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Hydrogeochemical Evaluation of Groundwater in Shallow Aquifer System of Udhampur-Dun Terrace, J&K, India

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Abstract: ***An intermontane depression developed due to folding of Siwalik molasses called as Udhampur Dun. This depression provided a site for deposition of terraces that extends from east of Dudhar Khad to Bramin Di Khad in Udhampur District and another stretch starts from Manwal in Udhampur district to Billawar in Kathua District. The area is devoid of deeper aquifer systems, thus depend either on surface water resources or shallow dugwells and springs for quenching their water requirements.In this study an attempt has been made to assess the effect of geochemical processes and antropogenic activities on quality of shallow aquifer system of Udhampur-Dun Terrace. Fifteen groundwater samples were collected from the dugwells NHNS during pre monsoon season viz., May 2012. These water samples were chemically analyzed for major physicochemical parameters viz. pH, Ca, Mg, Na, K, Cl, SO_4, HCO_3, NO_3, F, TH and Fe. The results were compared with the water quality standards of BIS for drinking purpose.***

Keywords: Ground water, dugwells, BIS, physico-chemical parameters, cations, anions.

1. Introduction

Water is elixir of life and two third of earth's surface is covered by it. But UNEP and WHO (1996) argued that it is not sufficient merely to have access to water in adequate quantities, the water also needs to be of adequate quality to maintain health and it must be free from harmful biological and chemical contamination. Water being a universal solvent, easily picks up impurities during its flow, gets contaminated by human activities and agriculture or industrial wastes. To safeguard the long-term sustainability of the groundwater resources the quality of the water needs to be continuously monitored (Raihan and Alam, 2008).

2. Study Area

The study area is a part Udhampur Dun belt. This Udhampur Dun is an enclosed basin, surrounded by hills of Middle and Lower Siwalik group of rocks. This basin provided a site for terrace deposits that extend from east of Dudhar Khad to Bramin Di Khad, and another stretch starts from Manwal of Udhampur District to Billawar in Kathua District. The slope is from northeast to southwest. This area experiences a sub tropical climate. Summers are quite hot and dry and last from March to June, followed by monsoon season from July to September. Winter season is quite cold and starts from November and ends in February. The Udhampur Dun terrace deposits comprise of fragments of sandstone, shale, igneous and metamorphic rocks. The sediments of this deposit were derived mainly from Siwalik group of rocks that are deposited in variable depths and occur in the form of isolated sub-Recent to Recent valley fill deposits. They comprise of coarse clastic boulders, cobbles and pebbles interbedded with lenticular bodies of clay, silt, sand and gravels. This semi consolidated type of rock formation is devoid of deeper aquifers. Here ground water occurs in perched bodies or in the moderately weathered parts. Thus, there are no tube-wells in the area and the sources of water supply are minor seepages in the form of springs, river tributaries, dug wells or shallow hand pumps constructed by State Government Organization especially for drinking purpose.

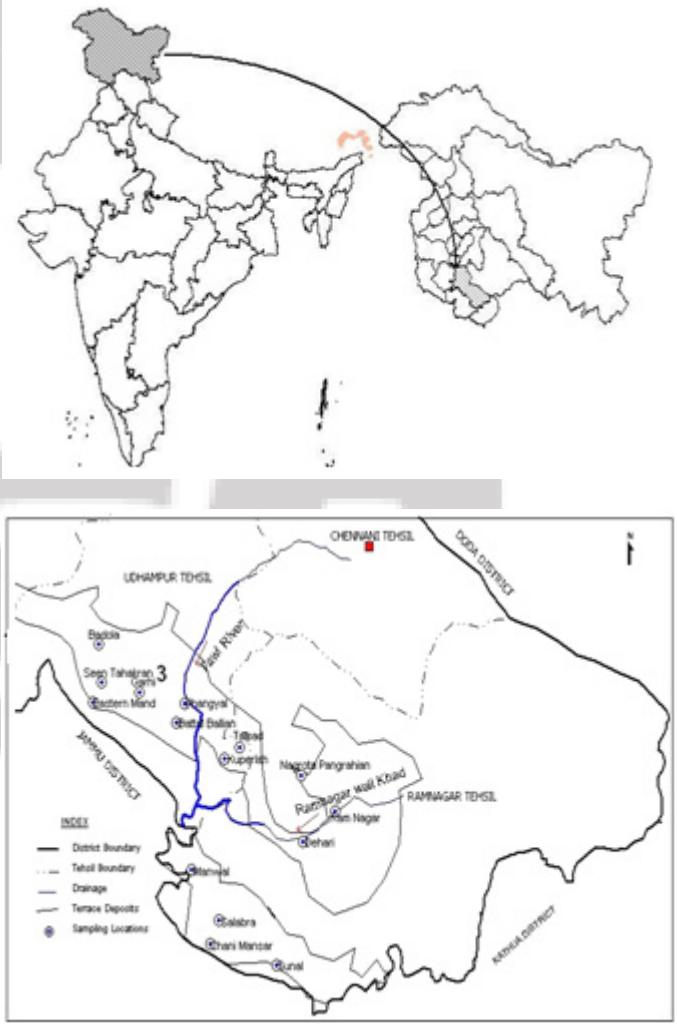

Figure 1: Location Map of the Ground Water Samples in the study area

3. Methodology

To assess the ground water quality fifteen ground water samples were collected from dugwells, of the study area, during May 2012. Two sets of water samples were collected at each of the fifteen sampling points. One was for the measurement of anions and cations and the other set, for identification of Fe element that was acidified with 1:1 hydrochloric acid to discourage the formation of precipitates and to keep the metal ions in the dissolved state. The water samples for basic cations and anions were collected in white polyethylene bottles of 1 L capacity were rinsed out 3-4 times with sampling water. Then the containers were filled up to the brim and were immediately sealed to avoid exposure to air. The containers were then labeled for identification and brought to the laboratory.

The groundwater samples were analyzed for various water quality parameters such as pH, Electrical conductivity (EC), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), Chloride (Cl^-), Sulphate (SO_4^{-2}), Nitrate (NO_3^-), Fluoride (F^-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Iron (Fe), Total hardness (TH) as per standard methods (APHA, 1998). The analytical precision of ions measurements was determined by calculating the absolute error in ionic balance, which was found less than 5% in all samples.

4. Results and Discussions

4.1 Assessment of physicochemical parameters of groundwater

Hydrogeochemistry is the study of behavior of dissolved chemical constituents in groundwater that are governed by the geochemical properties and principles. Therefore the chemical composition of groundwater is related to the rock formation with which it comes in contact. The concentration levels of the different hydrogeochemical constituents dissolved in water determines its usefulness for various purposes. However, the use of water for any purpose is guided by standards set by the Bureau of Indian Standards and other agencies. In this study, the results of the analyzed chemical parameters in the study area were correlated with those of the BIS (BIS, 2004).

The statistical range of the water chemistry is represented in Table 1. The mean temperature fluctuated between a narrow range of 22˚C - 24˚C, except at Badola where it was 20˚C, which is the lowest and at Manwal 25˚C which is the recorded highest water temperature during the study period. This suggested that most of the sites the water is affected by air temperature.

The pH value ranged from a low of 6.9 (Phangyal) to a high of 7.9 (Channi Mansar). The slightly alkaline pH (>7) may be due to limestone rich sediments that are brought by the two tributaries of Tawi viz., Duddar Khad and Birhun Khad that dissect the Trikuta dolomitic limestone, lib[illegible] Mg and alumino-silicates into the solution.

The EC values in water samples range from 240 µs/cm (Talpad) to 1400 µs/cm (Battal Ballian) which shows that 3 water samples (20%) are marginal waters (500–2000 µS/cm) as per limits of BIS while the rest (80%) show fresh water type.

4.2 Cation and anion chemistry

The major cations and anions make the bulk of groundwater quality (Masoud, 2013). The concentrations of Ca^{2+}, Mg^{2+}, Na^+ and K^+ in water samples varied in the ranges of 22 -160, 6 - 24, 8 - 91 and 0.3 - 3.6 mg/ L, respectively, which were far below the recommended maximum concentrations. The concentration of soluble iron was found to vary within 0.13-0.42 mg/ L with an average of 0.278 mg/ L.

Bicarbonate concentrations in all the samples were found in the range of 104-244 mg/l. The Cl^- content of groundwater samples varied from 10.7- 359 mg/l. One sample contains somewhat higher chloride values compared to other 14 samples. The SO_4^{-2} concentrations were 0.01 - 65 mg/l. which are well within the desirable limits of BIS. NO_3^- concentration ranged from 1.42-18 mg/l, was within the limit of 45 mg/l. The dominance of cations and anions in the area is in the order of Ca^{2+}> Mg^{2+}> Na^+> K^+ and HCO_3^- > Cl^- > SO_4^{-2} >NO_3^- respectively (figure 2).

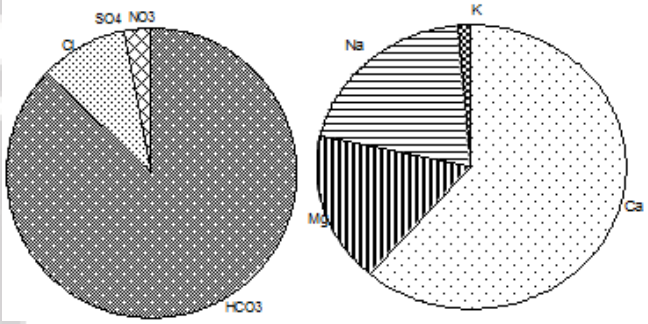

Figure 2: Pie diagram of Median values of Major ions

Table 1: Statistical Range of the water chemistry in Study Area

Parameters	*BIS Limits*		*Dugwells*			
	Desirable Limit	*Permissible limit*	*Min*	*Max*	*Mean*	*Median*
Temperature ˚C			20	25	22.6	23
pH	6.5-8.5	No relaxation	6.9	7.9	7.5	7.57
EC µmhos/cm at 25°C	500	2000	240	1400	457	400
CO_3^{2-} (mg/l)	-	-	0	0	0	0
HCO_3^- (mg/l)	-	-	104	244	179.3	189
Cl^- (mg/l)	250	1000	10.7	359	49.98	21
NO_3^- (mg/l)	45	100	1.42	18	9.4	6.62
F^- (mg/l)	1.0	1.5	0.01	0.15	0.059	0.08
SO_4^{2-} (mg/l)	200	400	0.01	65	12.28	0.01
Ca^{2+} (mg/l)	75	200	22	160	50.67	46
Mg^{2+} (mg/l)	30	100	6	24	13.46	13
Na^+ (mg/l)	-	-	8	91	24.74	15
K^+ (mg/l)	-	-	0.3	3.6	1.29	1
Fe (mg/l)	0.3	1.0	0.13	0.42	0.278	0.26
TH as $CaCO_3$ (mg/l)	300	600	230	610	185.7	160

4.3 Total Hardness

Hardness is an important criterion for determining the usability of water for domestic, drinking and many industrial purposes and results from the presence of divalent metallic ions, of which calcium and magnesium are the most

abundant in the groundwater. The Total hardness of the groundwater in the study area is ranging from 105 to 500 mg/l and according to Sawyer and Mc Carty's (1967) classification it belongs to very hard class.

Table 2: Classification of Hardness of Water Samples of Study Area

Number of Samples	*Soft 0-60 mg/l TH*	*Moderate 61-120 mg/l TH*	*Hard 121-180 mg/l TH*	*Very Hard > 180 mg/l TH*
15	00	05 (33.33)	04 (26.66)	6 (40%)

4.4 Classification of Ground water and Facies

Hydrochemical facies are generally distinct zones that cation and anion concentrations are described within defined composition categories (Ophori & et.al.,1989) The facies appears as a function of the lithologic, solution kinetic and flow patterns of the aquifer (Raju & et.al, 2009). Piper diagram (Piper, 1944) is a useful graph, which is used to explain these facies where the upper part of this diagram (diamond-shaped) is divided into six classes as follows: (1) $CaHCO_3$ Type, (2) NaCl Type, (3) Mixed $CaNaHCO_3$, (4) Mixed CaMg Cl, (5) CaCl Type and (6) $NaHCO_3$ types. The hydrochemical data of groundwater from study area was plotted on the Piper diagram as in Figure 3 where most of the groundwater samples (40%) fall in the field as a mixture of Ca-Mg-HCO_3 and Ca-HCO_3 types. Rest of the samples fall under mixed type viz. Ca-Na-Mg-HCO_3-Cl, Ca-Mg-Na-HCO_3-Cl, Ca-Mg-HCO_3-Cl and Ca-HCO_3-Cl. From this figure, it is observed that the alkaline earth ($Ca^{2+}$and Mg^{2+}) signification exceeds the alkalis (Na^+ and K^+) and the acids (HCO_3^- and Cl^-) are dominant in the study area indicating that the water quality in the study area is fresh and has low dissolved solid contents. The alkaline earth metals thus not only contribute to the major type of water in the area but also are a cause of hardness of water.

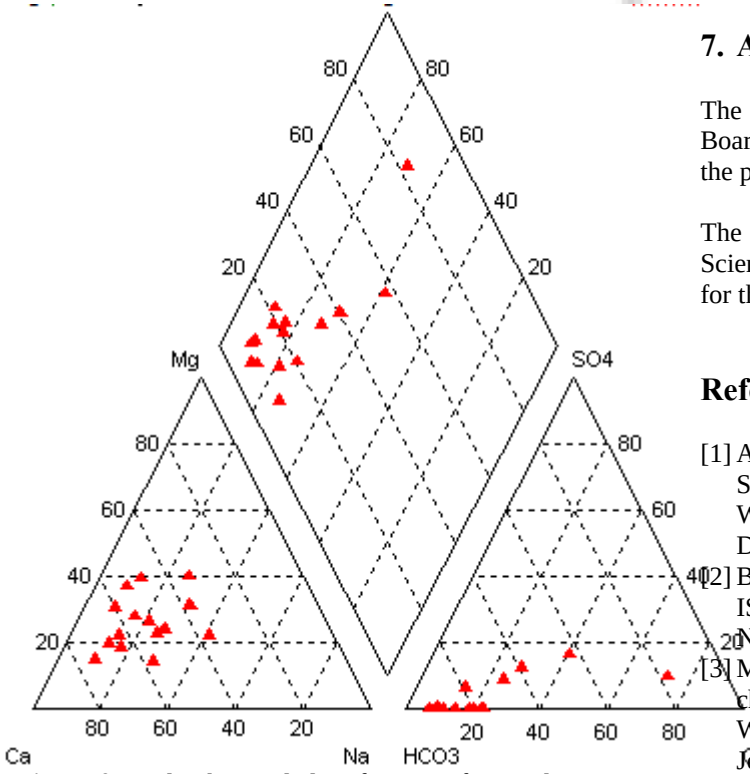

Figure 3: Hydrochemical classification of groundwater in the study area base on Piper Trilinear diagram

5. Conclusions

Interpretation of hydrochemical analysis reveals that the groundwater in the study area is fresh. Assessment of water samples was done according to BIS standards shows that most of the water samples are suitable for drinking. The groundwater is slightly alkaline with pH's ranging from 6.9 to 7.9 with an average of 7.5. The bicarbonate (HCO_3) acquires the higher concentrations of the anions, while sodium (Ca^{2+}) and magnesium (Mg^{2+}) acquire the higher concentrations of the cations. The concentrations of the major ions are within the maximum standard limits, according to the Bureau of Indian Standards (BIS, 2006). The concentration of the iron ranges from 0.13-0.42 mg/ L with an average of 0.27 mg/ L.

The sequence of the abundance of major cations and anions is Ca^{2+}> Mg^{2+}> Na^+> K^+ and HCO^-_3 > Cl^- > SO_4^{-2} > NO_3^- respectively. In this area, the dominant hydrochemical facies of groundwater is Ca-Mg-HCO_3 and Ca-HCO_3 types. It was also noticed that alkaline earth metals (Ca^{2+} + Mg^{2+}) exceeds the alkali metals (Na^+ + K^+) and acids (HCO_3^- + Cl^-) are dominant.

6. Future Scope

The Udhampur-Dun Terrace is a fluvial deposit consists of loose unconsolidated sediments that lack deeper aquifers thus construction of tubewells here is not feasible. Thus, the structures of shallow aquifers viz. dugwells and handpumps are the only sources that cater the demand of water of the inhabitants in this area. The shallow aquifers are more vulnerable to contamination and the loose sediments of terraces adds up to this possibility, therefore, in future these ground water resources must be regularly monitored in terms of quality as well as quantity.

7. Acknowledgement

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Author Profile

Dr. Pragya Khanna is an Associate Professor in Zoology, Govt. College for Women, Parade Ground, Jammu. She has 14 Years of research experience on Cytology of Chironomids and Environmental assessment of Major and minor water bodies of Jammu region with special reference to heavy metals, pesticides and industrial effluents. She has worked on a number of projects funded by DST and UGC on the above mentioned aspects. Currently, she is working on a major project funded by the J&K State Council for Science and Technology, Department of Science and Technology, J&K Govt. entitled, "Physico-chemical and microbiological analysis of underground water in and around Jammu region and study on the genotoxic effect of different pollutants". Dr. Khanna has reported 14 new species of Chironomus from Jammu and Kashmir, out of which 7 form the first time reports from the world. She has been conferred with 16 national and international awards and honours. She has authored 31 research papers, 5 monographs, 3 books, more than 300 popular articles and has attended 56 conferences and seminars in different parts of the country and has presented papers and chaired sessions. She has also delivered a number of Invited Lectures in different Universities and Colleges. She is in the Editorial Board of various International/National Journals and has reviewed several research papers. She is the Life member of various International/National scientific agencies.

Priya Kanwar is an Assistant Hydrogeologist in Central Ground Water Board, Ministry of Water Resources, Jammu. She has 12 years of experience in the field of Ground Water with expertise in Exploratory Drilling, Ground Water Monitoring, Artificial Recharge Projects, Water Supply Studies, Groundwater Quality Issues and Quantifying Groundwater Resources. She was involved in organizing and coordinating Mass Awareness and Training programs to make aware the user agencies, stake holders, Central and State Departments about the issues of water development and management. Currently she is doing the aquifer mapping project of the board, in the limestone and alluvial areas of Udhampur, Reasi, Rajouri and Jammu Districts. She has been conferred with the appreciation letter from the chairman of the board for working in harsh terrain of Ladakh especially in Siachen. She is the member of various International/National scientific agencies.