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Comparative study of physicochemical parameters of groundwater and surface water of rawatsar, Hanumangarh (Rajasthan)

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Abstract

A study on the comparison of surface water and groundwater quality in Rawatsar Tehsil of Hanumangarh district (Rajasthan) was carried out. Different sites were selected for analysis of groundwater and surface water. Physicochemical parameters of water such as pH, EC, TDS, Turbidity, Alkalinity, Chloride, DO, COD, Na and K were analyzed using standard methods for all the samples. It was found that pH and EC were within the BIS permissible limit. All water samples have chloride content more than BIS standard values, showing the dominance of chloride ions in the study area. From the present study, surface water and groundwater samples have higher turbidity and high content of total dissolved solids, alkalinity, chloride, sodium and potassium. Groundwater dominates chloride, carbonate, sodium and potassium ions. Hence, surface water and groundwater need to be treated before end-use. This preliminary study needs to be researched further for a better understanding of hydrogeochemistry of groundwater and chemistry of surface water in Rawatsar.

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Introduction

Water is the basis of human existence. It is getting contaminated day by day due to anthropogenic activities such as overexploitation of water resources, discharge of chemicals and other wastes, etc. It has become a concerned issue to tackle water contamination. In place of the same, water analysis is essential to check whether the water quality is following standards prescribed by the competent authority. Several studies have been done on analysis of water quality including surface water and groundwater (Choudhary et al. 2007; Gandhi & Namboodiri 2009; Singh et al. 2009; Mahananda et al. 2010; Sharma 2011; Singh et al. 2013; Asare-Donkor et al. 2016; Kumar et al. 2016; Midha et al. 2016; Lawrence 2017; Tiwari et al. 2017; Toure et al. 2017; Olasoji et al. 2019; Jha et al. 2020; Verma et al. 2020). Indiscriminate exploitation of ground water for agricultural and industrial

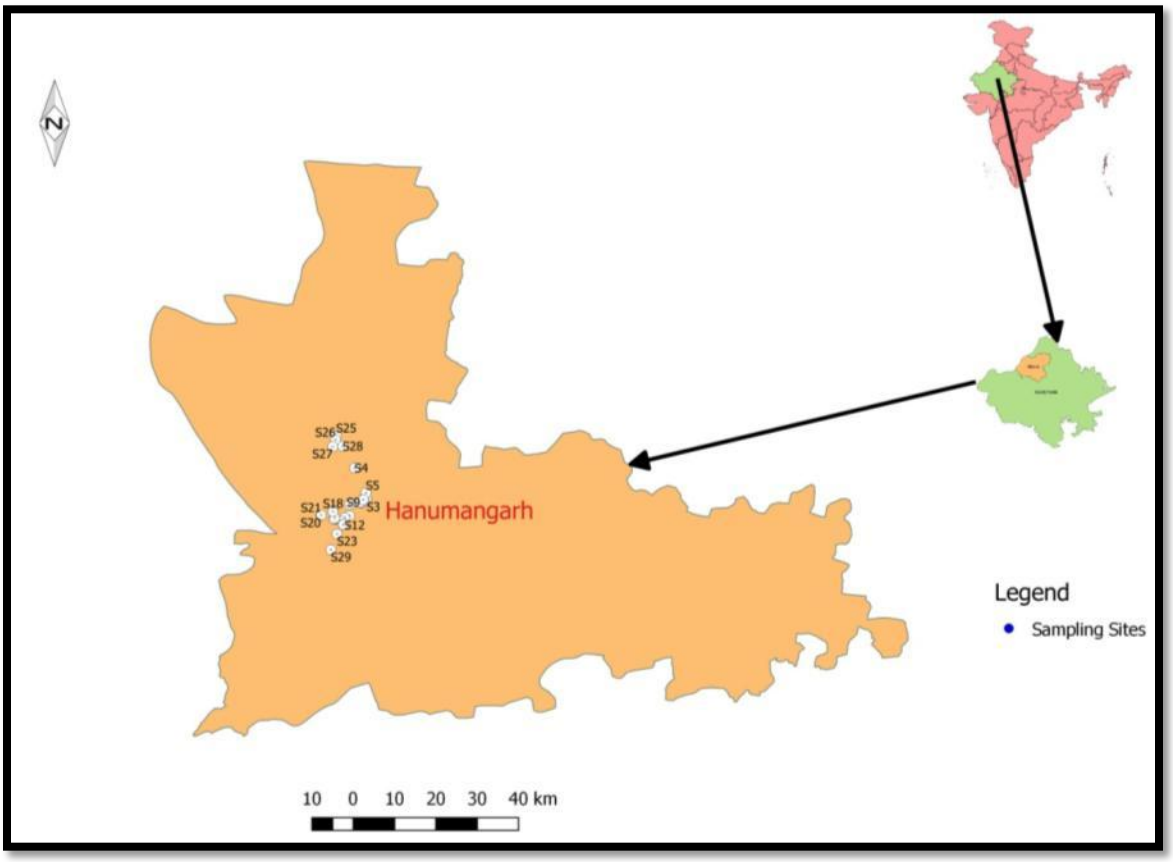
purpose is affecting the quality and quantity of ground water. Ground water quality is getting poor due to excessive dose of iron, manganese, chloride, sulphates, total dissolved solids, hardness, alkalinity or acidity (Sankar et al. 2014). The present study was done in Rawatsar Tehsil of Hanumangarh district (Rajasthan) with the aim of a comparative study of surface water and groundwater quality in the study area.

Materials and Methods

Study area: The study area is Rawatsar which is located between the latitudes 29°14' to 29°10' N and longitudes 73°48' to 74°20' E in Hanumangarh district of Rajasthan (Figure 1).

Figure 1: Map showing the sampling locations in Rawatsar, Hanumangarh.

Rawatsar falls under the western part of Hanumangarh. It is a municipality city divided into 25 wards. The total population of Rawatsar is 35,102 out of which 18,308 are male and 16,794 are females (Census of India 2011). The study area is irrigated by Rawatsar and Naurangdesar distributaries of Indira Gandhi Canal (IGNP) respectively. The climate of the area is hot and arid with extremes of temperature (average temperature 25.4°C), erratic and scanty rainfall (239 mm annual) and high evapotranspiration (Maurya 2017). Hanumangarh district is an undulating plain covered with a thick layer of wind-blown sand which forms the part of the Great



Indian Thar Desert. Northwestern parts of this district have broader plains and southeastern part of this district is comparatively more hilly area. The Ghaggar River is the only major river in the district which is locally known as Ghaggar Naala. Highest elevation of 239 m found in Rawatsar block. The sand dunes are generally 4 to 5 meters high except in the south western part of Hanumangarh where they are more intensely developed, being sometimes 10 to 15 meters in height (Hydrogeological atlas of Rajasthan Hanumangarh district 2013).

The entire Hanumangarh district is covered by Quaternary Alluvium overlain by thin veneer of wind-blown sand in the central part and by high dunes in the southern Part. In the northern part and in the Ghaggar flood plain, alluvium is without any blown sand cover. Quaternary alluvium is mostly fluvial in origin and consists of alternating sequence of sand, silt and clay. The thickness of alluvium varies from 100 m in the southern part to over 400 m in the northern part (Hanumangarh-central ground water board). The northern part of the district is covered by arid soils which are characterized by alluvial soils. These soils are loamy in character. Central part of the district is characterized by entisols, i.e., desert soils which are loamy along Ghaggar river course. Southern part of the district is characterized by arid soils i.e. non-calcic brown desert (Hanumangarh-central ground water board). Sample collection: Water sampling was carried out during February to March, 2018 at the selected sampling sites as shown in Table 1. A total of thirty water samples were collected for physico-chemical analyses. Samples included surface water (river, wastewater and pond) and ground water (well and hand pump). Water samples were collected in 1 litre polyethylene bottles. These bottles were previously washed with detergent, rinsed with tap water and then with distilled water and finally rinsed three times with the source water samples. The water samples were carefully labeled and stored in a refrigerator at a temperature between 0°C and 4°C.

Table 1. Selected sampling sites in Rawatsar (Hanumangarh)

Sample code	Latitude	Longitude	Location	Type of water
S1	29°15.8960'N	074°24.1146'	Daab	Waste water-SW
S2	29°15.8831'N	074°24.1298'	Bawdi shiv mandir	Tube well-GW
S3	29°15.7596'N	074°24.4247'	Mishtri market	Hand pump-GW
S4	29°19.6307'N	074°22.9428'	IGNP (Lakhuwali head)	SW
S5	29°16.5775'N	074°24.3382'	Near khetarpalji temple	Drinking water -SW
S6	29°15.5104'N	074°24.1753'	New dhanmandi	Hand pump-GW
S7	29°15.3451'N	074°23.7514'	Near bahra house	Waste water- SW
S8	29°15.3508'N	074°23.7659'	Near main highway	Sam water-SW
S9	29°15.3989'N	074°23.6398'	Near main highway	Hand pump-GW

S10	29°15.1515'N	074°22.3289'	Gorkhnathji temple	pond-SW
S11	29°13.7704'N	074°22.3289'	26 DWD	Tube well-GW
S12	29°13.4990'N	074°21.7075'	29 DWD	Water wax diggiI-SW
S13	29°13.0711'N	074°21.2690'	31 DWD	Tube well-GW
S14	29°13.3532'N	074°20.5067'	30 DWD	Tube well-GW
S15	29°13.3620'N	074°20.3605'	30 DWD	Hand pump-GW
S16	29°13.3605'N	074°20.3599'	30 DWD	Tube well-GW
S17	29°13.4898'N	074°20.5062'	30 DWD	Tube well-GW
S18	29°14.3626'N	074°20.2903'	16 KWD	Joda-SW
S19	29°14.2803'N	074°20.2748'	16 KWD	Tap water
S20	29°13.8058'N	074°18.7954'	Khodan	Sahwa lift canal-SW
S21	29°13.8429'N	074°18.8414'	Khodan	Hand pump-GW
S22	29°15.7292'N	074°23.9955'	Rawatsar	Tap water
S23	29°11.5275'N	074°20.7809'	Dhannasar	Tube well-GW
S24	29°12.6785'N	074°21.5509'	Param industry	tube well-GW
S25	29°23.6206'N	074°20.6733'	Mainawali	Hand pump-GW
S26	29°23.1066'N	074°20.6058'	Mainawali	Hand pump–GW
S27	29°22.2548'N	074°20.2495'	Mainawali	Rain water-Tap water
S28	29°22.2972'N	074°21.4785'	Mainawali	Hand pump–GW
S29	29°09.5754'N	074°20.0244'	Aapniyojna	Water supply diggi-SW
S30	29°12.6785'N	074°21.5509'	Param industry	Tap water

Physicochemical water analysis: Physicochemical parameters of water such as pH, EC, TDS, Turbidity, Alkalinity, Chloride, DO, COD, Na and K were analyzed for all the samples. All physicochemical water parameters were estimated by standard methods (Maiti, 2011). pH, electric conductivity (EC) and Total Dissolved Solids (TDS) were measured by using the water analyzer kit (Model Systronics 371). Turbidity was measured by Naphalometer. Alkalinity and chloride was measured by titration methods. Chloride was estimated by Mohr's Argentrometric method using phenolphthalein and methyl orange indicators. Dissolved Oxygen (DO) was measured by the Azide modification of Winkler Method while Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were estimated using incubation followed by titration and open reflux method respectively. However, sodium (Na) and potassium (K) were analyzed by flame photometer.

Results and Discussions

Physicochemical parameters of surface water and ground water in Rawatsar (Hanumangarh) were analyzed and obtained results are given in Table 2 to 4. Tables 5 to 7 represent the range of surface water, ground water and tap water of the study area

respectively. Table 8 shows the Bureau of Indian Standard for drinking water (BIS, 1991).

Table 2. Physicochemical surface water quality of Rawatsar village

S.N.	Sample Code	pH	EC	TDS	Turbidity	Alkalinity	Cl	DO	COD	Na	K
1	S1	6.2	11.9	6330	1.8	168	30,530	0.2	66	250	8
2	S4	6.9	0.37	259	0.3	238	71	6.4	27.6	3.5	0.3
3	S5	6.8	0.23	161	0.1	72	78.1	5.9	98	4	1
4	S7	6.8	2.2	1540	4.6	288	3053	0.1	163.2	255	8.5
5	S8	6.6	1.8	1260	3.5	358	2556	0	72	270	9
6	S10	7.0	0.37	259	0.7	40	2627	5.5	58	25	7.5
7	S12	7.09	0.27	189	0.7	66	2343	5.6	52	22	1
8	S18	6.6	0.54	378	2.8	204	1988	2.2	50	150	6
9	S20	6.4	0.31	217	4.6	150	191.7	6.2	28.6	1.35	0.3
10	S29	4.3	0.3	217	2.3	90	252	5.5	72	150	7.8

All parameters are in mg/l except pH, EC (µS/cm) and turbidity (NTU).

Table 3. Physicochemical ground water quality of the Rawatsar

S.No	Sample Code	pH	EC	TDS	Turbidity	Alkalinity	Cl	COD	Na	K
1	S2	7	5.8	4050	0	190	6816	24	5	0.2
2	S3	6.6	8.6	6020	2	162	10579	57.6	365	8.5
3	S6	6.3	9.4	6580	0	246	9585	113.2	295	7.5
4	S9	6.3	16.9	11830	4.2	180	24140	200	345	7
5	S11	7.4	1.3	910	0	286	2130	52	300	6
6	S13	7.1	9.8	6860	0	244	13277	92	250	8.5
7	S14	7.4	5.2	3640	0	344	6035	82	200	7
8	S15	7.8	2.4	1820	2.3	316	3053	80	211	9
9	S16	7.2	6.5	4550	0	550	6248	81	252	8.5
10	S17	6.9	2.3	1610	0.2	316	2840	83	199	8.3
11	S21	7.3	0.83	581	0.4	598	134.9	72	310	10
12	S23	7.6	6.2	4340	0.1	640	8875	79.6	275	7.5
13	S24	7.3	8.8	6160	0	560	10153	65	171	6.9
14	S25	7.1	3.8	2660	0	232	3905	75.1	310	9.5
15	S26	7.2	0.75	525	4.8	308	2627	80	315	7.9
16	S28	7.01	2.2	1540	0.7	300	2840	72	150	7.8

All parameters are in mg/l except pH, EC (µS/cm) and turbidity (NTU).

Table 4. Physicochemical Tap water quality of the Rawatsar

S. No.	Sample code	pH	EC	TDS	Turbidity	Alkalinity	Cl	COD	Na	K
1	S19	6.7	0.31	217	0	144	1917	30	5	0.45
2	S22	7.5	0.36	252	0.3	188	159.75	27.4	1.35	0.35
3	S27	6.93	0.31	217	0.2	114	127.8	28.3	1.35	1
4	S30	6.3	0.28	196	1.6	130	3408	28.5	2.5	1.5

All parameters are in mg/l except pH, EC (µS/cm) and turbidity (NTU).

Table 5. Physico-chemical parameters of surface water samples with their analyzed range in Rawatsar (Hanumangarh)

Parameters	Range	Minimum	Maximum
pH	4.3-7.09	S29 (Aapni yojna diggi)	S12 (29 DWD)
EC	0.23-11.9 µS/cm	S5 (Near khetarpalji temple)	S1 (Daab)
TDS	161-8330 mg/l	S5 (Near khetarpalji temple)	S1 (Daab)
Turbidity	0.1-4.6 NTU	S5 (Near khetarpalji temple)	S7 (Near bahra house)
Alkalinity	40-358 mg/l	S10 (Gorkhnathjimandir)	S8 (Sam water)
Cl	71-30,530 mg/l	S4 (IGNP CANAL)	S1 (Daab)
DO	0-6.4 mg/l	S8 (Sam water)	S4 (IGNP CANAL)
COD	27.6-163.2 mg/l	S4 (IGNP CANAL)	S7 (Near bahra house)
Na	1.35-270 mg/l	S20 (Sahwalift canal, khodan)	S8 (Sam water)
K	0.31-9 mg/l	S4 (IGNP CANAL)	S8 (Sam water)

Table 6. Physico-chemical parameters of ground water samples with their analyzed range in Rawatsar (Hanumangarh)

Parameter	Range	Minimum	Maximum
pH	6.3-7.8	S6 (New dhanmandi)	S15 (30 DWD)
EC	0.75-16.9 µS/cm	S26 (mainawali)	S9 (ward no 3)
TDS	525-11830 mg/l	S26 (mainawali)	S9 (ward no 3)
Turbidity	0-4.8NTU	S2, S6, S11, S13, S14,S16, S19, S24, S25	S26 (mainawali)
Alkalinity	162-640 mg/l	S3 (Mishtri market)	S23 (Dhannasar)
Cl	134.9-24140 mg/l	S21 (khodan)	S9 (ward no 3)
COD	24-200 mg/l	S2 (Bawdishivmandir)	S9 (ward no 3)
Na	5-365 mg/l	S2 (Bawdishivmandir)	S3 (Mishtri market)
K	0.2-10 mg/l	S2 (Bawdishivmandir)	S21 (khodan)

Table 7. Physico-chemical parameters of Tap water samples with their analyzed range in Rawatsar (Hanumangarh)

Parameter	Range	Minimum	Maximum
pH	6.3-7.5	S30 (POP industry)	S22 (Rawatsar)
EC	0.28-0.36µS/cm	S30 (POP industry)	S22 (Rawatsar)
TDS	196-252 mg/l	S30 (POP industry)	S22 (Rawatsar)
Turbidity	0-1.6 NTU	S19 (16 KWD)	S30 (POP industry)
Alkalinity	114-188 mg/l	S27 (mainawali)	S22 (Rawatsar)
Cl	127.8-3408 mg/l	S27 (mainawali)	S30 (POP industry)
COD	27.4-30 mg/l	S22 (Rawatsar)	S19 (16 KWD)
Na	1.35-5 mg/l	S22 (Rawatsar)	S19 (16 KWD)
K	0.35-1.5 mg/l	S22 (Rawatsar)	S30 (POP industry)

Table 8. Physico chemical standard parameters of drinking water by Bureau of Indian standard (BIS: IS 10500, 1991)

S. No.	Parameters	Permissible limit
1	pH	6.5-8.5
2	EC	50 µS/cm
3	TDS	500 mg/l
4	Turbidity	1 NTU
5	Alkalinity	200 mg/l
6	Chloride	250 mg/l
7	D.O.	4-8 mg/l
8	COD	300 mg/l
9	Na	180 mg/l
10	K	0.2 mg/l

pH: In the present study area, groundwater has the pH ranging from 6.3 (New dhan mandi) to 7.8 (30 DWD) which indicates that the water is slightly acidic to normal in nature. Surface water has the pH ranging from 4.3 (aapni yojna) to 7 (gorkhnath ji temple, mansrowar) which indicates that the water is acidic nature owing possibly due to hydrolysis of carbonates present in water. Most of the brackish waters on other hand show pH from 7.58 to 7.95 indicating normal to slightly alkaline character. Electrical Conductivity (EC): The conductivity of natural water is between 50 to 1500 µS/cm (Toure et al., 2017). In the study area the EC varies from as low as 0.23 µS/cm in the surface water of near Khetarpal ji temple (S4) to as high as 16.9 µS/cm in the hand pump water of near main highway, Rawatsar (S9). A big difference is observed between the conductivity values of surface water and ground water.

Total Dissolved Soilds (TDS): The total dissolved solids of surface water ranged from a minimum of 161 mg/l of near khetarpal ji temple, Rawatsar (S5) to a maximum of 8330 mg/l daab (S1), Rawatsar. Similarly the

variation of total dissolved solids of ground water ranged from a minimum of 525 mg/l of mainawali (S26) to a maximum of 11,830 mg/l of near main highway, Rawatsar (S9). The total dissolved solids of tap water 217 mg/l of 16 KWD (S19) and 252 mg/l of Rawatsar (S22). TDS of rain water is 217 mg/l of mainawali (S27). Eleven samples are below the standard value. Highest TDS value is 11,830 mg/l of near main highway, rawatsar (S9). Their minimum values were recorded in 161 mg/l (S5) for surface water. Our findings are corroborated with Mahananda et al. (2010). Hence, TDS of water are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles (Mahananda et al. 2010). Water with high dissolved solids may induce an unfavorable physiological reaction in the transient consumer and generally are of inferior palatability. The Indian Council of Medical Research (ICMR) has recommended 500 mg/l as acceptable and 1500 mg/l as maximum permissible limit of TDS (Maurya 2017).

Turbidity: Turbidity consists of suspended particles in the water and may be caused by a number of materials organic or inorganic. The standard maximum permissible limit for turbidity of tap water is 1 NTU. The samples studied for turbidity range between 0 NTU to 4.8 NTU. S1, S3, S7, S8, S9, S15, S18, S20, S26, S29 and S30 were found above the permissible limit and rest samples were below the permissible limit. The mean turbidity of the samples collected within the sampling period was all below the WHO for drinking water maximum permissible limit of 5 NTU. Hence, according to WHO, all samples are within permissible limit for turbidity. The occurrence of turbidity in surface water may be permanent or seasonal. Turbidity is an indication of the effectiveness of filtration and coagulation of water supplies.

Chloride: The presence of chlorides in natural waters can mainly be attributed to dissolution of salt deposits in the form of chloride ions (Cl^-). It is the major form of inorganic anions in water for aquatic life. The BIS has recommended 250 mg/l as acceptable limit of chloride. In the present study area, the lowest concentration of Cl^- is of 71 mg/l (IGNP CANAL-S4) and maximum concentration is 30,530 mg/l (daab, rawatsar-S1). Six samples (S4, S5, S20, S21, S22, S27) were found below the permissible limit and rest samples were above the permissible limit.

Alkalinity: Alkalinity indicates the levels of carbonate and hydroxyl groups in water although hydroxyl is uncommon in natural water. Alkalinity leads to corrosion and influences chemical and biochemical reactions in the water and also imparts bitter taste. The BIS standard for alkalinity is 200 mg/l for drinking water. In the present study area, the lowest value of alkalinity is 40 mg/l (Gorkhnath ji temple, rawatsar-S10) and maximum value is 640 mg/l (Dhannasar-S23). Thirteen samples (S1, S2, S3, S5, S9, S10, S12, S19, S20, S22, S27, S29 and S39) were found below the permissible limit and rest samples were above the permissible limit. Most of the water samples have higher alkalinity showing presence of carbonates ions in water samples.

Sodium and potassium: Sodium (Na) varied widely between 1.35 to 365 mg/l in fresh water in the study area. Na is a dominant cation and varies from 1.35 mg/l of the sahwa lift canal (SW-S20), rawatsar (tap water-S22), mainawali (rain water collection-S27) to 365 mg/l in mishtri market, rawatsar (S3). The major source of sodium and potassium is weathering of rocks besides the sewage and industrial effluents. Potassium (K) in natural water comes from potash feldspars, micas and feldspathoids and evaporates. K ranges between 0.20 mg/l (Bawdi shivmandir-S2) to 10 mg/l (khodan-S21) in the study area. The study shows that Na and K are the dominant cation in the region.

Dissolved Oxygen (DO): Dissolved oxygen is very important parameter of water quality and an index of physical and biological process occurring in water. When temperature increases gas solubility of water decrease and microbial activity increase; both these changes can reduce DO in water. WHO standard specifies minimum value under the DO test as 5 mg/l. The samples studied for dissolved oxygen range between 0 (S8-Sam water, Rawatsar) to 6.4 mg/l (S4-IGNP). Sample S8 is waste water and it showed nil dissolved oxygen.

COD: The chemical oxygen demand (COD) of the samples which gives the empirical values of the oxygen requirement for the oxidation of organic matter. The standard maximum permissible limit for COD water is 300 mg/l. The samples studied for COD range between 24 mg/l (bawdi shivmandir, rawatsar-S2) to 163.2 mg/l (near bahra house, rawatsar-S7). Ten samples (S4, S5, S10, S12, S19, S20, S22, S27, S29 and S30) were found below the permissible limit and rest samples were above the permissible limit.

Conclusion

From the present study, it was found that tap water is potable. However, chloride content in few tap water samples were above the permissible limit given by BIS. Surface water and ground water samples have higher turbidity and high content of total dissolved solids, alkalinity, chloride, sodium and potassium. Ground water have dominance of chloride, carbonate, sodium and potassium ions. Contamination of water resources need to be resolved by proper treatment. This is a preliminary study. So, further research is required to understand the hydrogeochemistry of ground water and chemistry of surface water in Rawatsar village.

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