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ORIGINAL ARTICLE

Physico-chemical study of Ground Water of SIDCUL-Rudrapur of Udham Singh Nagar district, Uttarakhand

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ABSTRACT

The water samples for the physico-chemical analysis were collected from the deep and shallow hand pumps of the 24 locations during post-monsoon and pre-monsoon periods of SIDCUL (State Industrial Development Corporation Uttarakhand Limited) near Rudrapur of Udham Singh Nagar district, Uttarakhand to analyzed for pH, EC, TDS, Turbidity, Temperature ,Ca, Mg, CO_3, HCO_3,Cl, Na, K, BOD, COD, NO_3 and Free CO_2,. The physico-chemical properties of the ground water sample were determined using standard methods of water quality analysis. The analysis was carried out in water quality laboratory of the Department of Irrigation & Drainage Engineering, College of Technology. Results showed that pH (6.05 to 6.62), EC (320 µS/cm to 832.5 µS/cm), TDS (220 mg/l to 520 mg/l),turbidity (0.12 NTU to 0.75 NTU), Total acidity (34.37 to 101.25), Total alkalinity (145 mg/l to 371.25 mg/l), Temperature (22.72 ℃ to 25.87 ℃), Free carbon dioxide (7.15 mg/l to 50.05 mg/l), Nitrate (0.6 mg/l to 0.97 mg/l) Calcium hardness (26.02 to 59.05 mg/l), Magnesium hardness (8.97 mg/l to 26.95 mg/l). Total hardness (40 mg/l to 86 mg/l). BOD (0.37 mg/l to 3.1 mg/l), COD (4 mg/l to 35.67 mg/l),Carbonate for all samples was calculated as 0 mg/l except for water sample near Amogh enterprise where it ranged from 0 to 48 mg/l with an average value of 18 mg/l and for water sample at a residence near transit camp, it ranged from 0 to 60 mg/l with an average value of 36 mg/l. Bicarbonate (280.68 mg/l to 906.1 mg/l), Chloride (0.11 mg/l to 91.31 mg/l), Sodium content (4.75 mg/l 18 mg/l), Potassium (3 mg/l to 24.25 mg/l) were significantly different across the different stations during post monsoon and pre monsoon.

Key Words: *Physico-chemical, Electrical conductivity, TDS, BOD, COD*

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INTRODUCTION

Groundwater is one of the most valuable natural resources, which supports human health, socio-economic development, and functioning of ecosystems [1]; [2]. Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. In India, where groundwater is used intensively for irrigation and industrial purposes, a variety of land and water-based human activities are causing pollution of this precious resource. Water pollution is the contamination of water bodies such as lakes, rivers, oceans, and groundwater [3]. It occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful constituents. Water pollution is a major problem in the global context 4]. Sometimes pollutants like plant nutrients, bacteria, viruses, pesticides, herbicides, hydrocarbons, heavy metals and other toxic chemicals can enter through the groundwater thereby polluting it. Shallow groundwater is often affected by the land use. The quality of groundwater has been affected through domestic, agricultural and industrial pollution. Nitrates is predominant in western of Delhi [5]. Groundwater in deeper aquifers beneath the layers of rock or clay that do not let water through has better protection from pollution because it is not directly connected to the surface environment. Contaminants that may be present in source water include: Microbial contaminants such as viruses and bacteria, from sewage treatment plants, septic systems, agricultural livestock operations and wildlife. Inorganic contaminants, such as salts and metals can be naturally occurring or come from urban storm-water runoff (streets and parking lots), industrial or domestic wastewater discharges, oil and gas production, mining or farming. Pesticides and herbicides from a variety of sources such as agriculture, urban storm-water runoff and residential uses. Organic chemical contaminants, including synthetic and volatile organic chemicals, are byproducts of industrial processes and petroleum production. They can also come from gas stations, urban storm-water runoff and septic

systems. Radioactive contaminants can be naturally occurring or can come from oil and gas production, mining activities or medical use.

The degradation of water quality has severe effects in context with drinking, agriculture and industrial purposes. Drinking impure water results in various harmful diseases like diarrhea, blue baby diseases if excess of nitrate is present in water. In industries if water has more hardness due to chlorides and sulphides it is not suitable for the cleaning purposes. In agriculture if water has more salt concentrations then it reduces permeability of soil and infiltration is reduced. More nitrate concentration is harmful for drinking but safe for irrigation purposes. Keeping these facts in view a study on physico-chemical properties of ground water and its suitability for drinking purpose was carried out in the industrial area of SIDCUL (State Industrial Development Corporation of Uttarakhand Limited) of Rudrapur.

MATERIAL AND METHODS

Study Area

The study area is located in SIDCUL (State Industrial Development Corporation Uttarakhand Limited) near Rudrapur of Udham Singh Nagar district. The geographical area of the district is 3055 Km^2. It is located between latitude 28˚59'22.27" to 29°02'12.82" N and laterally extends between longitudes 79˚23'16.05" to79°26'48.07"E. The climate varies from sub-tropical and sub-humid with three distinct seasons i.e. summer, monsoon (rainy season) and winter. The average annual rainfall is 1475 mm.

Sample Collection

The water samples for the physico-chemical analysis were collected during post monsoon (8th November 2014 and 22th November 2014) and pre monsoon period (14th march 2015 and 11th April 2015) from the deep and shallow hand pumps at the 24 locations (Table-1) of the study area. Samples were collected using plastic bottles and were kept in the incubator at a temperature of so that no or minimum changes occur in the physico-chemical properties of the water samples.

Physico-chemical analysis

The physic-chemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Bicarbonate (HCO_3), Carbonate (CO_3), Chloride (Cl^{-}), Turbidity and Nitrate (NO_3) were determined using standard methods. BIS standards of water quality parameters for drinking purpose were used to check the suitability of water for drinking.

RESULTS AND DISCUSSION

Results of physico-chemical parameters of the ground water samples of 24 locations located near SIDCUL Rudrapur region showed that

Suitability of Physico-chemical Properties of Water Samples for Drinking Purpose as per BIS

The values of physico-chemical characteristics of water samples are given in tables 2(a) 2(b) and 2(c).

pH

For all the samples analyzed, minimum pH was observed in water sample near Dineshpurturn whose value was 6.05 and maximum of 6.62 in water sample near Chattarpur turn (D.H.P). Water samples collected from I block near labor colony DHP, Prachin Van Shakti temple, near Amogh Enterprises, Transit Camp (residence), Chattarpur turn , Chattarpur village residence were found to be under the permissible limit i.e. 6.5-8.5 and were considered suitable for drinking purpose while all the other samples were unsuitable for drinking purpose.

Electrical conductivity

For all the samples analyzed, minimum EC was observed in water sample near transit camp whose value was 320 µS/cm and maximum value of 832.5 µS/cm in water sample near Shiv Shakti Dharma Kanta, Fulsunga.

Total dissolved solids

For all the samples analyzed, minimum TDS was observed in water sample near Amogh Enterprises whose value was 220 mg/l and maximum of 520 mg/l in water sample near Shiv Shakti Dharma Kanta, Fulsunga. All samples analyzed were within the desirable range of TDS while samples collected from Shiv Shakti Dharma Kanta, Fulsunga and Electromech Pvt. Ltd. were outside the desirable range but within permissible limit.

Turbidity

For all the samples analyzed, minimum turbidity was observed in water sample near K Block whose value was 0.12 NTU and maximum of 0.75 NTU in water sample near Dineshpur turn. As per BIS norms, desirable limit for turbidity is 5 NTU and permissible limit is 10 NTU. All the water samples analyzed were within the desirable limit for drinking purpose.

Total acidity

For all the samples analyzed, minimum total acidity was observed in water sample near HCL Chowk whose value was 34.37 and maximum of 101.25 in water sample near PrachinVanshakti temple Fulsunga road.

Total alkalinity

For all the samples analyzed, minimum total alkalinity was observed in water sample near Transit camp (residence) whose value was 145 mg/l and maximum of 371.25 mg/l in water sample near Matkota market and Dineshpur turn.

Temperature

For all the samples analyzed, minimum temperature was observed in water sample near Matkota market whose value was 22.72 °C and maximum of 25.87 °C in water sample near Dineshpur turn.

Free carbon dioxide

For all the samples analyzed, minimum free carbon dioxide was observed in water sample near transit camp (residence) whose value was 7.15 mg/l and maximum of 50.05 mg/l in water sample near police station Haldi.

Nitrate

For all the samples analyzed, minimum nitrate content was observed in water sample near Block near labor colony whose value was 0.6 mg/l and maximum of 0.97 mg/l in water sample near Chattarpur village and Fulsunga camp.

Calcium hardness

For all the samples analyzed, minimum calcium hardness was observed in water sample near transit camp residence whose value was 26.02 mg/l and maximum of 59.05 mg/l in water sample Fulsunga road near Shiv Shakti Dharma Kanta, Fulsunga.

Magnesium hardness

For all the samples analyzed, minimum magnesium hardness was observed in water sample near HCL Chowk and Matkota temple whose value was 8.97 mg/l and maximum of 26.95 mg/l in water sample near Shiv Shakti Dharma Kanta, Fulsunga road.

Total hardness

For all the samples analyzed, minimum total hardness was observed in water sample near Transit camp (residence) whose value was 40 mg/l and maximum of 86 mg/l in water sample near Shiv Shakti Dharma Kanta, Fulsunga. As per BIS norms, desirable limit is 300 mg/l and permissible limit is 600 mg/l. All the water samples analyzed were within the desirable range for total hardness.

Bio-chemical oxygen demand

For all the samples analyzed, minimum BOD was observed in water sample near Dineshpur turn whose value was 0.37 mg/l and maximum of 3.1 mg/l in water sample near Matkota temple.

Chemical oxygen demand

For all the samples analyzed, minimum COD was observed in water sample near I-Block whose value was 4 mg/l and maximum of 35.67 mg/l in water sample near plot no. 1, Ashok.

Carbonate

Concentration of carbonate for all samples was calculated as 0 mg/l except for water sample near Amogh enterprise where it ranged from 0 to 48 mg/l with an average value of 18 mg/l and for water sample at a residence near transit camp, it ranged from 0 to 60 mg/l with an average value of 36 mg/l.

Bi-carbonate

For all the samples analyzed, minimum bi-carbonate was observed in water sample near transit camp (residence) whose value was 280.68 mg/l and maximum of 906.1 mg/l in water sample near Matkota market and Dineshpur turn.

Chlorine

For all the samples analyzed, minimum Chloride was observed in water sample near Chattarpur village residencewhose value was 0.11 mg/l and maximum of 91.31 mg/l in water sample near Electromech Pvt. Ltd.Rudrapur . As per BIS norms, desirable limit is 250 mg/l and permissible limit is 1000 mg/l for Chloride and all the water samples analyzed were within the desirable range for chloride.

Sodium

For all the samples analyzed, minimum sodium content was observed in water sample near Chattarpur turn and Fulsunga camp whose value was 4.75 mg/l and maximum of 18 mg/l in water sample near K-Block near barrier.

Potassium

For all the samples analyzed, minimum potassium was observed in water sample near transit camp (residence) whose value was 3 mg/l and maximum of 24.25 mg/l in water sample near K-Block near barrier.

Table: 1 Location of ground water sampling sites

Sites	Location	Latitude	Longitude	Altitude above MSL
1.	Artesian well H-block	29°01'31.25"N	79°26'15.20"E	230m
2.	H-block (residence)	29°01'31.96"N	79°26'16.08"E	230m
3.	I-block near labor colony (residence)	29°00'46.36"N	79°26'09.99"E	227m
4.	I-block(D.H.P.)	29°00'45.66"N	79°26'11.13"E	226m
5.	K-block near barrier	28°59'51.10"N	79°26'39.57"E	223m
6.	PrachinVanshakti temple Fulsunga road	28°59'25.76"N	79°25'49.94"E	220m
7.	Fulsunga camp	28°59'24.09"N	79°26'26.83"E	220m
8.	Fulsunga road near Shiv Shakti Dharma Kanta	28°59'23.43"N	79°25'40.60"E	220m
9.	Fulsunga road near Amogh Enterprises	28°59'23.07"N	79°25'19.90"E	217m
10.	Transit camp	28°59'22.50"N	79°24'47.96"E	217m
11.	Transit camp residence (D.H.P.)	28°59'22.27"N	79°24'47.27"E	217m
12.	Sector-6 near Electromech Pvt. Ltd. Rudrapur	29°00'15.61"N	79°24'43.88"E	219m
13.	HCL Chowk	29°00'26.87"N	79°24'27.37"E	217m
14.	Matkota temple	29°00'29.21"N	79°24'01.08"E	223m
15.	Matkota market	29°00'36.18"N	79°24'00.65"E	226m
16.	Behind Ashok Leyland(plot no.1)	29°01'06.39"N	79°23'46.78"E	221m
17.	Behind Ashok (plot no.3)	29°00'52.78"N	79°23'36.81"E	220m
18.	Dineshpur turn	29°01'41.93"N	79°24'05.29"E	235m
19.	Chattarpur turn (D.H.P)	29°01'50.66"N	79°23'26.78"E	225m
20.	Chattarpur village(residence)	29°01'38.02"N	79°23'16.05"E	224m
21.	Chattarpur village(D.H.P)	29°01'38.26"N	79°23'17.57"E	225m
22.	Horticulture Research Centre	29°01'45.44"N	79°24'51.58"E	233m
23.	Anandibai temple	29°02'11.07"N	79°25'39.05"E	230m
24.	Police station Haldi	29°02'12.82"N	79°26'48.07"E	237m

Table 2(a) Average physico-chemical properties of ground water of nearby area

S. No.	Parameters	Permissible limit range for drinking water (BIS)	Artesian well H-block	H- block (residence)	I-block near labour colony (residence)	I-block near (D.H.P.)	K-block near barrier	Prachinvanshakti temple Fulsunaga road	Fulsunga camp	Fulsunga road(near Shiv Shakti Dharma Kanta)
1	Temperature	-	23.9	24	23.57	24.52	23.17	24	23.7	25.4
2.	pH	6.5-8.5	6.33	6.15	6.4	6.5	6.43	6.5	6.27	6.27
3.	EC	-	340	545	522.5	445	425	442.5	552.5	832.5
4.	TDS	300-600	232.5	278	310	262.5	252.5	260	330	**520**
5.	Turbidity	10-25	0.2	0.45	0.3	0.3	**0.12**	0.15	0.2	0.4
6.	Ca Content	75-200	18.03	20.04	20.64	20.04	14.63	15.03	19.64	**23.65**
7.	Ca hardness	-	45.04	50.04	51.59	50.04	36.53	37.53	49.04	**59.05**
8.	Total hardness	300-600	55	63	68	59.5	58	54.5	60.5	**86**
9.	Mg hardness	-	9.96	12.96	16.41	9.46	21.47	16.97	11.46	**26.95**
10.	Mg content	30-100	2.43	3.16	4.00	2.31	5.24	4.14	2.79	**6.57**
11.	CO_3	-	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
12.	HCO_3	-	588.82	777.97	610.17	521.7	619.32	576.61	604.07	796.27
13.	Cl	250-1000	0.31	1.05	0.65	0.22	0.12	0.18	2.29	31.23
14.	Na	-	11.5	8	**16.75**	12.25	18	7.25	**4.75**	8
15.	K	-	6.75	**4**	5	6.5	**24.25**	7.75	6.25	10.25
16.	Alkalinity	200-600	241.25	318.75	250	213.75	253.75	198.75	247.5	326.25
17.	Acidity	-	40.63	56.25	79.37	60.63	55.62	**101.25**	90	78.75
18.	BOD	5	2.16	2.43	1.79	2.26	3.0	2.23	1.14	2.11
19.	COD	10	6	7.33	6	**4**	6	8.33	11	18
20.	NO_3	45-100	0.74	0.72	**0.60**	0.76	0.96	0.92	**0.97**	0.95
21.	Free CO_2	-	15.4	25.85	26.4	25.85	27.5	28.6	29.7	44

Table 2(b) Average physico-chemical properties of ground water of nearby area

S. No.	Parameters	Permissible limit range for drinking water (BIS)	Fulsunga road near Amogh Enterprises	Transit camp	Transit camp residence (D.H.P.)	Sector-6 near Electromech Pvt. Ltd.Rudrapur	HCL Chowk	Matkota temple	Matkota market	Behind Ashok Leyland (plot no.1)
1	Temperature	-	23.4	25.12	21.75	25.75	24.55	24.35	**22.72**	24.02
2.	pH	6.5-8.5	6.65	6.27	6.5	6.1	6.37	6.4	6.15	6.22
3.	EC	-	387.5	580	**320**	**817.5**	370	422.5	735	495
4.	TDS	500-2000	220	342.5	**200**	502.5	212.5	242.5	437.5	287.5
5.	Turbidity	5-10	0.35	0.3	0.32	0.5	0.275	0.38	0.6	0.62
6.	Ca Content	75-200	12.83	17.83	**10.42**	19.64	15.03	14.03	20.24	17.23
7.	Ca hardness	-	32.02	44.53	**26.02**	49.04	35.03	35.03	50.54	43.03
8.	Total hardness	300-600	45.5	68	**40**	67	46.5	44	69	63.5
9.	Mg hardness	-	13.47	23.46	10.98	17.96	**8.97**	**8.97**	18.46	20.46
10.	Mg content	30-100	3.28	5.72	3.89	4.38	**2.19**	**2.19**	4.50	4.99
11.	CO_3	-	18	**0**	**36**	**0**	**0**	**0**	**0**	**0**
12.	HCO_3	-	515.59	784.07	**424.07**	640.67	540.00	578.28	**906.1**	729.15
13.	Cl	250-1000	0.19	2.45	0.13	**91.31**	0.26	0.27	3.97	0.29
14.	Na	-	8.5	11.25	7	10.75	8	7.25	10	8.5
15.	K	-	9.75	10.5	9.25	9.75	7.25	9.75	11	6
16.	Alkalinity	200-600	226.25	321.25	**145**	262.5	221.25	242.5	**371.25**	298.75
17.	Acidity	-	39.37	90	38.75	68.75	**34.37**	38.75	66.25	88.12
18.	BOD	5	1.43	1.48	**3.08**	1.56	2.69	3.1	0.87	1.27
19.	COD	10	16.67	25	6	34	26.67	12.67	10	35.67
20.	NO_3	45-100	0.81	0.79	0.78	0.79	0.75	0.71	0.74	0.77
21.	Free CO_2	-	8.8	28.05	**7.15**	29.15	23.1	33	38.5	39.05

Table 2(c) Average physico-chemical properties of ground water of nearby area

S. No.	Parameters	Permissible limit range for drinking water (BIS)	Behind Ashok Leyland (plot no.3)	Dineshpur turn	Chattarpur turn(D.H.P.)	Chattarpurvillage (residence)	Chattarpur village (D.H.P.)	Horticulture Research Centre	Anandibai temple	Police station Haldi
1	Temperature	-	23.85	**25.87**	24.8	24.2	25.12	23.95	24.72	24.02
2.	pH	6.5-8.5	6.27	**6.05**	**6.62**	6.57	6.47	6.22	6.32	6.15
3.	EC	-	552.5	622.5	402.5	410	415	580	580	615
4.	TDS	500-2000	325	370	235	235	237.5	347.5	345	365
5.	Turbidity	5-10	0.55	**0.75**	0.32	0.35	0.3	0.325	0.4	0.4
6.	Ca Content	75-200	20.64	21.24	18.44	13.43	14.23	21.44	20.92	19.44
7.	Ca hardness	-	51.54	53.04	46.03	33.53	35.53	53.54	52.04	48.54
8.	Total hardness	300-600	68.5	78	61.5	58.5	61	79.5	76	70.5
9.	Mg hardness	-	16.96	24.96	15.46	24.97	25.47	25.96	23.95	21.96
10.	Mg content	30-100	4.13	6.09	3.77	6.09	6.21	6.33	5.84	5.36
11.	CO_3	-	0	0	0	0	0	0	0	0
12.	HCO_3	-	829.83	**906.10**	555.25	564.40	550.75	714.05	829.83	817.62
13.	Cl	250-1000	0.73	2.11	0.21	**0.11**	0.26	0.37	0.73	2.74
14.	Na	-	6	7.75	**4.75**	6.5	7.5	7.75	7.5	5.25
15.	K	-	6.75	6.25	7.5	6.75	8	6	7.25	8.5
16.	Alkalinity	200-600	340	**371.25**	227.5	231.25	227.5	292.5	340	335
17.	Acidity	-	58.75	81.87	38.75	72.5	44.37	90.62	71.875	64.37
18.	BOD	5	0.75	**0.37**	0.73	1.51	0.75	0.87	0.67	0.97
19.	COD	10	34.67	14.33	6.33	16.33	6	10.67	8.33	14.33
20.	NO_3	45-100	0.73	0.77	0.73	0.96	**0.97**	0.93	0.90	0.90
21.	Free CO_2		33.55	47.85	20.35	25.3	28.05	35.2	49.5	**50.05**

SUMMARY AND CONCLUSIONS

The present study was conducted to study the physico-chemical properties of ground water samples in pre and post monsoon from SIDCUL-Rudrapur in Udham Singh Nagar district of Uttarakhand. For the study of spatial and temporal variation in the water quality, the sampling was done at 24 locations in the area. The categorization of available water samples for their suitability for drinking purpose were assessed with the help of criteria given by Bureau of Indian Standards. This study shows that ground water is the only source for people in the study area, and the results of the chemical analyses of ground

water indicate considerable variation. The water quality in the investigated area is found to be suitable for drinking in few locations, while as out prior treatments

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