinsed three times with distilled water before use. This preparation ensures that the containers are clean and free from pollutants that might impact the water samples. After collection, the water samples were promptly conserved following standard techniques stated in the APHA (American Public Health Association) standards from 2005 for ensuring sample integrity throughout transport and storage.The examination of the water samples was undertaken using established procedures indicated in the APHA standards. These methods offer consistency and dependability in monitoring numerous factors including as pH, turbidity, dissolved oxygen, nutrients, and potentially pollutants. This systematic method is vital for gathering reliable data on the quality and properties of the water from these distinct sources.

Table 1. Sampling site, sources, code of water samples

S. NO.	Sampling site	Water source	Site code
1	Alewa	Hand pump	A1
2	Dalamwala	Bore well	A2
3	Dahola	Hand pump	A3
4	Khanda	Bore well	A4
5	Naguran	Hand pump	A5
6	Pegan	Bore well	A6
7	Shahpur	Hand pump	A7
8	Ahirka	Bore well	A8
9	Assan	Hand pump	A9
10	Barodi	Hand pump	A10
11	Igrah	Hand pump	A11
12	Kinana	Hand pump	A12
13	Buana	Hand pump	A13
14	Devrar	Hand pump	A14
15	Fatehgarh	Hand pump	A15
16	Julana	Hand pump	A16
17	Rajgarh	Hand pump	A17
18	karsola	Bore well	A18
19	Dablain	Hand pump	A19
20	Garhi	Hand pump	A20
21	Ghaso	Hand pump	A21
22	Rewar	Hand pump	A22
23	Kalawati	Bore well	A23
24	Kalwa	Bore well	A24
25	Burain	Bore well	A25
26	Pillukhera	Bore well	A26
27	Anta	Bore well	A27
28	Batini	Bore well	A28
29	Hatt	Bore well	A29
30	Singhpura	Bore well	A30

IV. SPECIFICATIONS OF DRINKING WATER

According to data from the World Health Organization, 1, 230 million people lacked access to clean water in 1975. The United Nations chose to proclaim 1981 to be the International Year of Drinking Water Supply and Sanitation because to these horrifying realities. The availability of clean drinking water for the general public was given considerable consideration in the Fifth Five Year Plan of India. The standard was therefore created with the intention of evaluating the quality of water resources and verifying the efficacy of water treatment and supply by the relevant authorities. This was done through comparative chemometric studies of water quality parameters of drinking underground water of rural & urban areas. According to India's eleventh five-year plan document (2007–12), Various regulatory authorities like Bureau of Indian Standards (BIS), Indian Council of Medical Research (ICMR) and World Health Organization (WHO) have established permissible range of quality parameters of safe drinking water to provide a safety margin to safeguard public health. Safe range of various physiochemical properties set by various governing bodies are listed in table 2

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Table 2. Analytic methods, BIS, ICMR & WHO parameters for the drinking water

Parameter	BIS standard	ICMR standard	WHO standard
pH	6.5 – 8.5	7.0 – 8.5	6.5 – 8.5
TDS (mg/L)	500 - 2000	500-3000	1000
TH (mg/L)	300-600	300-600	500
Ca2+ (mg/L)	75-200	75-200	200
Mg2+ (mg/L)	30-100	50	50
Cl− (mg/L)	250-1000	200-1000	200
Turbidity(NTU)	1	1-5	5
SO_4^{2-}(mg/L)	200-400	200-400	400
NO_3^- (mg/L)	45-100	20-100	10
PO_4^{3-} (mg/L)	-	-	-
Na^+ (mg/L)	-	-	200/15
K^+(mg/L)			
Fe^{3+} (mg/L)	0.3-1.0	0.1	1.0
F^- (mg/L)	1.0	1-1.5	1.5

V. RESULTS AND DISCUSSION

Thirty samples were taken from hand pumps, tube wells from villages, temples, bus station, and several diverse sites. These samples were evaluated for different physicochemical characteristics . The approach used for the analysis was from standard method (APHA). All the results are compared with the allowable limit established by the Bureau of Indian Standards (BIS),Indian Council of Medical Research (ICMR) and World Health Organization (WHO). Characterizations of the physio-chemical parameters of different locations in District Jind, Haryana, India are reported in Tables 3

Table 3. Chemical characteristics of ground water of different places of jind City

Site code	ph	TDS	EC	TH	TA	Ca^{2+}	Mg^{2+}	Cl^-	F^-	SO_4^{2-}	PO_4^{3-}	NO_3^-	Na^+	K^+
A-1	6.89	594	0.992	382	187	69	55	198	0.8	65	5	18	102	9
A-2	7.52	582	0.871	290	185	82	62	154	0.7	198	5	32	188	4
A-3	7.29	730	1.126	370	286	93	58	152	0.6	54	8	31	132	47
A-4	7.31	685	1.080	450	298	108	56	236	1.1	99	4	31	254	23
A-5	7.37	599	0.994	395	202	96	53	187	0.9	83	2	19	122	18
A-6	7.58	987	1.882	455	255	98	87	199	1.7	83	1	21	267	19
A-7	7.25	1128	2.003	998	436	207	126	425	1.2	154	1	39	365	20
A-8	7.33	1252	1.155	595	587	195	80	437	4.9	194	2	45	301	29
A-9	7.07	1093	1.543	690	354	185	85	273	0.9	135	6	36	264	28
A-10	7.47	965	1.321	490	332	88	69	259	0.8	141	3	31	136	15
A-11	7.50	1595	1.920	990	489	204	179	295	1.4	352	8	18	254	27
A-12	7.82	984	1.310	920	496	182	130	119	1.5	198	1	19	141	28
A-13	6.35	995	2.624	705	398	149	85	291	0.9	105	2	15	298	22
A-14	6.30	897	1.879	905	212	125	69	250	1.9	90	6	20	265	70
A-15	6.95	972	1.972	695	347	114	91	328	1.5	91	1	30	225	61
A-16	6.46	997	1.025	550	266	121	52	160	1.7	165	1	31	198	71
A-17	7.30	885	1.654	660	388	109	43	366	5.5	98	2	8	265	60

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A-18	7.06	950	2.105	946	799	205	125	471	1.8	286	2	40	248	19
A-19	7.63	1440	2.870	1150	845	201	171	496	1.7	294	2	39	368	39
A-20	8.12	929	1.310	495	398	111	92	252	2.9	148	1	57	254	16
A-21	7.99	1013	1.852	655	332	161	82	258	2.9	252	2	80	298	59
A-22	8.31	1756	1.713	480	321	190	65	200	5.9	112	1	19	112	120
A-23	7.27	1590	2.060	690	598	150	85	390	5.8	198	2	18	165	28
A-24	8.64	1704	1.102	590	499	191	96	365	2.9	154	4	39	238	19
A-25	7.57	1126	1.360	793	421	118	72	299	1.4	265	1	66	203	29
A-26	7.29	922	1.802	646	287	150	90	183	0.8	96	2	39	131	19
A-27	8.60	672	1.809	810	254	140	25	198	0.6	98	0	65	163	19
A-28	8.99	984	1.708	800	298	138	34	105	1.8	125	3	14	152	9
A-29	8.03	1590	1.144	800	554	117	68	352	1.4	198	0	16	263	15
A-30	8.56	979	1.829	550	396	196	71	207	1.9	158	2	28	282	17

All parameters have been expressed as mg/L except pH and EC. The unit of EC is mS

pH

One important ecological component that affects many calculations related to geochemical equilibrium and stability is the pH of the water. The salinity of the nearby soil and the sample area's geology usually have an impact on the pH of the water. The appropriate pH range for drinking water is 6.5 to 8.5. The district's water has an acceptable pH range, with the exception of a few locations where it exceeds the ideal limit and has a slightly alkaline tendency. The pH values of the water samples used in the present research vary from 6.3 to 8.99.

Total dissolved solids (TDS)

Total Dissolved Solids (TDS) in potable water have a recommended limit of 500 parts per million (ppm) and a maximum allowable level of 2000 parts per million, according to the Bureau of Indian Standards (BIS). Throughout the area, the average TDS value is higher than the recommended threshold of 500 ppm. In particular, the A22 region has a concerning high TDS of 1756 ppm. The probable reason of this increased TDS level is groundwater contamination from domestic garbage dumped into pits and ponds, which seeps into the water table. The elevated TDS levels may also be attributed to the area's extensive usage of aglicultural chemicals.

Electrical Conductivity (EC)

The Jind district's mean electrical conductivity was determined to be 1.346 dS, with a low value of 0.992 dS and a high value of 2.870 dS. Total dissolved solids (TDS) and total hardness have a positive correlation with electrical conductivity (EC). The EC value was found to be greater in the A7, A13, and A19 locations, most likely as a result of the water's increased content of dissolved salts and ionic compounds. Given that water's electrical conductivity increases with increasing electrolyte concentrations, this connection makes sense. Because of this, the quantity of dissolved solids and conductivity have a direct relationship, and their seasonal changes are comparable.

Total hardness (TH)

The ability of water to react with soap is indicated by its water hardness, which is an important characteristic for a variety of uses. The standard allowable limit for overall hardness has been established at 300 ppm of $CaCO_3$ by the Indian Council of Medical Research (ICMR) and the Bureau of Indian Standards (BIS). The majority of the collection sites show total hardness levels that are higher than the tolerance limit of 300 ppm. The mean value of total hardness for Jind District is 487, with a standard deviation of 233.

Total alkalinity (TA)

Water samples from Jind had alkalinity levels ranging from 185 ppm to 845 ppm, which is far higher than the maximum allowable level of 600 ppm and the usual desired limit of 120 ppm. This high alkalinity suggests that natural salts, mostly from dissolved minerals in the soil, are present in significant amounts. Hydroxide, carbonates, bicarbonates, and organic acids are the main ionic species that are responsible for this alkalinity; they are all characteristic of the area's natural water sources and activities.

Chloride(Cl^-)

Because of its ability to hasten the corrosion of metals in distribution systems, chloride is an important signal for identifying groundwater pollution. A maximum of 250 parts per million is allowed for chloride in drinking water. Water samples at Jind had chloride values ranging from 105 ppm to 496 ppm. This high concentration of chloride may be the consequence of pollution from industry and household trash, or it may be the result of natural processes like water flowing through salt deposits in the soil.

Calcium ($Ca^{2+)}$

An important consideration when evaluating the quality of drinking water is the percentage of calcium. Water samples at Jind have varying calcium concentrations, ranging from 69 ppm to 205 ppm.The BIS recommended limits for calcium are determined to be within the Jind district's mean value of 87 (desirable up to 75 but allowed up to 200). High calcium concentrations are probably caused by gypsum, dolomite, and limestone deposits or by water seeping through them.

Magnesium(Mg^{2+})

Water samples from every site in Jind had magnesium concentrations ranging from 25 ppm to 179 ppm, with a mean value of 72. With the exception of samples from A11 and A19, the majority of samples fell under the 150 ppm magnesium in drinking water acceptable level. The discharge of industrial effluents and urban runoff may lead to elevated magnesium levels, which can be attributed to industrial operations and urbanization. regional environmental variables and climate conditions.impact the rates of mineral dissolution and water chemistry.

Sodium(Na^+)

A content of sodium (Na+) over 50 mg/L renders the water unfit for residential use and poses serious health risks. The district's total Na+ content varies from 102 mg/L to 365 mg/L, with a mean of 278 mg/L.

Potassium(K^+)

With the exception of site A22, the potassium (K+) content in the water samples from the several locations in the Jind area ranges from 4 mg/L to 120 mg/L, with a mean value of 32.45 mg/L. The BIS-mandated limits for potassium ion concentration are permitted up to 100 mg/L**.**

Fluoride (F^-)

Fluoride levels in drinking water may not exceed 1.0 mg/L, with the possibility of an increase to 1.5 mg/L if other sources of water are not available. Increased fluoride content in drinking water causes physical deformity and tooth damage. Consumption of excessive fluoride drinking water may lead to the feared sickness "fluorosis." The fluoride concentration in the groundwater of Jind District varied between 0.6 and 5.5 mg/L. In order to avoid possible health hazards linked to prolonged exposure to high fluoride concentrations, it is nevertheless important to monitor and regulate the fluoride levels in drinking water.

Sulphate (SO_4^{2-})

For household use, a sulphate level of greater exceeding 200 mg/L is undesirable. Exceeds this threshold and irritates the gastrointestinal tract, especially if groundwater also contains Mg2+ and Na+. As long as Mg2+ levels don't go over 30 mg/L, the 200 mg/L allowable limit may be increased to 400 mg/L. Waters with concentrations higher than 1000 mg/L are purgative. in the Safidon Block's groundwater, varied from 54 to 352 mg/L. Nearly everywhere had sulfate concentration that was below the highest allowable allowed range, making it safe for human consumption.

Phosphate(PO_4^{3-})

The water samples taken from the collection locations had phosphate concentrations ranging from 1 mg/L to 8 mg/L. The average phosphate value found in Jind district is 2.6 mg/L with a standard deviation of 1.7, falling within the WHO's recommended range (maximum allowable level of 5 mg/L).

VI. CONCLUSION

The physio-chemical properties of the groundwater samples collected from seven blocks in District Jind, Haryana, India, vary, and these features impact the quality of the drinking water. A slightly alkaline tendency is shown by the pH of water samples taken in the vicinity; this tendency is usually below acceptable limits for drinking water quality. Certain locations had alkalinity and TDS measurements that were within the acceptable range, suggesting that the environment there was suitable for drinking and domestic use.Fluoride levels above WHO recommendations were discovered in many groundwater testing, suggesting a potential health concern. This indicates that treatment protocols could be necessary to reduce fluoride contamination in affected areas. All things considered, Jind Block's groundwater is deemed suitable for residential use and drinking. To prevent pollution and ensure the safety of drinking water, areas with elevated levels of fluoride, chloride, and hardness may need to be treated. The groundwater tests showed no signs of contamination from pesticides, fertilizers, animal feces, or sediments. It is crucial to refrain from disposing of household and animal waste close to water sources in order to safeguard the purity of the water. Reduce the amount of fertilizers and pesticides used in agriculture and stick to standard-quality products to lessen the pollution of groundwater. By forming ethical behaviors and reducing their exposure to pollution, each individual may contribute to the preservation and conservation of water resources. In conclusion, while the overall district groundwater often satisfies drinking water needs, some areas need special attention because of elevated concentrations of certain contaminants, such fluoride. For the benefit of the local population, prolonged water quality maintenance will need appropriate mitigating measures and ongoing monitoring.

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