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Groundwater evaluation for irrigation in and around Dharamshala area, Himachal Pradesh, India

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ABSTRACT: The study is based on the groundwater hydrochemistry assessment for irrigation use in Dharamshala (Kangra, Himachal Pradesh) and the area surrounding it. To analyze the water quality, 33 groundwater samples were collected for three seasons (post-monsoon, winter season, and pre-monsoon) with different analytical indices such as Electrical conductivity (E.C), Total dissolved solids (T.D.S), Percent sodium (%Na), Sodium adsorption ratio (SAR), Kelly's index (KI), Permeability index (PI), Residual sodium carbonate (RSC), Soluble sodium percent (SSP) and Magnesium Hazard (MH). The results show some samples with values of magnesium hazard KI, PI and SSP more than the permissible limits set by various standards.

KEYWORDS: Hydrochemistry, analytical indices, permissible, irrigation, SAR.

I. INTRODUCTION

Groundwater system of India varies as its topography and geology varies from region to region. Indo-Gangetic plain in central India is enriched with a large number of aquifers. Water pollution through Industries, domestic content, uneven urbanization and intrusion, pest control chemical usage and their run off, soil erosion and silting etc. is increasing with a pace (CPCB, 1995). Along with a good soil structure and properties, a good water quality is also quite important for a better crop production (Suresh A,2020). The harmful effects of land use and land cover in developing countries are very resilient (Deepa et al, 2018). The study of hydro chemical properties is helpful to assess the water quality for drinking, irrigation purposes. (Suresh, A et al; 2019). It is important for further conservation and groundwater sustainability and management. The increasing industrialization, development and tourism interventions can harm the water and soil quality. Water quality analysis is a vital tool for getting better crop yield. The Socio-Economic structure depends largely on agriculture (Deepa et al, 2017). To evaluate the water quality a total number of 33 samples were collected from different groundwater sources such as hand pumps, bore wells etc. in Dharamasala and some of the area surrounding it. The samples were collected for three seasons that is for post-monsoon, winter season and pre-monsoon season. The water quality for irrigational usage was analyzed based on various indices such as Electrical conductivity (E.C), Total dissolved solids (T.D.S), Percent sodium (%Na), Sodium adsorption ratio (SAR), Kelly's index (KI), Permeability index (PI), Residual sodium carbonate (RSC), Soluble sodium percent (SSP) and Magnesium Hazard (MH).

Study area:

Dharamasala is one of the wettest known places in Himachal Pradesh, situated in the north-west part of the state in the vicinity of outer Himalayas known as the Dhauladhar range and lies in the Beas river basin in district Kangra. The local population depends on the rainfall and groundwater sources for their doings. Rainfall is the only source of groundwater recharge in the area. Other than that, the seepage from steams, highland inflows and irrigated fields is the significant source for groundwater recharge. These come under mid to high altitude lakes, situated at a height of 2000m and 2934m respectively from mean sea level. These lakes are also recharged by snow melting and by the seasonal rain fall. The area experiences around 200mm average rainfall in monsoon season (July to mid-September) and an average amount of 120mm in winter season (Deepika, 2015) while it can

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reach up to 3000mm during monsoon season. Whereas the groundwater discharge mainly takes place through bore wells and tube wells, the effluent seepage of groundwater occurs through springs, stream base flow and Baories (local name for groundwater seepage at the surface).

General geology of the study area:

Dharamasala area is part of Lower Siwaliks on southern side of the Dhauladhar range in the NW Himalayan zone. This Siwalik system is formed in the fordeep basin created at the time of Himalayan evolution, which was filled lately by the scraped debris of both deep marine at base and fresh water sediment above called flysch and mollase facies respectively.

Geomorphology of the area:

The area is composed of two types of soils, Alfisol and Ultisol (CGWB, 2008). Alfisol is the soil present in the Sub mountainous regions. It comprises of a leached basic or acid soil with clay enriched B horizon. The Ultisol is highly weathered and leached brown red or reddish yellow acid soil with a clay rich B horizon. It occurs in warm humid climates mainly.

The rock formations of Kangra district ages from pre-Cambrian to Quaternary. The area's hydrogeology is divided into two units i.e. fissured formations and porous formations. (CGWB, 2008).

II. MATERIALS AND METHODS

A total number of 33 groundwater samples are collected from Dharamasala and some villages around the border area for three seasons i.e. for post monsoon (October, 2015), winter season (January, 2016), and pre monsoon season (June, 2016) in (Table 1). The samples are analyzed in geochemical laboratory using standard methods to examine the quality for various physico-chemical parameters such as pH, Electrical conductivity, TDS, major cations and anions. The water quality for irrigational usage was analyzed based on various indices such as Electrical conductivity (E.C), Total dissolved solids (T.D.S), Percent sodium (%Na), Sodium adsorption ratio (SAR), Kelly's index (KI), Permeability index (PI), Residual sodium carbonate (RSC), Soluble sodium percent (SSP) and Magnesium Hazard (MH). The results are assessed according to the bureau of Indian standards (BIS, 1991), Indian Standard Institution (ISI, 1983) and world health organization (WHO, 2004) standards for irrigational usage.

III. RESULTS AND DISCUSSION

Electrical conductivity (E.C):

From post-monsoon season 96.9% of groundwater samples show excellent class of water and 3.03 of water samples show good water quality. Winter season shows 51.5% of water samples under excellent water class, and 48.5% of the samples have good quality water class, while pre-monsoon season shows 81.8% of water samples with excellent water class and 18% in good water class (Table 2).

Total dissolved solids (TDS):

The highest permissible limit for Total dissolved solids is 2000 mg/l for irrigation water. The groundwater samples tested for post-monsoon season are ranged from 55.47 mg/l to 55.47 mg/l with an average value of 98.13 mg/l whereas, those for winter and pre-monsoon season are ranged from 104.71 mg/l to 274.53 mg/l with an average value of 172.56 mg/l, and 76.85 mg/l to 210.67 mg/l with an average value of 126.98 mg/l respectively. So, all the groundwater samples show the values under the permissible limit.

Sodium adsorption ratio:

To study the usage of water for irrigation purpose, sodium adsorption ratio is important parameters. It is expressed as the ratio of Sodium concentration in to square root of one half of the sum of Calcium and Magnesium concentrations. All the values are expressed in meq/l. The following equation (1) expresses the relation.

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{\frac{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+}}{2}}}$$

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Sodium adsorption ratio (SAR) for post monsoon season is ranged from 0.23-0.42, while for winter season it is ranged from minimum value of 0.20 to maximum of value 0.24, and for pre-monsoon season from a minimum value of 0.20 to maximum of 0.30. All the values for surface water collected for all the three seasons show the water quality in excellent condition (Table 3).

Percent sodium (%Na):

Percentage of Na^+ in water is an important parameter to evaluate the water quality for irrigation. It is examined by measuring relative proportion of cations (Na^+, K^+, Ca^{2+} Mg^{2+}) present in water, where all the concentrations are in meq/l. It is expressed by the following formula using the equation (2).

$$\%Na^+ = \frac{Na^+ + K^+}{Na^+ + K^+ + Ca^{2+} + Mg^{2+}} \times 100$$

In post monsoon season 12 % of water samples come under the excellent water class, 76 % of samples have good water quality, 9% of samples have permissible water for irrigation, while 3% of water of the water sample has doubtful water quality. In case of winter season 76% of samples are in excellent water class while 24% shows good water class. In case of pre-monsoon season 42% of the samples have excellent water quality, 55% of the samples have good water class while 3% of the samples have permissible water quality for irrigation (Table 4).

Residual sodium carbonate (RSC):

The high amount of residual sodium carbonate present in water highly affects the physical properties of soil to be irrigated. It decreases the permeability and sodium binding tendencies of the soil. So, it is quite important parameter for the study of irrigational water. The values are used in meq/l. It is calculated by means of the following equation:

$RSC = (HCO3^- + CO_3^-) – (Ca^{2+} + Mg^{2+})$

All the values tested for residual sodium carbonate are found to be <1.25 so fall under safe water quality. 100% of the samples tested for residual sodium carbonate are found to be <1.25 so fall under safe water quality class (Table 5).

Kelly's ratio (KR):

Wilcox (1958) and Kelly (1940) have verified the ill effects of sodium ion on the soil by water used for irrigation. The values used to calculate this ratio is in meq/l. It is represented as follows:

$$\text{Kelly's ratio} = \frac{Na^+}{(Ca^{2+} + Mg^{2+})}$$

The Kelly's ratio less than one shows that the water is suitable for irrigation while if the value of KR exceeds one, then it shows the excess of sodium concentration in water which indicates that the water is unsuitable for irrigation. In case of post-monsoon season 100% samples are under good water class for irrigational use, for winter season and pre-monsoon season 97% of the samples are under good water class while the rest 3% is found to be unsuitable (Table 5).

Permeability index (PI):

Permeability index is affected by sodium, Calcium, magnesium, and bicarbonate concentration in the soil. Excessive amount of bicarbonate and carbonate ion into the water causes the precipitation of calcite and magnesite into the soil which reduces the permeability of soil (Bohn et al. 1985; Domenico and Schwartz, 1990). All the ions used to express the permeability index are in meq/l. It is calculated using the following equation:

$$PI = \frac{Na^+ + \sqrt{HCO_3^-}}{Na^+ + Ca^{2+} + Mg^{2+}} \times 100$$

The water quality range for permeability index is represented in table 5. The samples tested for groundwater during three seasons show the values under suitable class of water quality. According to the permeability index results groundwater samples for post-monsoon season 6% samples are found to be in suitable water class while 96% are under unsuitable category. For winter season 67% are suitable while 33% are under unsuitable water class. For pre-monsoon season only 3 % of the groundwater samples are found to be under suitable water class while 97% are unsuitable (Table 5).

Soluble sodium percent (SSP):

It is calculated for irrigation water using the following formula:

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$$SSP = \frac{Na^+ \times 100}{Na^+ + Ca^{2+} + Mg^{2+}}$$

Where the concentration of all the ions is expressed meq/l.

In case winter season 100% of the water sample are found to be under good water class while in case of post-monsoon and pre-monsoon 97% of the samples are under good water class while the rest 3% are found to be under bad water class (Table 5).

Magnesium hazard:

Normally, Calcium ion and magnesium ion present in water are in balanced state. The high magnesium concentration in water can distress the crop production. Magnesium hazard is evaluated by the Calcium and magnesium molar ratio using the following formula:

$$MH = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \times 100$$

Out of the groundwater samples collected from post-monsoon season 100% of the water samples found to have excellent water quality. In case of winter season 79% shows excellent water quality while 21% are found to be under unsuitable water class and from pre-monsoon season 89% samples are found to be under excellent water class while rest 11% are found to be unsuitable for irrigational usage on the basis of magnesium hazard. Except those all other sample values fall under the excellent class of water for irrigation (Table 5).

Table1: Irrigation properties of water samples from post-monsoon, winter and pre-monsoon season.

		E.C	T.D.S	%Na	SAR	KI	PI	RSC	SSP	MH
		µS/cm	mg/l	meq/l	meq/l	meq/l	meq/l	meq/l	meq/l	meq/l
Post-monsoon	**Min.**	86.6	55.47	14.4	0.48	0.2	58	-1.0	14.39	12
	Max.	269	179.99	71.1	1.19	2.4	210	0.3	71.08	44
	Average	147.9	98.13	34.3	0.81	0.5	91.3	-0.3	31.58	28.5
Winter season	**Min.**	170.92	104.71	0.2	0.00	0.00	34	-0.36	0.0	25
	Max.	420.21	274.53	33.6	1.47	0.49	77	-2.17	33	85
	Average	271.58	172.56	15.4	0.36	0.19	60	-1.04	14.6	46
Pre-monsoon	**Min.**	118.52	76.85	13.30	0.16	0.12	59	-0.55	10.78	19
	Max.	290.24	210.67	60.17	1.76	1.49	109	0.04	59.82	79
	Average	182.57	126.98	24.3	0.49	0.33	83	-0.30	22.62	38

Table2: Salinity hazard classes (Wilcox, 1955) for groundwater.

EC in µmhos/cm at 25°C	**Quality of Water**	**No. of groundwater samples exceeding limits.**					
		Post-monsoon		**Winter season**		**Pre-monsoon**	
<250	Excellent	32	96.9%	17	51.5%	27	81.8%
250-750	Good	1	3.03%	16	48.5%	6	18%
750-2250	Permissible	-		-		-	
250-5000	Doubtful	-		-		-	
>5000	Unsuitable	-		-		-	

Table3: Classification of sodium adsorption ratio for groundwater.

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Parameter (meq/l)	Range	Water class	No. of groundwater samples exceeding limits.		
			Post-monsoon	Winter season	Pre-monsoon
SAR	<10	excellent	33	33	33
	10-18	good	-	-	-
	18-26	doubtful	-	-	-
	>26	unsuitable	-	-	-

Table4: Classification of percent sodium for groundwater.

Parameter (meq/l)	Range (mg/l)	Water quality	No. of groundwater samples exceeding limits.					
			Post-monsoon		Winter season		Pre-monsoon	
Percent sodium (%Na)	<20	Excellent	4	12%	25	76%	14	42%
	20-40	Good	25	76%	8	24%	18	55%
	40-60	Permissible	3	9%	-		1	3%
	60-80	Doubtful	1	3%	-		-	
	>80	Unsuitable	-		-		-	

Table5: Classification of groundwater for irrigation properties with the percentage of samples exceeding permissible limit.

Parameter	Range	Water Class	Post-monsoon		Winter season		Pre-monsoon	
			No. of samples	% of samples	No. of samples	% of samples	No. of samples	% of samples
KR	<1	Good	33	100	32	97	32	97
	>1	Unsuitable	-	-	1	3	1	3
SSP	<50	Good	32	97	33	100	32	97
	>50	Bad	1	3	-	-	1	3
PI	<60	Suitable	2	6	22	67	1	3
	>60	Unsuitable	31	94	11	33	32	97
MH	<50	Excellent	33	100	26	79	29	89
	>50	Unsuitable	-	-	7	21	4	11
RSC	<1.25	Safe	33	100	33	100	33	100
	1.25-2.5	Marginal	-	-	-	-	-	-
	>2.5	Unsuitable	-	-	-	-	-	-

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IV. DONEEN CLASSIFICATION

The permeability index has been really important factor in irrigation for good amount of crop production. The increasing population rate leading to decline in vegetation cover is affecting the water resources (Deepa et al, 2017). The graph is classified into three classes (Doneen, 1964) class I, class II, and class III. Figure 1, 2, and 3 shows the water classification for irrigation on the basis of permeability for post-monsoon season, winter season and for pre-monsoon season respectively. According to the graphs plotted, in case of post monsoon season maximum samples fall into class III indicating 25 % of the maximum permeability, while some of the samples fall into Class II which represents 75 % of the maximum permeability, and none of the sample falls under class I. In case of winter season, all the samples fall into class I and class II showing 75 % of the maximum permeability. For pre-monsoon season half of the samples fall under class III with 25 % of the maximum permeability, while the other half fall into class II indication 75% of the maximum permeability. The samples which fall under class I and II are suitable for irrigation, while the ones which fall into class III are considered to be unsuitable.

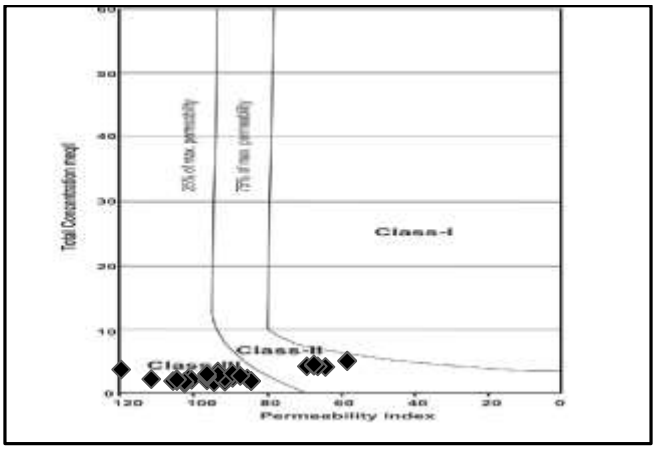

Figure 1: Permeability index for groundwater during post-monsoon season.

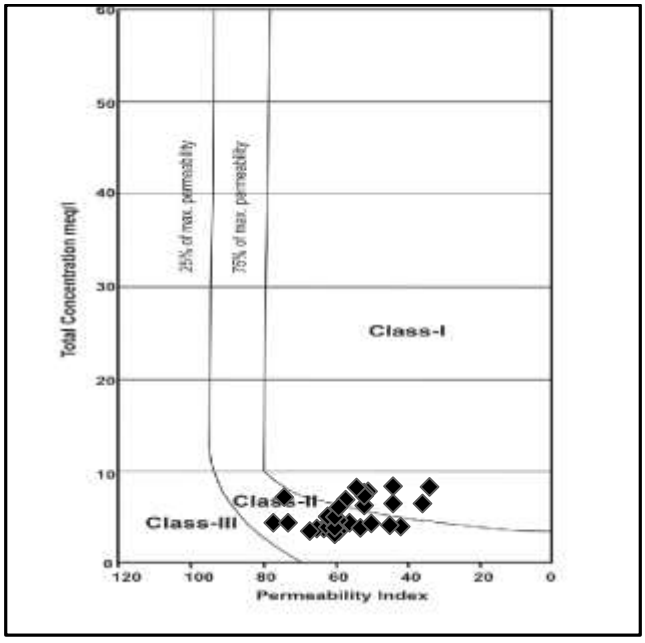

Figure 2: Permeability index for groundwater during winter season.

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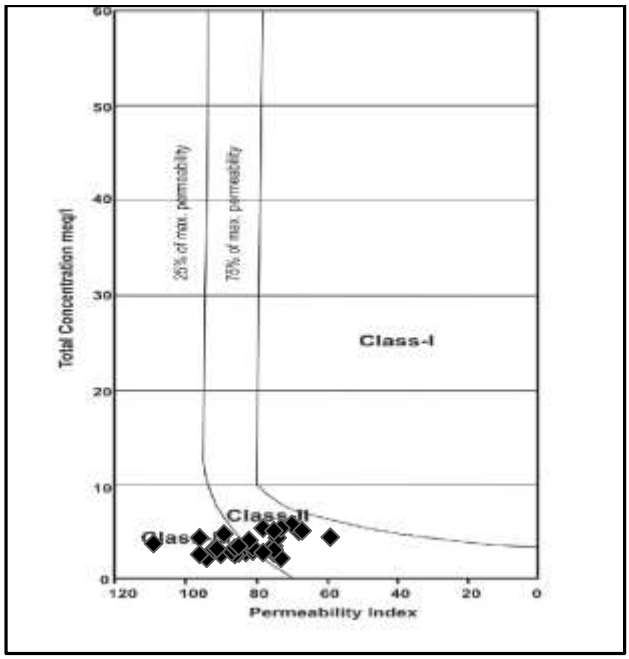

Figure 3: Permeability index for groundwater during pre-monsoon season.

V. CONCLUSION

The groundwater quality of the samples collected from the study area is found to be good for irrigational usage. Out of the different parameters examined electrical conductivity shows the water quality in the range from good to excellent for all the seasons, SAR values also show the excellent quality, % Na results also shows the results from a range from excellent to permissible range while one sample fall under doubtful water class. According to other parameters such as RSC, SSP and KR maximum samples fall under the safe or good class of water whereas few comes under unsuitable and bad class. Permeability index results shows that the maximum water samples fall under unsuitable water class for all the seasons, while in case of Magnesium hazard (MH) maximum samples are under excellent water class except few from winter season and pre-monsoon season. It can be a matter of concern in future as the high magnesium ratio can make the soil more alkaline ((Paliwal, 1972). So, the results of the study show that the groundwater quality of Dharamshala is suitable for irrigational usage, but the problem with soil alkalinity may arise in future

VI. REFERENCES

[1] BIS (1991). Indian standard drinking water specification, Bureau of Indian standard.

[2] Bohn HL, Mcneal BL, O'connor GA (1985) Soil Chemistry. Wiley Interscience, New York, p 341

[3] Central Ground Water board (2008), groundwater information booklet, Kangra district, Himachal Pradesh, India.

[4] ISI (1983) ISI Specification for drinking water, 15:10500: 1983. Indian Standard Institution, New Delhi.

[5] Domenico PA, Schwartz FW (1990) Physical and chemical hydrogeology. John Wiley and Sons,New York

[6] Doneen LD (1964) Water quality for agriculture. Department of Irrigation, University of California, Davis. 48

[7] Kelly WP (1940) Permissible composition and concentration of irrigated waters. In: Proceedings of the A.S.C.F, 607

[8] Nathalia, Deepa & Suresh, Arjun & Singh, Neha. (2018). Monitoring land use/cover changes during the mining activities in Aravalli Hill Region. 10.13140/RG.2.2.28840.67849.

[9] Nathalia, Deepa & Krishan, Gopal & Kishore, Naval. (2017). Socio-Economic Change Impact After the closure of Mining Activities. A Case study of Aravalli Hills of Faridabad District, Haryana. Current World Environment. 12. 10.12944/CWE.12.2.12.

[10] Nathalia, Deepa & Kumar, K & Kishore, Naval & Krishnan, Gopal. (2017). Environmental Change Detection using Geo -Spatial Techniques in Aravalli hills and Environs (Faridabad District, Haryana).

ISSN- 2394-5125 VOL 7, ISSUE 15, 2020

[11] Paliwal KV (1972) Irrigation with saline water (p.198) Monogram No. 2 (New series). IARI, New Delhi
[12] Suresh, A., Jindal, T., & Khan, S. A. (2019). An Integrated Approach for Risk Assessment of Groundwater Contamination Using Lysimetric Studies. Pollution Research, 38(2), 491-4

[13] Suresh, A., & Jindal, T. (2019). Lysimetric Studies to Estimate the Solute and Contaminant Transport in Hydrogeological Profile. Ecology, Environment and Conservation, 25, S102-S105.
[14] Suresh, A.; Jindal, T. (2020) Phthalate Toxicity. Preprints, 2020040209 (doi: 10.20944/preprints202004.0209.v1).
[15] Thakur, D., and Kansal, D. (2015). Assessing Factors Controlling the Hydrochemistry and suitability of Groundwater for Drinking Purpose in Dharamshala Area of Himachal Pradesh, India.
[16] Todd DK, Mays LW (2005) Groundwater hydrology. 3rd edn. Wiley, Hoboken, NJ, 656
[17] sustainable China, International Journal of Water Resources Development, 34:3, 327-336, DOI:
[18] 10.108U.S. Salinity Laboratory (1954) Diagnosis and improvement of saline and alkaline soils. U.S. Dept. of Agriculture. Hand Book, 60, 160
[19] 17. WHO (1984) Guidelines for drinking water quality (vol. 1) Recommendations, World Health Organization, Geneva
[20] 18.Wilcox LV (1955) Classification and use of Irrigation water. US Dept of Agriculture, Washington, Circular No. 969:19