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Impact of Ghaggar river on the Physicochemical parameters of underground water of Sirsa, Haryana, India

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Abstract

The Ghaggar is the main river of Sirsa district. The agriculture of Sirsa district mainly depends up on water supply of Ghaggar river. Water quality parameters of groundwater of Sirsa district needs to be constantly observed. We have analysed 16 water quality parameter of underground H_2O of two villages of Sirsa district that is Khairenkan and Nejadela Kalan (Duration: June 20 – May 21). The 16 parameters like TDS, pH, alkalinity, conductivity, heavy metals, turbidity, COD, BOD, nitrates, hardness, sulfates, phosphates, metals like Fe, Cr, Pb, Na, K, Cu, etc. were analysed by using a conductivity meter, AAS, Flame photometer, pH meter, turbidity meter, and UV-visible spectrophotometer. The underground Water Quality Index (WQI) was observed for one year emphasizing on the determination of mean of chemical, biological, and physical parameters. The WQI of the socioeconomic, and geographical important region was monitored. The different physico-chemical parameters were compared with WHO standards.

Keywords: Physicochemical parameters, Alkalinity, hardness, Khairenkan, Water quality index

Introduction

Two third of our earth's surface is covered with water. Despite that pure and safe drinking water available is only 1%. Most of the water resent in sea and glacier is not suitable for drinking and other irrigation purposes. Further, groundwater level at some places is gone so deep that it is not available easily. Even if water at some places present at a suitable height is not fit for drinking purposes. Drinking water quality can be judged by different physico-chemical parameters like TDS, conductivity, turbidity, pH, heavy metals, alkalinity, COD, hardness, BOD, etc[1-5]. WHO has fixed a certain acceptable range of different physico-chemical parameters of drinking water. A tremendous increase in population, urbanization, industry, and agricultural water requirement, leads to very serious safe and pure drinking water problems among us. Water is very essential for both plants as well as a human being. No one can even think of life without water. Water is very essential in shaping human, land, and climate life. During the past few years, there is a huge demand for a large amount of freshwater due to the burst in population and increase in industrial activities due to growth in industrial civilization[6].

The quality of water has a very large impact on agriculture and human being. It is very essential to know the quality of water to be supplied for drinking and irrigation purposes[7-9]. There is an urgent requirement for the proper identification of pure and safe drinking water in different parts of the earth's crust. Few heavy metals, beyond their acceptable range, enter our food chain may lead to serious disorders[10-12]. The Sirsa district of Haryana touches the boundary of two states that is Rajasthan and Punjab and hence the influence of the three states. Sirsa district of Haryana has geographical, historical, political (SC reserved constituency), religious, and sociocultural importance making a different district in Haryana state. The underground water of Sirsa district is mainly dependent on rain, and the Ghaggar river (popularly called as Barssatti river). The chemical substance present in underground water like trace elements, heavy metals, detergents, pesticides, petroleum products, acidic and basic impurity, etc. affects the quality of water[13]. Similarly, physical parameters like temperature, pH, turbidity, etc. also affect the quality of water. Similarly, the presence of biological parameters like bacteria, viruses, spores, pigments, phytoplankton, BOD, COD, dissolved oxygen, etc. also affects the quality of the underground water[14]. The huge demand for underground water for drinking, agriculture, industrial, purposes, improper sewerage facilities, and improper water management facility leads to change in the physical, biological, and chemical composition of underground water[15]. The link between population, climate, and ecology must be understood to have a balance between the three so that our ecosystem and biodiversity should not be disturbed.

Physiochemical parameters are very essential parameters used to find the quality and characteristics of ground water. Physiochemical parameters provide valuable information about the chemical and physical properties of water, and hence help to determine suitability of ground water for different purposes such as irrigation, drinking, and industrial use. A few important physiochemical parameters of ground water are listed as: i. *pH*: pH is a measure of the acidity of water on a scale from 0 to 14. It indicates the concentration of H ions present in the water. pH values less than 7 indicates acidity, while greater than 7 indicates alkalinity. The ideal pH range for most purposes is generally between 6.5 and 8.5, ii. *Electrical Conductivity (EC)*: EC measures the waters ability to conduct an electrical current, which is influenced by the concentration of dissolved ions in the water. Higher EC generally indicates a high concentration of dissolved salts. EC is often used as an indicator of water salinity and can influence its usability for irrigation, iii. *Total Dissolved Solids (TDS)*: TDS represents the total concentration of dissolved substances in water, including minerals, salts, organic and inorganic compounds. TDS is typically measured in ppm. High TDS levels can affect the taste of water and may indicates the presence of contaminants, iv. *Dissolved Oxygen (DO)*: DO refers to the amount of O_2 in water, which is crucial for aquatic life. It can vary depending on temperature, pressure, and the presence of organic matter, v. *Turbidity:* It measures the cloudiness of water caused by suspended particles. High turbidity is an indication of sediment runoff, organic matter, or other pollutants. Turbid water can interfere with light penetration, affect aquatic life, and make water treatment processes more challenging, vi. *Temperature:* Temperature of water plays an important role in determining the health and viability of aquatic ecosystems. It affects dissolved O_2 levels, metabolic rates of aquatic organisms, and the solubility of various substances. Viii. *Chemical Composition:* The chemical composition of ground water includes various parameters such as concentrations of dissolved O_2, nitrogen compounds, PO_4, heavy metals, pesticides, and other contaminants.

These parameters help identify potential sources of pollution and assess the overall water quality. Regular monitoring of these physiochemical parameters of ground water is necessary to ensure the safety and usability of ground water. Different government and non-government agencies like public health, environmental organizations, and water management authorities depends on these parameters to make informative decisions regarding water treatment, resource allocation, and pollution control measures.

In the present study, we have investigated the effects of human activities and influence of Ghaggar water on the quality of ground water of two villages of district Sirsa, Haryana. We have estimated 16 different physico-chemical parameters like conductivity, pH, alkalinity, TDS, heavy metals, BOD, turbidity, hardness, nitrates, phosphates, sulfates, COD, elements like Pb, Na, Cu, Cr, K, Fe, etc. of underground water of two villages of Sirsa district (Haryana) i.e., Khairenkan, Nejadela Kalan and compared the data with WHO standard parameters. Our research is directly related to the benefit of the society so that people of that area become aware of the ground water quality of that area so that they can plan their agricultural production accordingly.

Materials and Methods

100ml of underground water was collected in PVC sample bottles from two villages of Sirsa district i.e., Khairenkan, and Nejadela Kalan from the tube well source. The first fraction of water was discarded. Then water was collected in a 25mL capacity plastic bucket. Water was allowed to stand for some time. Then 100mL of water was collected in a sample bottle at 10cm below the water level. The precaution was kept in mind that water gets disturbed at a minimum level so that amount of dissolved oxygen must not change while sampling the underground water.

Total Hardness: Procedure: In a 20mL sample of ground water, a 5mL buffer solution (NH_4Cl and NH_4OH) was added followed by a few drops of Eriochrome Black-T (EBT) indicator. The blue color appeared in the buffered solution at pH 10. It turns red, on complexation with calcium, magnesium, orothermetalions. After adding EBT, the wine-red color appears. 10mL of this solution was titrated with 0.1M Ethylenediamine tetraaceticacid (EDTA) till the endpoint (appearance of blue color). Titrations were repeated three times[16-19].

Permanent Hardness: Selected 100mL ground water from two villages of Sirsa district. Now, heated the given sample until it becomes half in volume. The sample was filtered with ordinary filter paper. Added 50mL of distilled water. To 20 mL of this solution, 5mL buffer solution (NH4Cl + NH4OH) with Eriochrome Black-T (EBT) as indicator was added. Then it was titratedwith0.1MEDTAtilltheendpointappearance of blue color[12,21].

Temporary Hardness:= Total Hardness–Permanent Hardness.

p-alkalinity: In 20 ml of ground water, 2-3 drops of phenolphthalein indicator were added. Then, it was volumetrically run with 0.1N hydrochloric acid solution. After titration, the colour changes from light pink to colorless due to the acidic medium of HCl[22].

m-alkalinity: In 20mL of underground water, 2-3 drops of indicator (methyl orange) was added. Then it was volumetrically titrated with 0.1N HCl solution. At the endpoint, the colour changes from yellow to red[23].
Total Alkalinity = p-Alkalinity+ m-Alkalinity.

Dissolved Oxygen: Chemicals used: Manganese Sulphate ($MnSO_4$), Alkali Iodide Azide, Sulphuric Acid, Starch, $Na_2S_2O_3$.xH2O.

Procedure: In a100mL underground water sample, 0.68g of $MnSO_4$ was added followed by 2mL of alkali iodide azide. Then 2mL H_2SO_4 of dilute sulphuric acid was added. The resultant solution was titrated with sodium thio-sulphate till the appearance of pale yellow colour. 2ml of starch solution was added. The solution becomes blue. Now titrated continuously till the blue colourdisappears[24-26].

Test for COD (Chemical Oxygen demand): Preparation: 3.5g of $FeSO_4.7H_2O$ and 7.5g of $C_{12}H_8N_2.H_2O$ were added to 400ml of water (double distilled). Mixed properly and the total volume was made to 500ml by adding distilled water.

Procedure (COD): 10ml of underground water sample was taken in a RB flask. Few glass beads were added. 1ml of Hg_2SO_4 solution was added. Add 5ml of potassium dichromate solution. 15mL silver sulfate and dilute sulphuric acid solution was added very slowly and carefully. It was then refluxed for 2h. After digestion, the condenser was rinsed with 25mL of water. 2-3 drops of Ferro in indicator was added and then titrated with 0.025M ammonium ferrous sulfate till the equivalence point[27].

BOD: (Biochemical Oxygen Demand): Material used: Alkaline iodide-azide solution, Manganese sulfate, Sulphuric acid, Starch solution 0.025N sodium thiosulphate.

Procedure: In 100 ml of the underground water sample, 2mL of manganese sulfate was added to the BOD bottle carefully by inserting the pipette just below the surface water. 2ml of alkali-iodide-azide reagent was added in the same manner. "Close the bottle and mix the sample by inverting it many times. A brownish cloud will appear in the solution as an indicator of the presence of dissolved oxygen. Allow the brown precipitate to settle. Add 2mL of sulphuric acid carefully without forming air bubbles. Close to the bottle and mix the solution well to dissolve the precipitate. Keep the bottle in a BOD incubator for 5 days of incubation. After incubation, titrate 50mL of sample water with 0.025N sodium thiosulphate to a pale yellow color. Then add 2mL of starch solution. So, the samples turn in blue. Continue the titration till the sample gets clear and note down the reading. The concentration of dissolved oxygen in the sample is equivalent to the number of milliliters of titrant used[28].

Results and Discussion

Water is very essential for sustaining life on the earth. Water used for drinking and irrigation purposes should be clean, pure, and should be free from impurities. But due to a large number of industrial and other developmental activities water available for drinking and agricultural purposes is being polluted constantly. There are different sources of water like rainwater, river water, pond water, groundwater, seawater, etc. The quality of water (Physical, Chemical, and biological) varies a lot depending upon the source of water. Seawater is not fit for drinking and agriculture purposes due to a large number of dissolved salts (3% NaCl) makes it unfit for use. The quality of groundwater also varies a lot from place to place. The quantity of groundwater is also decreasing day by day. The groundwater level is also going down day by day and in some places in Haryana state, groundwater is available at 500 feet. It is very essential to know the effects of the addition of pesticides in the fields on the groundwater quality, heavy metal contents in groundwater, and effects of industrial influents on the quality of underground water in Sirsa district.

Parameters like temperature, pH, electrical conductivity, total dissolved solids, Ca, Mg, K, Na, CO_3, HCO_3, chloride, SO_4, NO_3, total hardness as $CaCO_3$, Fluoride, Fe, Pb, Cd, Cr, heavy metal ions, alkalinity, biochemical oxygen demand, chemical oxygen demand, etc. needs to be estimated in the rural region of Sirsa (Haryana). The WQI was calculated by the use of Equation (1)[29-31]

$$WQI = \sum_{i=1}^{p} W_i L_i \quad (1)$$

Where: WQI is water quality analysis, W_i is the statistical weight and L_i is the water quality parameter observed for different underground water samples[32].

The underground water quality rating was calculated by the use of Equation (2):[33]

$$q_r = \left\{\left[\frac{V_{actual} - V_{ideal}}{V_{standard} - V_{ideal}}\right] \times 100\right\} \quad (2)$$

The ideal value of dissolved oxygen and pH were taken to be 14.6 and 7, respectively. The standard value of parameters was taken as suggested by WHO.

The overall water quality parameters index was calculated by the use of Equation (3):[34]

$$OWQI = \sum \frac{q_i\, w_i}{W_i} \quad (3)$$

Here, OWQI stands for the overall water quality index.
Table-1 shows standard values of the water quality index as prescribed by the Central Pollution control board.

Table-1: Standard values of Water Quality Index (WQI) and Water Quality Rating (WQR) as prescribed by Central Pollution Control Board (CPCB).

WQI	Water Quality Rating	Grading
0-25	Excellent	A
26-50	Good	B
51-75	Poor	C
76-100	Very poor	D
100 Onwards	Not suitable	E

Table-2 shows Flame Photometric and UV-VIS spectrophotometric evidence of underground water of two villages of Sirsa district. Sodium metal concentration was found higher in underground water of Khairenkan village as compared to Nejadela Kalan. According to the WHO, "the maximum permissible limit of Sodium in underground water is 200mg/L".

The potassium metal was found higher in Nejadela Kalan compared to Khairenkan village The WHO requirement of maximum Potassium content in underground water is 50mg/L. The optical density of nitrate was found higher in Nejadela Kalan village as compared to Khairenkan. The optical density of phosphate was found higher in Khairenkan village as compared to Nejadelan Kalan. The optical density of sulfate was found higher in Khairenkan village. The WHO requirement of Nitrates in underground water is 2.5µg/L. Similarly, the WHO requirements of Phosphate are 0.5µg/L. The WHO requirements are sulphate is 1.1µg/L[35].

Table-2: Flame Photometric and UV-Vis. spectrophotometric evidence of underground water of two villages of Sirsa district.

Water Sample	Na (ppm)	K (ppm)	Nitrate (at 220.0 nm)	Phosphate (at 690.0 nm)	Sulphate (at 420.0 nm)
Khairenkan	75.5	1.43	0.5689	0.3187	1.7449
Nejadela Kalan	35.7	2.5	2.805	0.2883	0.6759

Table-3 shows the average value of Physico-chemical parameters (pH, conductivity, TDS, and Turbidity) of two villages underground water samples of Sirsa district. The average pH was found maximum in Nejadela Kalan (8.01) as compared to Khairenkan. The WHO requirements of underground water pH range is 6.5-8.5. The order of conductivity was almost similar with somewhat higher in Nejadela Kalan (293.4µS/m). The WHO requirements of maximum permissible limit of conductivity are 250S/cm. The average TDS was found to be higher in Nejadela Kalan village i.e., 230.3 ppm as compared to Khairenkan village. The WHO recommended level of TDS in underground water is 300mg/L for good and 300-600mg/l is fare and 600-900 mg is poor. The average turbidity was found higher in Nejadela Kalan (43.2NTU) as compared to Khairenkan village. The WHO requirement of turbidity in underground water is 4-5 NTU[36,37].

Table-3: Physio-chemical average properties (pH, conductivity, TDS, and Turbidity) of water samples of two villages of Sirsa district.

Underground Water Sample	pH	Conductivity (mS)	TDS (ppm)	Turbidity (NTU)
Khairenkan	7.41	213.4	195.7	31.6
Nejadela Kalan	8.01	293.4	230.3	43.2

Table-4 shows atomic absorbance spectroscopy (AAS) analysis of underground water samples of two villages of Sirsa district. The elemental iron was found to be higher in Nejadela Kalan i.e., 0.201. The element copper and chromium were not detected in the underground water of the villages under study. The element lead was found similar in Nejadela Kalan and Khairenkan villages i.e., 0.594 ppm.

Table-4: Atomic absorbance spectroscopic (AAS) analysis of water samples of two villages of Sirsa district.

Underground Water Sample	Iron (Fe)	Copper (Cu)	Chromium (Cr)	Lead (Pb)
Khairenkan	0.159	ND	Not Detected	0.594
Nejadela Kalan	0.201	ND	Not Detected	0.594

Table-5 shows volumetric titration analysis (Hardness) of different underground water samples of the Sirsa district. The total hardness was found higher in Khairenkan village (250 ppm) as compared to Nejadela Kalan village (215 ppm) of Sirsa district. The permanent hardness was also found higher in the underground water of Khairenkan village. The WHO requirements for the recommended hardness of underground water are 200-600mg/L.

Table-5: Volumetric titration analysis (Hardness) of different underground water samples of two villages of Sirsa district

Water Sample	Hardness ($CaCO_3$ equivalence)		
	Total	Permanent	Temporary
Khairenkan	250	250	0
Nejadela Kalan	215	150	65

Table-6 shows volumetric titration analysis (Alkalinity) of different underground water samples of the Sirsa district. The total alkalinity was found to higher in Nejadela Kalan village i.e., 15mEq/L, as compared to Khairenkan village (12mEq/L). The WHO requirements of alkalinity in the underground water sample are 200-600mg/L.

Table-6: Volumetric titration analysis (Alkalinity) of different underground water samples of two villages of Sirsa district.

Water Sample	Alkalinity (mEq/L)		
	p-alkalinity	m-alkalinity	Total
Khairenkan	0	12	12
Nejadela Kalan	0	15	15

Table-7 shows volumetric titration analysis (dissolved oxygen) of different underground water samples of the Sirsa district. The dissolved O_2 (mL) was found higher in Khairenkan village (0.1 ml) as compared to Nejadela Kalan village (0.2 mL). The WHO requirements of recommended dissolved oxygen in the underground water sample are 2-5mg/L. Table-8 shows seasonal variation in physiochemical parameters, standard deviation, and Water Quality Index (WQI) of Khairenkan village of Sirsa district. The pH was found maximum in August 2021 and minimum in May 2021. The temperature of underground water was found maximum in June 2020 (25^0C) and minimum in February 2021. The hardness was found maximum in August 2020 i.e., 307ppm. The TDS was found maximum in Dec. 2020 i.e., 238ppm. Table-9 seasonal variation in physiochemical parameters, standard deviation, and underground Water Quality Index of Nejadela Kalan village of Sirsa district. The pH was found maximum in May 2021 (8.6) and minimum in Feb. 2021 (7.7). The hardness was found to be maximum in August 2020 (236ppm). The TDS was found maximum in Dec. 2020 i.e., 238 ppm.

Table-7: Volumetric titration analysis (Dissolved Oxygen) of underground water samples of two villages of Sirsa district.

Water Sample	Dissolved O_2 (ml)
Khairenkan	0.1
Nejadela Kalan	0.2

Figure-1 shows the average physicochemical data of ground water of Khairenkan village of Sirsa district. The magnitude of hardness was maximum followed by the TDS parameter. The magnitude of dissolved oxygen was found to be the minimum of all the seven investigated physicochemical parameters of Khairenkan village.

Figure-2 shows the average physicochemical data of ground water of Nejadela Kalan village of Sirsa. The magnitude of TDS was maximum followed by the hardness parameter. The magnitude of dissolved oxygen was found to be the minimum of all the seven investigated physicochemical parameters of Nejadela Kalan village.

From Table-1 to 9 and Figure-1 and 2, it is concluded that the hardness level of Khairenkan village was higher and TDS of Nejadela Kalan village of Sirsa district was higher. Hence, the underground water of Khairenkan and Nejadela Kalan villages of Sirsa district is suitable for both drinking and agricultural purposes. The turbidity of Nejadela Kalan village was higher than Khairenkan village. The nitrates, Fe and K content were higher in the underground water of Nejadela Kalan village and hence are more suitable for agriculture purposes. Hence, based on physicochemical data of ground water of two villages of Sirsa (Haryana), the underground water of Khairenkan and Nejadela Kalan villages are suitable both for drinking as well as agricultural purposes and the Ghaggar river has very little effect on the quality of underground water of two villages Sirsa district.

Conclusions

Physicochemical parameters and trace elements of underground water of two villages of Sirsa (Haryana) were estimated by using different titrimetric and instrumental techniques. The 16 physicochemical data like conductivity, pH, alkalinity, TDS, turbidity, heavy metals, COD, BOD, nitrates, hardness, phosphates, sulfates, elements like Cr, Pb, Fe, Na, K, Cu, etc. were analysed. The WQI and Water Quality Rating were estimated for the underground water samples of two villages of Sirsa district. The hardness of Khairenkan and TDS of Nejadela Kalan was found to be maximum. Hence, the underground water of Khairenkan and Nejadela Kalan were suitable for drinking and agricultural purposes as compared to WHO standards. The turbidity of Nejadela Kalan was higher than Khairenkan village. The nitrates, Fe and K content were higher in the underground water of Nejadela Kalan village and hence is more suitable for agriculture purposes. Hence, based on physicochemical investigation of ground water of two villages of Sirsa, the underground water of Khairenkan and Nejadela Kalan villages are suitable both for drinking as well as agricultural purposes and the Ghaggar river has very little effect on the quality of underground water of two villages Sirsa district.

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Table-8: Seasonal variation in eight physico-chemical parameters, Water Quality Index (WQI) and standard deviation (SD) of Khairenkan village of Sirsa district.

Parameter	June 2020	Aug. 2020	Oct. 2020	Dec. 2020	Feb. 2021	April 2021	May 2021	Average	Standard deviation	WQI
pH	8.0	8.1	7.7	7.3	7.4	7.5	7.1	7.58	0.07	12
Temp.	25	21	18	16	14	17	21	18.85	1.7	1.4
Dissolved O_2	0.7	0.8	1.0	1.1	0.9	0.6	0.6	0.81	0.1	21
Alkalinity	15	11	10	14	17	8	9	12.0	1.4	0.2
Hardness	250	307	209	220	265	303	267	260.1	2.4	3.4
TDS	230	233	235	238	237	234	235	234.5	1.3	0.4
Turbidity	11	13	15	17	18	16	14	14.8	1.2	0.3

Table-9: Seasonal variation in eight physicochemical parameters, standard deviation (SD), and underground Water Quality Index (WQI) of Nejadela Kalan village of Sirsa district.

Parameter	June 2020	Aug. 2020	Oct. 2020	Dec. 2020	Feb. 2021	April 2021	May 2021	Average	Standard deviation	WQI
pH	8.4	8.3	8.1	7.8	7.7	8.5	8.6	9.4	0.06	14
Temp.	23	20	18	15	13	16	20	17.85	1.4	1.1
Dissolved O_2	0.11	0.13	0.14	0.17	0.19	0.15	0.17	0.14	0.8	23
Alkalinity	15	11	15	14	17	15	14	16.8	1.1	0.3
Hardness	215	236	229	208	205	213	207	216	2.7	3.1
TDS	230	228	235	238	237	234	235	233.8	1.6	0.2
Turbidity	40	51	42	43	48	47	39	44.2	1.6	1.5

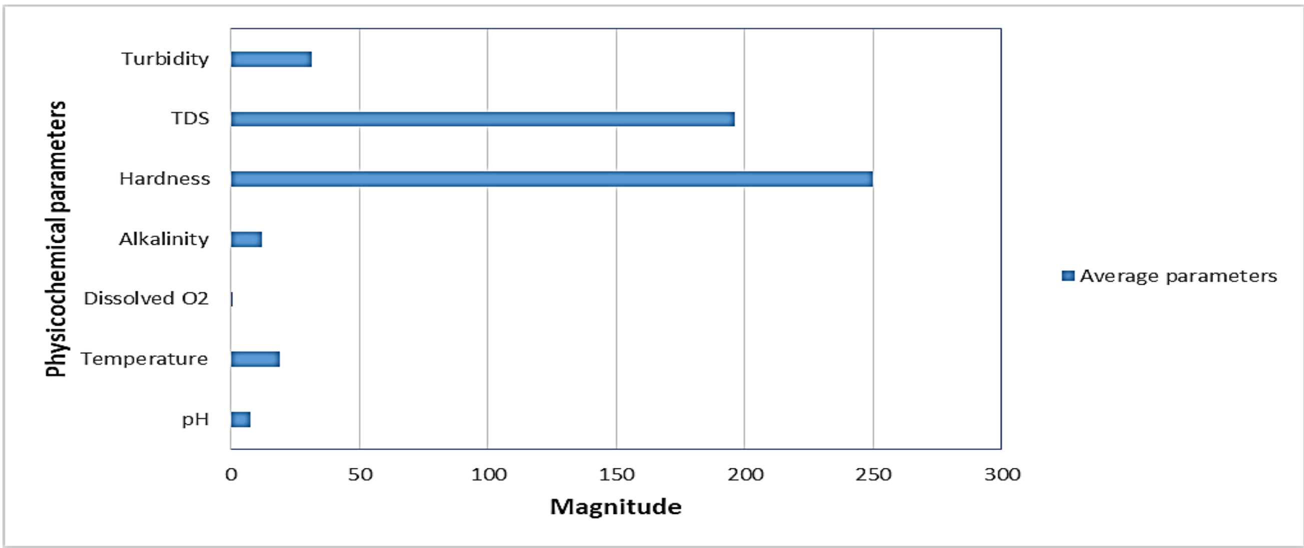

Figure-1: Average Physico-chemical parameters of underground water of Khairenkan village of Sirsa district.

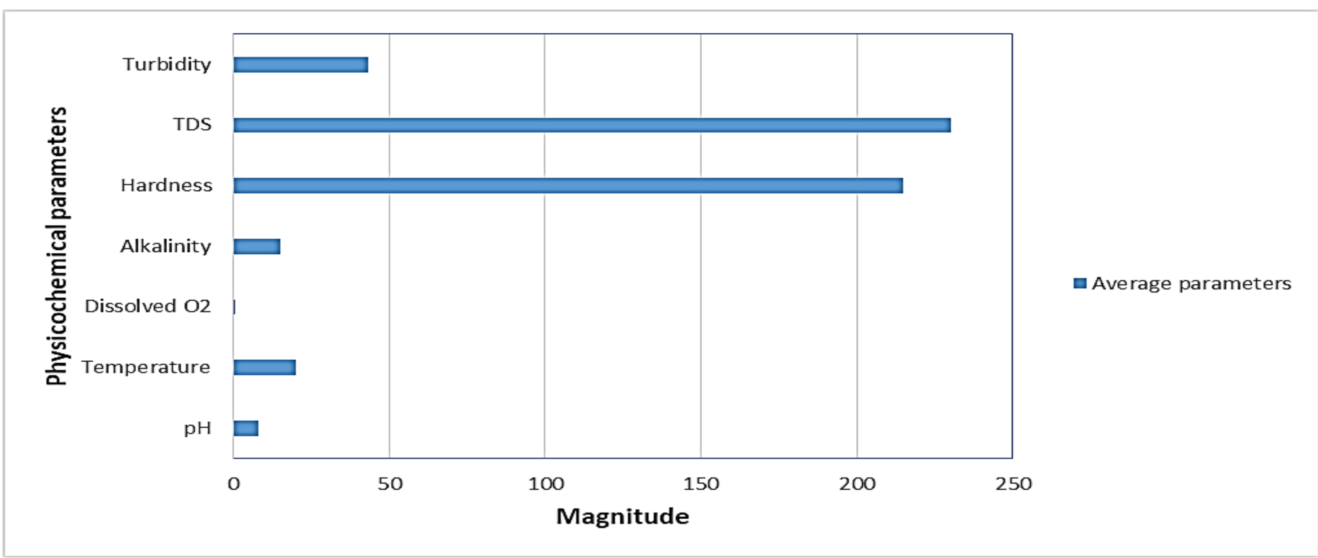

Figure-2: Average Physico-chemical parameters of underground water of Nejadela Kalan village of Sirsa district.

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