

Ground Water Suitability for Irrigation Purposes in SIDCUL-Rudrapur of Udham Singh Nagar District

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ABSTRACT

Ground water quality study is very important for sustainable development of water resources. The water samples from 21 locations were collected in a sterilized plastic bottle to check the irrigation suitability of shallow groundwater of SIDCUL near Rudrapur of Udham Singh Nagar district. The categorization of the ground water for irrigation was studied with the help of criteria given by Richard, Wilcox and Wescot and Ayers. As per Richards criteria, six and five water samples were found under C3 class of salinity in post monsoon and pre-monsoon period which implied that the water from these places was highly saline according to Richard. All the samples were found low (S1) alkali hazard except H-Block, Haldi Attariya Mandir, Pallavika nursery, Indra Chauraha during post monsoon period. All the water samples were found under low (S1) alkali hazard in pre-monsoon period. As per Wilcox criteria of % sodium, 1 out of 21 water samples were found under unsuitable category in

post-monsoon period. No water samples were found under unsuitable category in pre-monsoon period. As per Wescot and Ayers criteria on the basis of TDS, one out of 21 groundwater samples was having slight to moderate class for post-monsoon period.

Keywords Salinity, % sodium, Pre-monsoon and post-monsoon, TDS.

INTRODUCTION

Groundwater quality depends on large number physical, chemical and biological factors. Generally higher proportions of water quality parameters are found in groundwater than in surface water because of ground water interaction with various materials in geologic strata. In India, groundwater resources support nearly 50% of irrigated agriculture and more than 80% of freshwater demand for domestic use (Satapathy and Syed 2015, Singh *et al.* 2017). The Irrigation water should be free from any contamination such as toxic elements, and excessive amount of minerals that may be hazardous to plant (Kumar *et al.* 2018). Some of the chemical elements are very essential for plant growth, for example, Calcium, magnesium, but large quantities of them may cause adverse effect on plant development. Groundwater pollution by untreated industrial effluent has assumed great significance during recent years due to their toxicity and accumulative behavior. These elements, contrary to most pollutants, are not biodegradable and undergo a global eco-biological cycle in which natural waters are the main pathways.

Water pollution is the contamination of water bodies such as lakes, rivers, oceans, and groundwater (Matta *et al.* 2015). It occurs when pollutants are

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discharged directly or indirectly into water bodies without adequate treatment to remove harmful constituents. Water pollution is a major problem in the global context (Radha *et al.* 2007). The quality of groundwater has been affected through domestic, agricultural and industrial pollution. Nitrates is predominant in western of Delhi (Adhikary *et al.* 2010).

Essentially all activities carried out on land have the potential to contaminate the groundwater, whether associated with urban, industrial or agricultural activities. Large scale, concentrated sources of pollution such as industrial discharges, landfills and subsurface injection of chemicals and hazardous wastes, are an obvious source of groundwater pollution. These concentrated sources can be easily detected and regulated but the more difficult problem is associated with diffuse sources of pollution like leaching of agrochemicals and animal wastes subsurface discharges from latrines and septic tanks and infiltration of polluted urban run-off and sewage where sewerage does not exist or is defunct. Diffuse sources can affect entire aquifers, which is difficult to control and treat.

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.

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. The determination of the concentration levels of ground water quality parameters in these waters, as well as the elucidation of the chemical forms in which they appear is a prime target in environmental research today. Keeping these facts in view a study on physico-chemical properties of ground water and its suitability for irrigation purpose was carried out in the industrial area of SIDCUL (State Industrial Development Corporation of Uttarakhand Limited) of Rudrapur.

MATERIALS AND METHODS

The study area is located in SIDCUL (State Industrial Development Corporation Uttarakhand Limited) near Rudrapur of Udham Singh Nagar district, Uttarakhand (India). The geographical area of the district is 3055 Km². It is located between latitude 28°59'22.27" to 29°02'12.82" N and laterally extends between longitudes 79°23'16.05" to 79°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. Ground water samples for the physico-chemical analysis were collected on 17-November-2018 and 26-April-2019 from shallow hand pumps at 21 locations (Table 1) of the study area. Samples were collected using plastic bottles and were kept in the incubator so that no or minimum changes occur in the physico-chemical properties of the water samples.

Water quality criteria for irrigation

The categorization of the ground water, of SIDCUL area for their suitability for irrigation were studied with the help of criteria given by Richard (1954), Wilcox (1955) and (Wescot and Ayers 1984). The Richard criteria for irrigation was based on Salinity hazards ($\mu\text{S}/\text{cm}$) and Alkali hazards (Sodium Absorption Ratio). The Wilcox criterion for irrigation is based on Percent Sodium (% Na) and EC (ds/cm). The Wescot and Ayers criteria for irrigation is based on Salinity EC (dS/m), Specific ion toxicity (Sodium Absorption Ratio) and permeability (SAR and EC). To study the suitability of available water for irrigation, the following categorization parameters were calculated.

Mg:Ca ratio

It is the ratio of magnesium content to the calcium content in mg/l.

Percent sodium (%Na)

Sodium percent or the proportion of sodium among all the anions is usually expressed in terms of percent sodium. It was estimated that with the help of following relationship:

$$\%Na = \frac{Na + k}{ca + Mg + Na + K} \times 100 \quad (1)$$

where, Na, K, Ca, Mg are ions present in the effluent/ground water expressed in milli equivalents/

litre (meq/l).

Sodium adsorption ratio (SAR)

It is a ratio of soil extract and irrigation water used to express the relative activity of sodium ion exchange reaction with soils. It was estimated with the help of the following relationship:

$$SAR = \sqrt{\frac{Na}{\frac{Ca + Mg}{2}}} \quad (2)$$

Table 1. Values of different parameters for the assessment of suitability of water for irrigation for post and pre-monsoon period.

Sl. No.	Location	Latitude	Longitude	Mg:Ca ratio		EC		TDS		%Na	
				Post	Pre	Post	Pre	Post	Pre	Post	Pre
1	Phoolbagh center, near primary school	29°01'15.82"N	79°28'19.24"E	0.180	1.24	756	796	420	419	73.83	39.27
2	Model Medicinal Plant Garden	29° 1'54.88"N	79°27'52.27"E	0.064	2.36	621	635	315	337	14.07	14.29
3	Haldi Seed Processing Plant	29° 1'52.62"N	79°26'49.80"E	0.120	0.73	749	736	392	391	67.74	37.65
4	H-Block Haldi Pantnagar	29° 0'0.66"N	79°25'8.04"E	0.384	0.89	736	621	394	332	70.96	35.17
5	I-Block	29° 0'45.30"N	79°26'10.14"E	0.574	1.17	516	558	271	295	65.79	22.13
6	J-Block Haldi labor shed	29° 2'11.40"N	79°25'29.52"E	0.384	1.25	522	562	276	299	42.85	23.34
7	Horticulture Research Center	29° 2'11.40"N	79°25'2.88"E	0.435	1.26	388	426	205	228	33.33	19.57
8	Matkota TDC main road	29° 0'31.62"N	79°24'1.14"E	0.258	0.85	342	361	176	190	69.68	25.64
9	Nearby Chief Medical Officer Office road	29° 0'1.02"N	79°23'29.16"E	0.374	1.63	339	358	174	192	53.41	30.85
10	Opposite to Reserve Police Line gate	28°59'31.02"N	79°24'2.52"E	0.393	1.31	448	489	236	261	71.30	37.71
11	Haldi Attariya Mandir, Jagatpura	28°59'31.98"N	79°24'27.42"E	0.513	0.86	511	346	266	180	75.89	32.68
12	Raj auto service Attariya road	28°59'23.16"N	79°24'39.54"E	0.830	1.51	578	561	303	297	57.55	32.42
13	Pracheen Van Shakti Mandir	28°59'24.12"N	79°25'30.54"E	0.208	0.99	407	433	211	233	32.16	23.71
14	Mukesh road lines, Fulsunga	28°59'24.12"N	79°25'30.54"E	0.453	1.07	390	413	200	217	33.95	28.72
15	Pallavika nursery 18 Aavas Vikas	28°59'15.78"N	79°24'1.86"E	0.410	0.96	714	855	377	449	83.39	47.95
16	Near Hanuman Mandir, Bus station	28°58'39.72"N	79°24'4.62"E	0.529	0.87	569	566	294	310	70.96	39.31
17	Opposite to Tehsil, Gangapur road	28°58'27.48"N	79°24'32.10"E	1.002	1.13	1026	1162	542	611	44.61	50.35
18	Divya traders in front of Punjab National Bank, Phulsungi	28°58'32.34"N	79°25'10.98"E	0.923	1.51	502	533	256	281	42.86	31.16
19	Nand Vihar Colony	28°58'32.10"N	79°25'26.16"E	0.461	1.05	369	402	189	209	62.24	34.01
20	Balaji sweet shop near Police chauki Rampura (Kachahari purana court)	28°58'5.94"N	79°24'3.36"E	0.983	1.23	912	888	470	482	44.74	59.01
21	Indra Chauraha	28°58'17.16"N	79°23'41.82"E	1.187	1.27	1606	1045	844	552	79.28	60.64

Table 1. Continued.

Sl. No.	Location	Latitude	Longitude	SAR		ESP		SSP	
				Post	Pre	Post	Pre	Post	Pre
1	Phoolbagh center, near primary school	29°01'15.82"N	79°28'19.24"E	9.8	2.20	13.62	4.31	65.86	31.37
2	Model Medicinal Plant Garden	29° 1'54.88"N	79°27'52.27"E	0.16	0.51	1.47	1.98	3.17	10.00
3	Haldi Seed Processing Plant	29° 1'52.62"N	79°26'49.80"E	7.18	1.99	10.59	4.03	60.70	30.26
4	H-Block Haldi Pantnagar	29° 0'0.66"N	79°25'8.04"E	10.15	1.79	13.96	3.76	68.60	29.33
5	I-Block	29° 0'45.30"N	79°26'10.14"E	1.26	0.85	3.03	2.46	24.27	16.98
6	J-Block Haldi labor shed	29° 2'11.40"N	79°25'29.52"E	2.62	1.11	4.88	2.82	36.09	20.69
7	Horticulture Research Center	29° 2'11.40"N	79°25'2.88"E	1.06	0.72	2.74	2.28	20.36	15.91
8	Matkota TDC main road	29° 0'31.62"N	79°24'1.14"E	1.77	0.93	3.72	2.57	35.88	21.62
9	Nearby Chief Medical Officer Office road	29° 0'1.02"N	79°23'29.16"E	3.68	1.56	6.27	3.43	49.99	28.85
10	Opposite to Reserve Police Line gate	28°59'31.02"N	79°24'2.52"E	8.58	2.20	12.22	4.31	70.26	36.14
11	Haldi Attariya Mandir, Jagatpura	28°59'31.98"N	79°24'27.42"E	10.86	1.57	14.73	3.45	73.85	29.90
12	Raj auto service Attariya road	28°59'23.16"N	79°24'39.54"E	4.23	1.85	6.98	3.83	42.36	29.50
13	Pracheen Van Shakti Mandir	28°59'24.12"N	79°25'30.54"E	0.80	0.98	2.39	3.64	17.01	20.43
14	Mukesh road lines, Fulsunga	28°59'24.12"N	79°25'30.54"E	1.22	1.26	2.98	3.03	24.72	25
15	Pallavika nursery 18 Aavas Vikas	28°59'15.78"N	79°24'1.86"E	19.74	3.97	23.29	6.65	81.98	45.46
16	Near Hanuman Mandir, Bus station	28°58'39.72"N	79°24'4.62"E	9.52	2.47	13.27	4.68	69.17	37.15
17	opposite to Tehsil, Gangapur road	28°58'27.48"N	79°24'32.10"E	1.04	4.39	2.72	7.19	15.85	45.04
18	Divya traders in front of Punjab National Bank, Phulsungi	28°58'32.34"N	79°25'10.98"E	2.51	1.61	4.72	3.5	36.43	28.21
19	Nand Vihar Colony	28°58'32.10"N	79°25'26.16"E	2.28	1.65	4.42	3.56	37.28	31.25
20	Balaji sweet shop near Police chauki Rampura (Kachahari purana court)	28°58'5.94"N	79°24'3.36"E	2.47	5.89	4.67	9.04	32.98	56.42
21	Indra Chauraha	28°58'17.16"N	79°23'41.82"E	16.07	6.10	19.98	9.31	74.34	55.08

Where, Na, Ca and Mg are the concentration of the designated soluble anions expressed in meq/l.

Exchangeable sodium percentage (ESP)

It is the degree of saturation of the soil exchange complex with sodium. It was estimated with the help of the following relationship:

$$ESP = \frac{0.0126 + 0.01475 \times SAR}{1 + (0.0126 + 0.01475 \times SAR)} \times 100 \quad (3)$$

Where, SAR is Sodium Adsorption Ratio.

Soluble sodium percentage (SSP)

Soluble sodium percent is also called as percent

sodium and it was calculated with the help of the following relationship:

$$SSP = \frac{100 \times Na}{Ca + Mg + Na} \quad (4)$$

Where, Na, Ca and Mg are ions present in the samples and expressed in meq/l.

RESULTS AND DISCUSSION

Suitability of water quality for irrigation

Categorization of water for irrigation on the basis of criteria given by Richard (1954): The categorization of groundwater nearby the SIDCUL (Pantnagar) of Rudrapur area on the basis of criteria given by

Richard (1954) is given as in Table 2.

Classification on the basis of salinity hazards : It was observed from table 1 that the groundwater at Model Medicinal Plants Garden, Haldi Seed Processing Plant, H-Block Haldi Pantnagar, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, Chief Medical Officer Office road, Attariya road, Haldi Attariya Mandir, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Pallavika nursery 18 Aavas Vikas, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony, were found under class C2 of salinity. The water from these sites showed salinity and therefore can be used for irrigation on almost all types of crops and soil. The groundwater of Phoolbagh centre, near primary school, Opposite to Tehsil, Gangapur road, Balaji sweet shop near police chauki Rampura, Indra chauraha were found under class C3 of salinity for post-monsoon period, which implies that the water from these places was highly saline and therefore, should not be used for irrigation without proper drainage system. The good salt tolerated crop should be grown if irrigated with these waters.

It was observed from Table 1 that the groundwater at Model Medicinal Plants Garden , Haldi Seed Processing Plant, H-Block Haldi Pantnagar, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, Chief Medical Officer Office road, Attariya road, Haldi Attariya Mandir, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony, were found from class C2 of salinity. The water from these sites showed salinity and therefore can be used for irrigation on almost all types of crops and soil. The groundwater of Phoolbagh centre,

Pallavika nursery, Opposite to Tehsil, Gangapur road, Balaji sweet shop near police chauki Chauraha, were found under class C3 of salinity for pre-monsoon period, which implies that the water from these places was highly saline and therefore, should not be used for irrigation without proper drainage system. The good salt tolerated crop should be grown if irrigated with this water.

Classification on the basis of sodium hazard : It was observed from the table 1 that the groundwater at Phoolbagh Centre, Model Medicinal Plants Garden , Haldi Seed Processing Plant, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, Chief Medical Officer Office road, Attariya road, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony, Opposite to Tehsil Gangapur road, Balaji sweet shop near police chauki Rampura were found from class S1 of salinity, which implies that the water at all these locations had low sodium content and could be used for irrigation on almost all type. The groundwater at H-Block Haldi Pantnagar, Haldi Attariya Mandir, Pallavika nursery 18 Aavas Vikas, Indra Chauraha were found from class S2 of alkalinity for post-monsoon period.

It was observed from the table 1 that the groundwater at Phoolbagh Centre, Model Medicinal Plants Garden, Haldi Seed Processing Plant, H-Block Haldi Pantnagar, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, Chief Medical Officer Office road, Attariya road, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Haldi Attariya Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony, Pallavika nursery 18 Aavas Vikas, opposite to Tehsil Gangapur road,

Table 2. Irrigation suitability categorization given by Richard and Wilcox.

Problem	Parameter	Richard		Wilcox		
		Class	Limits	Parameter	Class	Limits
Salinity hazards	EC	Low(C1)	100-250	Percent Sodium	Excellent	< 20
		Medium (C2)	250-750		Good	20-40
		High (C3)	750-2250		Permissible	40-60
		Very high (C4)	2250-5000		Doubtful	60-80
Sodium (alkali hazard)	SAR	Low (S1)	0-10	EC (μ S/cm)	Unsuitable	>80
		Medium (S2)	10-18		Excellent	< 250
		High (S3)	18-26		Good	250-750
		Very high (S4)	>26		Permissible	750-2000
					Doubtful	2000-3000

Table 3. Irrigation suitability criteria given by Wescot and Ayers.

Problem	Parameter	Class	Limits
Salinity (affects the availability of crop water)	EC (ds/m)	None	<0.70
		Slight to moderate	0.70 - 3.0
		Severe	>3.0
	DS(mg/l)	None	<450
		Slight to moderate	450 – 2000
		Severe	>2000
Specific ion toxicity (affects the sensitivity of the crop)	Sodium adsorption ratio (SAR)	None	<3.0
		Slight to moderate	3.0 - 9.0
		Severe	>9.0
	None	0-3 &> 0.7	
		3 -6 &> 1.2	
		6-12 &> 1.9	
Permeability (affects the infiltration rates of water into the soil)	SAR and EC(ds/m)	Slight to moderate	12-20 &>2.9
			0-3 & 0.7-0.2
			3 - 6 & 1.2 -0.3
	Severe	6 -12 & 1.9- 0.5	
		12 -20 &>2.9-1.3	
		0- 3 &<0.2	
			3- 6 &<0.3
			6 - 12&<0.5
			12-20&<1.3

Balaji sweet shop near Police chauki Rampura, Indra chauraha were found from class S1 of Salinity for pre-monsoon period, which implies that the water at all these locations had low sodium content and could be used for irrigation on almost all type of soil with less harm to soil and crop.

Classification on the basis of percent sodium:

From the Table 1 it was found that the water at Model Medicinal Plants Garden was found under excellent category for irrigation. The water of Horticulture Research Centre, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga were found under good category for irrigation. The water nearby Chief Medical Officer Office road, Raj auto service Attariya road, Opposite to Tehsil, Gangapur road, Divya traders Fulsungi, Balaji sweet shop near police chauki, Rampura was found under permissible category for irrigation. The water at Phoolbagh Centre, Haldi Seed Processing Plant, H-Block, I-Block, Matkota TDC main road, Opposite to Reserve Police Line gate, Attariya road, Haldi Attariya Mandir, Hanuman Mandir, Nand Vihar Colony, Indra Chauraha was found under doubtful category for irrigation for post-monsoon period.

From the Table 1 it was found that the water of Model Medicinal Plants Garden, and HRC were found under excellent category for irrigation. Phoolbagh

Centre, Haldi Seed Processing Plant, H-Block, I-Block, J-Block Haldi labour shed, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Attariya road, Haldi Attariya Mandir, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony were found under good category for irrigation. The water at Pallavika nursery 18 Aavas Vikas, opposite to Tehsil Gangapur road, Balaji sweet shop near Police chauki, Rampura, Indra chauraha were found under permissible category for irrigation for pre-monsoon period.

Classification on the basis of electrical conductivity (EC): As given in table 1, on the basis of EC criteria, the groundwater at Model Medicinal Plants Garden, Haldi Seed Processing Plant, H-Block Haldi Pantnagar, I-Block, J-Block Haldi labour shed, HRC, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Haldi Attariya Mandir, Jagatpura, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga Rudrapur, Pallavika nursery 18 Aavas Vikas, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony were found under good category for irrigation. The groundwater

at Phoolbagh Centre, opposite to Tehsil Gangapur road, Indra Chauraha, were found under permissible category for irrigation for post-monsoon period.

As given in table 1, on the basis of EC criteria, the groundwater at Model Medicinal Plants Garden, Haldi Seed Processing Plant, H-Block Haldi Pantnagar, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Haldi Attariya Mandir, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony were found under good category for irrigation. The groundwater at Phoolbagh Centre, Pallavika nursery 18 Aavas Vikas, opposite to Tehsil Gangapur road, Indra Chauraha, were found under permissible category for irrigation for pre-monsoon period.

Categorization of water for irrigation on the basis of criteria given by Wescot and Ayers

The categorization of groundwater nearby the SID-CUL (Pantnagar) of Rudrapur area on the basis of criteria given by Wescot and Ayers (1984) is given as in Table 3.

Classification on the basis of salinity: From Table 1, it was found that on the basis of EC, the groundwater at Model Medicinal Plants Garden, I-Block, Matkota TDC main road, Haldi Attariya Mandir, Raj auto service Attariya road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders in front of Punjab National Bank, Fulsungi, Nand Vihar Colony were having no class thus the water at these points have no effect on the availability of water to the crop. The groundwater at Phoolbagh Centre, H-Block, Pallavika nursery 18 Aavas Vikas, Balaji sweet shop near Police Chauki Rampura, opposite to Tehsil Gangapur road, Indra Chauraha, Haldi Seed Processing Plant were having slight to moderate class therefore the water at these points for post-monsoon period.

From Table 1, it was found that on the basis of EC, the groundwater at Model Medicinal Plants Garden, H-Block, I-Block, J-Block Haldi labour shed, HRC, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Haldi Attariya Mandir, Raj auto service, Pracheen Van Shakti Mandir, Mukesh road

lines, Fulsunga, Hanuman Mandir, Bus station, Divya traders in front of Punjab National Bank, Fulsungi, Nand Vihar Colony were having no class therefore the water at these points have no effect on the availability of water to the crop. The groundwater at Phoolbagh Centre, Pallavika nursery 18 Aavas Vikas, Balaji sweet shop near Police Chauki, Rampura, opposite to Tehsil Gangapur road, Indra Chauraha, Haldi Seed Processing Plant were having class therefore the water at these points for pre-monsoon period.

From Table 1, on the basis of TDS, the groundwater at Phoolbagh Centre, Model Medicinal Plants Garden, H-Block, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Attariya road, Haldi Attariya Mandir, Raj auto service, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony, Phoolbagh Centre, Pallavika nursery 18 Aavas Vikas, Haldi Seed Processing Plant, Balaji sweet shop near police Chauki Rampura, opposite to Tehsil Gangapur road were having no class. The groundwater at Indra Chauraha were having slight to moderate class for post-monsoon period.

The groundwater at Phoolbagh Centre, Model Medicinal Plants Garden, H-Block, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Haldi Attariya Mandir, Jagatpura, Raj auto service, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Bus station, Divya traders in front of Punjab National Bank, Fulsungi, Nand Vihar Colony, Phoolbagh Centre, Pallavika nursery 18 Aavas Vikas, Haldi Seed Processing Plant were having no class. The groundwater at Balaji sweet shop near police Chauki Rampura, opposite to Tehsil Gangapur road, Indra Chauraha were having slight to moderate class for pre-monsoon period.

Classification on the basis of specific ion toxicity : From Table 1, on the basis of SAR, The groundwater at Model Medicinal Plants Garden, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Divya traders in front of Punjab National Bank, Fulsungi, Nand Vihar Colony, Balaji sweet shop near police Chauki

Rampura, Opposite to Tehsil Gangapur road plant were having no toxicity effect. The water at Haldi Seed Processing Plant, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Attariya road, Raj auto service, Attariya road were having slight to moderate effect on ion toxicity. The water at Phoolbagh Centre, H-Block, Haldi Attariya Mandir, Pallavika nursery 18 Aavas Vikas, Indra Chauraha were having severe effect of ion toxicity for post-monsoon period.

The groundwater at Phoolbagh Center, Model Medicinal Plant Garden, H-Block Haldi, Pantnagar, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Attariya road, Haldi Attariya Mandir, Raj auto service, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Phulsungi, Nand Vihar Colony, Phoolbagh Centre, Pallavika nursery 18 Aavas Vikas, Haldi Seed Processing Plant were having no toxicity effect. The water at Pallavika nursery 18 Aavas Vikas, Balaji sweet shop near Police chauki Rampura, Opposite to Tehsil Gangapur road, Indra Chauraha Sir Gotiya, in front of SBI were having slight to moderate effect of ion toxicity for pre-monsoon period.

Classification on the basis of permeability: As given in Table 1, on the basis of combined effect of SAR and EC, The ground water at Balaji sweet shop near Police chauki, Rampura, opposite to Tehsil Gangapur road, plant was not having any effect on the infiltration rate of water into the soil. The groundwater at Model Medicinal Plants Garden, I-Block, J-Block Haldi labour shed, Horticulture Research Centre, Matkota TDC main road, Pracheen Van Shakti Mandir, Mukesh road lines, Fulsunga, Divya traders in front of Punjab National Bank, Fulsungi, Nand Vihar Colony, Indra Chauraha, Haldi Seed Processing Plant, Raj auto service, nearby Chief Medical Officer Office road were found to have slight to moderate effect on infiltration rate of water. The groundwater at Opposite to Reserve Police Line gate, Attariya road, Pallavika Nursery 18 Aavas Vikas were found to have severe effect on infiltration rate of water for post-monsoon period.

The ground water at Phoolbagh Center, Haldi Seed Processing Plant was not having any effect

on the infiltration rate of water into the soil. The groundwater at Pallavika nursery, Balaji sweet shop, Police chauki Rampura, opposite to Tehsil, Indra Chauraha, Model Medicinal Plants Garden, H-Block, I-Block, J-Block, HRC, Matkota TDC main road, nearby Chief Medical Officer Office road, Opposite to Reserve Police Line gate, Haldi Attariya Mandir, Raj auto service, Pracheen Mandir, Mukesh road lines, Fulsunga, Hanuman Mandir, Divya traders, Fulsungi, Nand Vihar Colony were found to have slight to moderate effect on infiltration rate of water for pre-monsoon period.

CONCLUSION

As per the suitability criteria for irrigation purpose, given by Richard (1954), Wilcox (1955) and Wescot and Ayers (1984) the water samples of Phoolbagh center, Tehsil Rudrapur, Indra chauraha were unsuitable while all other samples were found to be suitable for irrigation purposes during post-monsoon period and the water samples of Phoolbagh center, Tehsil Rudrapur, Indra chauraha, Balaji Sweet shop Police chauki Rampura, Pallavika nursery were unsuitable while all other samples were found to be suitable for irrigation purposes during pre-monsoon period.

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