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Geospatial Approach for Mapping of Ground Water Quality of Outer Plains of Samba District, J&K, India

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Abstract: ***Ground water is ultimate, most suitable fresh water resource with nearly balanced concentration of the salts suitable for human consumption. Therefore, it is very important to monitor the quality of ground water especially if an area has all possible sources of pollution viz. Agriculture, Industry and Human population. The Outer Plains of Samba District was the area selected to assess the ground water quality. Mainly the area is agriculture based and along its perennial river Basanter an Industrial Estate is established since long time. The aim of the study is to present the distribution of various chemical constituents in the ground water of the study area in GIS environment for better understanding of the spatial distribution of each chemical parameter and mapping of the current situation of ground water quality. The most important chemical parameters of ground water like Electrical Conductivity (EC), Sulphate (SO_4), Nitrate (NO_3), Sodium (Na), Potassium (K), Calcium (Ca), Chloride (Cl), Magnesium (Mg), pH, Fluoride (F), Total Hardness (TH) and Iron (Fe) were selected and compared to the guideline values presented by Bureau of Indian Standards (BIS). The spatial distribution maps for each ground water parameter are prepared by interpolation of values by using natural neighbour method.***

Keywords: Ground water, Ground water quality parameters, BIS, Basanter, Samba

1. Introduction

Groundwater has become an essential commodity in recent decades due to industrialization and unplanned urbanization (Kumari et al., 2012). The occurrence and movement of groundwater in an area is governed by several factors, such as topography, hydro-geomorphology, geology, drainage pattern, land use, climatic conditions and inter relationships among these factors. The quality of groundwater is equally important as its quantity owing to the suitability of water for various purposes (Yidana and Yidana, 2010). The variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities (Subramani et al., 2005; Vijith and Satheesh, 2007; Nas and Berktay, 2010). Also, the quality of surface water and soil characteristics determines the composition and quality of the groundwater (Atapour, 2012).

The chemical properties of groundwater also depend upon the chemistry of water in the recharge area as well as on the different geochemical processes that are occurring in the subsurface. These geochemical processes are responsible for the seasonal and spatial variations in groundwater chemistry (Matthess, 1982). Poor quality of water adversely affects the human health and plant growth (WHO, 2004). The importance of water quality in human health has recently attracted a great deal of interest. In developing countries like India, around 80 % of all diseases are directly related to poor drinking water quality and unhygienic conditions (Olajire and Imeokparia, 2001; David et al., 2011; Khadri et al., 2013).

Therefore, the aim of the present study was to assess the ground water quality of the Outer Plains of Samba District and to present the distribution of various chemical constituents in the ground water of the study area in GIS environment for better comprehension of the spatial distribution of each chemical parameter and mapping of the present condition of ground water quality.

2. Study Area

Samba, a tehsil of Jammu District, got the status of an individual district in year 2007. As a district, it comprises parts of Jammu District that lies on its north western side and Kathua District on South-eastern side. On its north-eastern side lies the Udhampur District and the south-western boundary is bounded by the International Border with Pakistan. The study taken up in 2012 encompasses the boundaries of Samba Tehsil in the study area due to non availability of boundary of newly carved district.

The study area lies between latitude 32º26'25" and 32º48'12" N and longitudes between 74º52'04" and 75º10'56"E. The perennial Basantar River drains the study area. The drainage pattern is dendritic to sub-dendritic. The general topographic slope of the area is from northeast to southwest. The area comprises of alluvial fans, where coarser sediments lies closer to the Siwalik Hills called as Kandi formation and the finer sediments called Sirowal formation that extends far even beyond the International Border. Geologically these formations are classified as older and younger alluvium of Quaternary age. The ground water occurs at deeper depths in the Kandi belt and at shallow levels in the Sirowal belt. Its flow direction corresponds roughly with the topographic slope. In the study area, an industrial estate lies on the bank of Basantar River, due to which natural and anthropogenic condition prevails that are in turn reflected in the hydrological and ground water quality conditions of the area. The study area is in general an agriculture based area. The source of recharge in the area is rainfall, but the Sirowal belt

also gains a considerable recharge from seepage from canal system, return flows from surface and ground water irrigation

3. Data Used and Methodology

Based on the detailed hydrogeological investigation, ground water samples from 15 dug wells were collected during May 2012, throughout the study area for detailed water quality studies. Ground water samples were collected in new polyethylene bottles. Prior to sampling, these bottles were cleaned with pure water and also rinsed with the respective ground water under sampling. For fixing the total iron, samples were preserved in the field by adding dilute hydrochloric acid, as a preservative agent and transported to the laboratory following the standard guidelines (APHA, 1998). These water samples were analysed by adopting standard methods of analysis of water (APHA, 1998). 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) were analysed and compared with standards of BIS for drinking water (2012). The map showing locations of the sites from where ground water samples were collected is given as figure 1.

The base map of the study area was prepared using SoI Toposheets (no. 43 P/1,1:50 000) by using MapInfo Software. Geo-referencing of the sampling points and the spatial analysis for each parameter was done by making contours using interpolation by natural neighbour method and maps were prepared. These maps depicted the spatial distribution of various parameters which revealed the quality of shallow ground water in the area.

4. Results and Discussion

Geologically, the study area is underlain by recent alluvium consisting of sediments of reworked materials derived from the Siwalik formation. These sediments lay down as alluvial fans on hill slopes. The upper parts of these fans consist of coarser sediments like boulders, gravel and coarse sandy deposits, followed by the sediments of finer nature in the middle and finest like clay, silt and fine sand deposits on their terminal ends that extend widely and are comparatively in flatter parts of the fans.

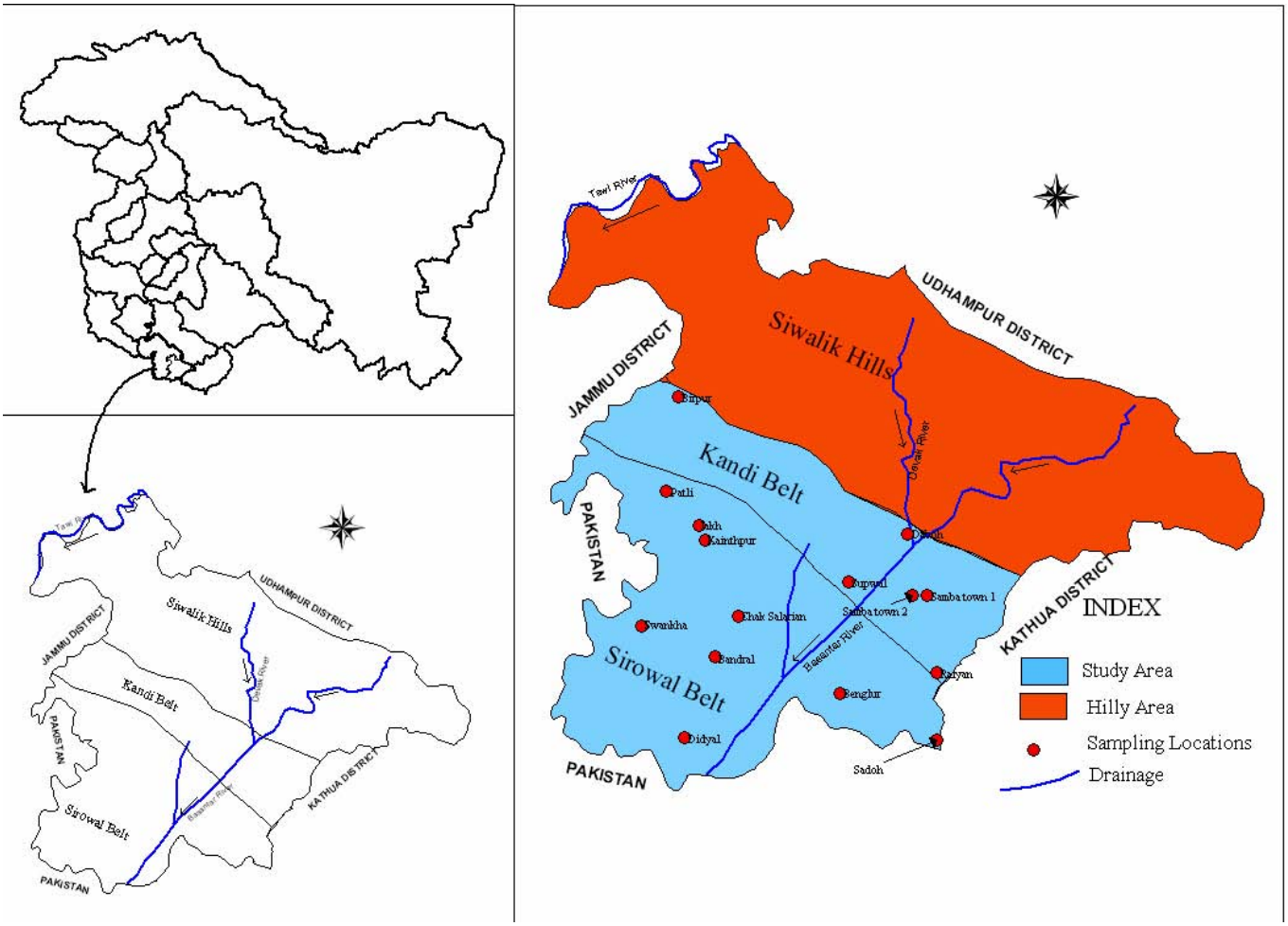

Figure 1: Location of Study area and Sampling sites

Hydrochemical Characterization

Generally ions are released into circulating ground water due to chemical processes between minerals of the aquifer rocks and infiltrated water (Subba Rao & Krishna Rao, 1990). It is important to consider the mineralogy of the aquifer material as it mostly decides which element gets into

water depending upon its solubility and contact time. The elements found in appreciable quantities as dissolved constituents in ground water are Na, K, Ca, Mg, Si, Bicarbonate, SO_4 and Cl (Davis and Dewist, 1966). The minimum and maximum values obtained from the analytical results of chemical parameters of ground water samples, were compared with the most desirable limits and maximum allowable standard guideline values of various parameters as recommended by the BIS for drinking and public health purposes are given in Table 1.

Table 1: Analytical Results of Chemical Parameters of Ground Water Samples

Parameters	BIS Limits		Dugwells	
	Desirable Limit	Permissible limit	Min	Max
pH	6.5-8.5	No relaxation	6.92	8.22
EC µmhos/cm at 25°C	500	2000	290	1290
HCO_3^- (mg/l)	-	-	250	660
Cl^- (mg/l)	250	1000	10	180
NO_3^- (mg/l)	45	No relaxation	2.45	113
F^- (mg/l)	1	1.5	0.01	0.62
SO_4^{2-} (mg/l)	200	400	0.01	40
Ca^{2+} (mg/l)	75	200	40	172
Mg^{2+} (mg/l)	30	100	7	34
Na^+ (mg/l)	-	-	17	190
K^+ (mg/l)	-	-	1.2	9.7
Fe (mg/l)	0.3	1	0	1.65
TH as $CaCO_3$ (mg/l)	200	600	200	560

The preferential order of the major ions is calculated and the order was $Ca^{2+}>Na^+>Mg^{2+}>K^+$ and $HCO_3^{2-}>Cl^->NO_3^{2-}>SO_4^{2-}$. Calcium and Sodium are the dominant cations and Bicarbonate and Chloride are the dominant anions in this region. The graphical representation of concentration of cations and anions in the ground water of study area is shown in figure 2 and figure 3 respectively.

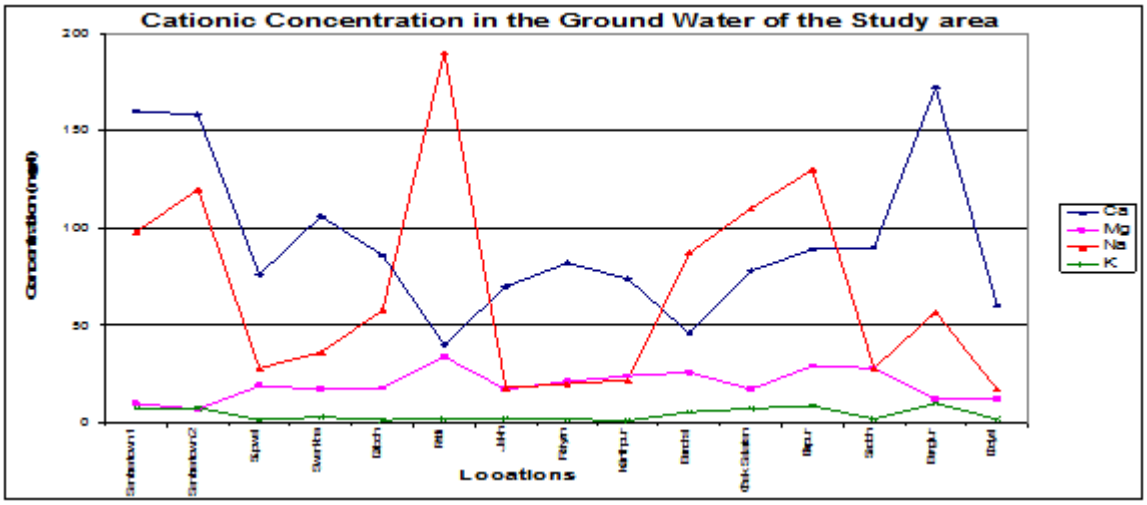

Figure 2: Graph showing Cationic concentration in ground water samples

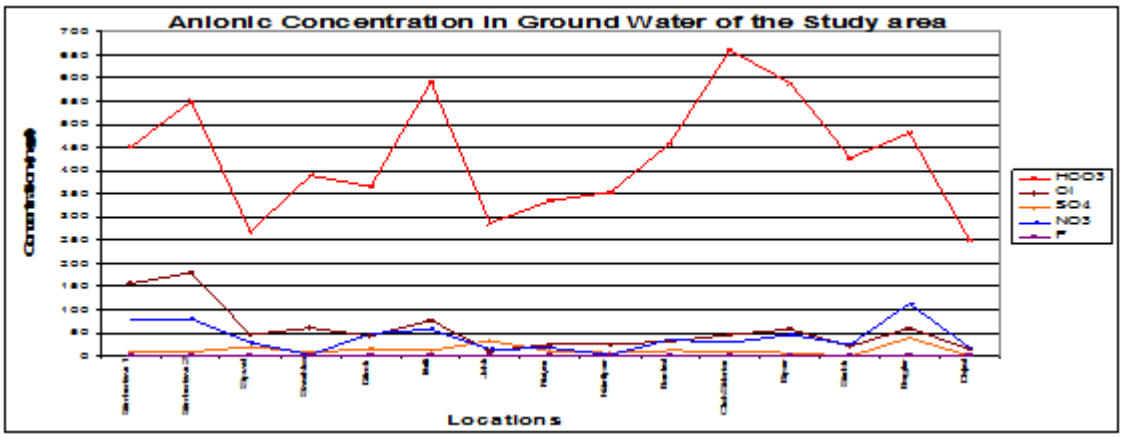

Figure 3: Graph showing Anionic concentration in ground water samples

pH

pH is defined as negative logarithm of Hydrogen ion concentration. The pH of ground water in the study area ranges from 6.92 to 8.22. The average pH for these 15 samples is 7.58. The pH values for all the samples are well within the limits prescribed by Bureau of Indian Standards (BIS, 2012) for various uses of water including drinking and other domestic supplies.

EC

The measurement of electrical conductivity is directly related to the concentration of ionized substances in water and may also be related to problems of excessive hardness and/or other mineral contamination. The average EC is 740.4 µmhos/cm at 25°C, the minimum EC of ground water was observed 290 µmhos/cm at 25°C at Bandral and maximum EC is 1290 µmhos/cm at 25°C at Samba Town 1. Figure 4 depicts the spatial distribution of EC in the study area.

Hardness

Water hardness is caused primarily by the presence of cations such as Calcium and Magnesium and anions such as Carbonate, Bicarbonate, Chloride and Sulfate in water. In the study area it varies from 200 to 560 mg/l as $CaCO_3$. According to Sawyer and McCarty's (2003) classification for hardness, none of the samples fall under soft and moderately hard class whereas 8 fall under hard and 7 samples under very hard class for water samples. The hardness classification is given in table 2 and shown in figure 4.

Table 2: Classification of water based on hardness by Sawyer and McCarty

Hardness mg/l as $CaCO_3$	Water class	Water samples
0-75	Soft	0
75-150	Moderate Hard	0
150-300	Hard	8 (200 - 290)
>300	Very hard	7 (335 - 560)

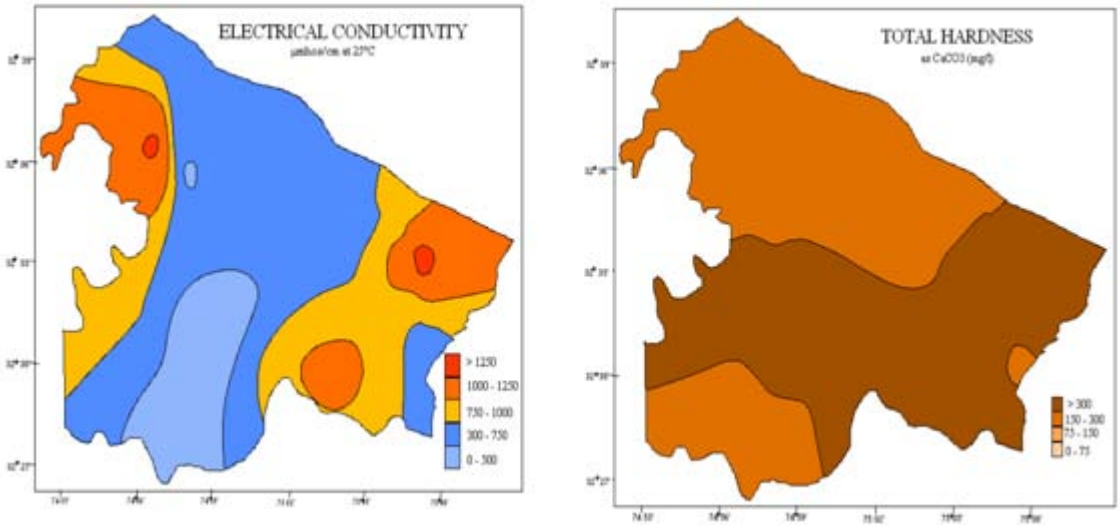

Figure 4: Electrical Conductivity and Hardness in ground water of the Study Area

5. Major Ionic Constituents

Cations

Calcium has a mean concentration of 92.4 mg/l, followed by Sodium and Magnesium which have mean concentrations of 67.93 and 19.4 mg/l respectively. The minimum and maximum values of Calcium, Sodium and Magnesium ranged from 40 to 172 mg/l, 17 - 190 mg/l and 7 - 34 mg/l respectively. Potassium (K^+) is the cation which is normally found at low concentrations in ground water (Sravanthi and Sudarshan, 1998). The concentration of K^+ in ground water sample in the study area has very low values and it ranges between 1.2 mg/l to 9.7 mg/l with a mean value of 4.22 mg/l. The spatial distribution of different cations in the ground water samples of the study area is shown in figure 5 and figure 6.

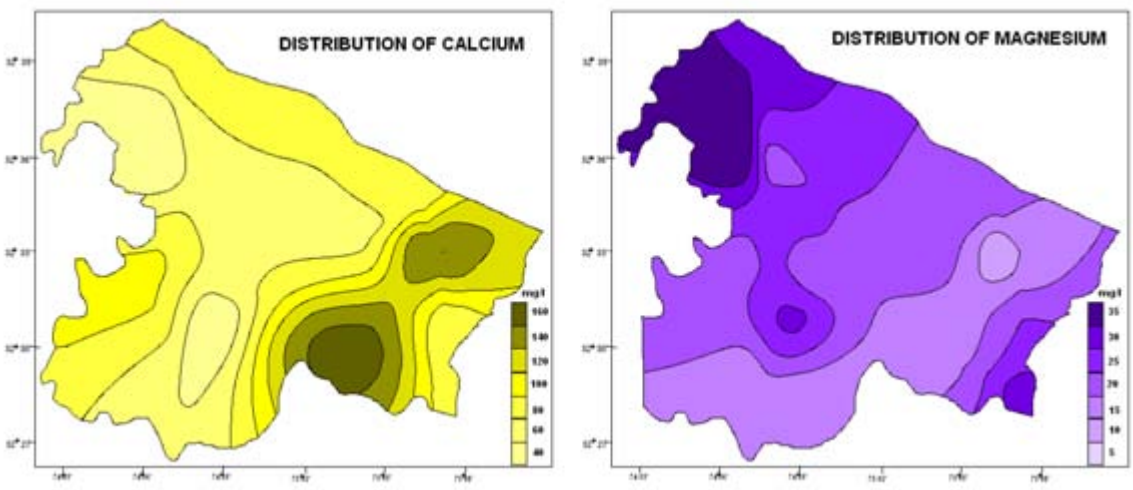

Figure 5: Spatial Distribution of Ca^{2+} and Mg^{2+} ions in the Study Area

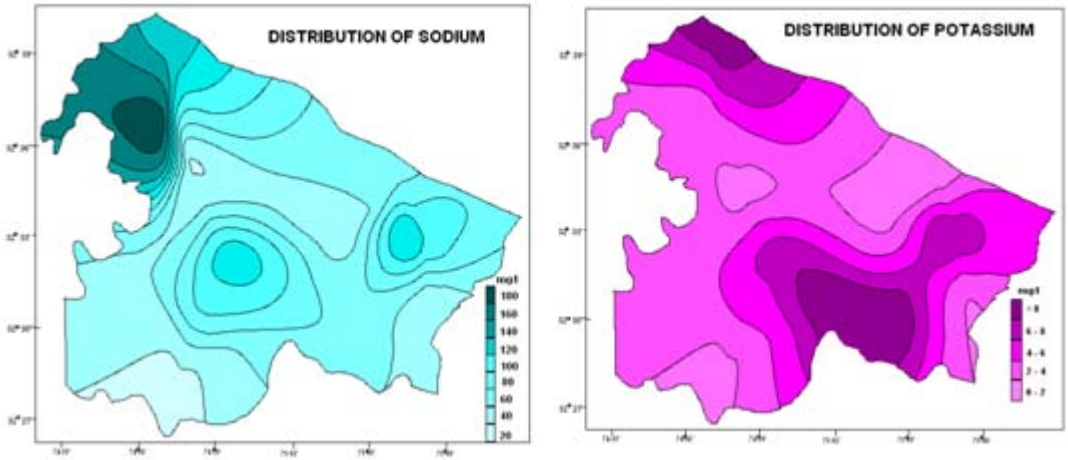

Figure 6: Spatial Distribution of Na^{2+} and K^{+} ions in the Study Area

Anions

Bicarbonate is the dominant anion, having a mean concentration of 430.73 mg/l, followed by Chloride which has a mean of 56.93 mg/l. The minimum and maximum concentrations of Bicarbonate ions and Chloride ions range from 250 to 660 mg/l and 10 to 180 mg/l respectively. Chloride is present in all natural waters, usually in relatively small amounts Sulphate in the study area has a wide range of concentrations, and the minimum value of 0.01 mg/l and maximum of 40 mg/l. Its mean concentration is 12.80 mg/l for the ground water samples analyzed. . The spatial distribution of Bicarbonate and Chloride ions in the ground water samples of the study area is shown in figure 7.

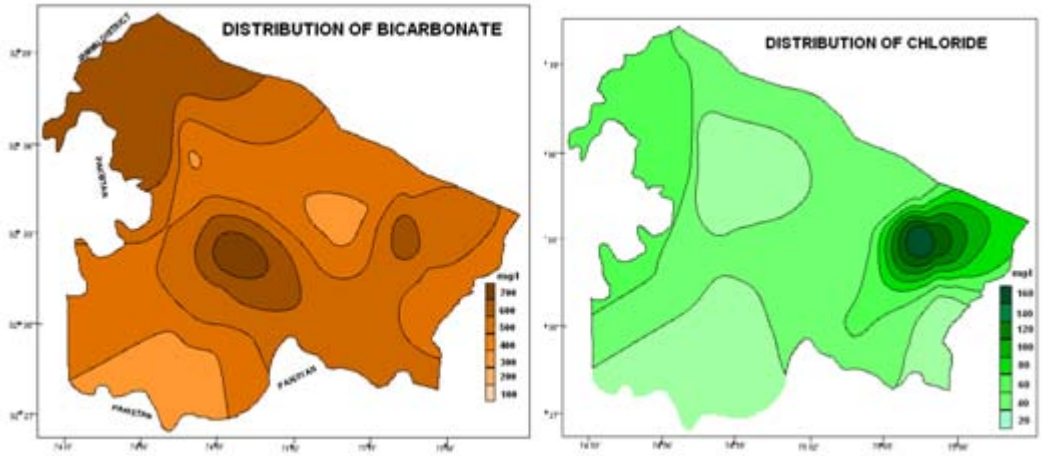

Figure 7: Spatial Distribution of HCO_3^{2-} and Cl^{-} ions in the Study Area

Sulphate occurs in water as the inorganic sulphate salts as well as dissolved gas (H_2S). Sulphate is not a noxious substance although high sulphate in water may have a laxative effect. The concentration of NO_3^{-} in the ground water samples ranges from 2.45 to 113 mg/l. The BIS permissible limit of NO_3^{-} is specified as 45 mg/l for drinking

water. The NO_3^- concentration exceeds the BIS limits in four ground water samples viz, Samba Town 1, Samba Town 2, Patli and Bengular. Sources of Nitrate in ground water include human activity such as application of fertilizer in farming practices, human and animal waste. The desirable concentration of Fluoride is 1.00 mg/l and maximum permissible limit is 1.5 mg/l as set by BIS, 2012. In the study area its concentration ranges between 0.01 to 0.62 mg/l with a mean of 0.174 mg/l, showing that the ground water of the study area has Fluoride ion concentration well within the permissible limits as set by BIS. The spatial distribution of Sulphate and Nitrate ions in the ground water samples of the study area is shown in figure 8.

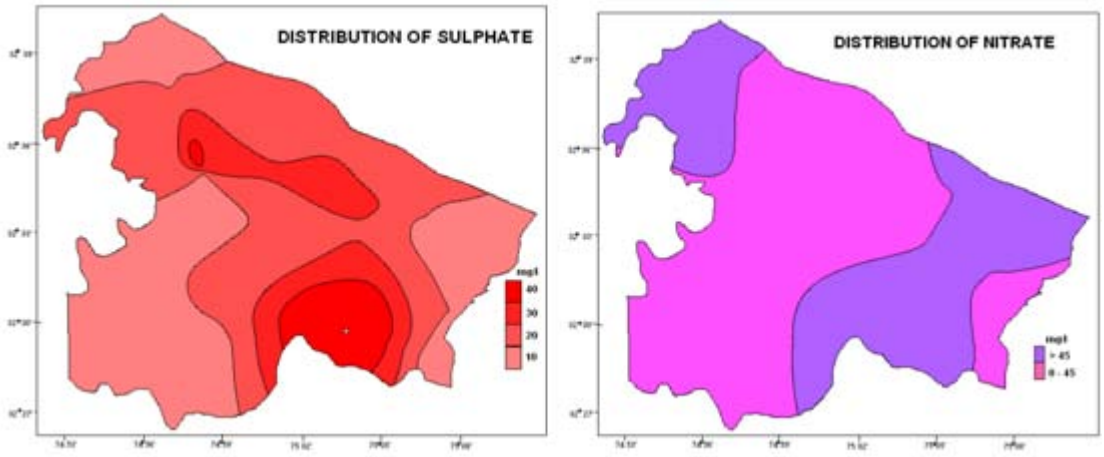

Figure 8: Spatial Distribution of SO_4^{2-} and NO_3^{2-} ions in the Study Area

Iron

Iron is a very common element found in the rocks and soils of the earth's crust. It is also an essential trace element for animal growth. Soluble ferrous Iron is present in natural water with a low Eh. In the study area, the concentration of iron is between 0.00 and 1.65 mg/l with the mean of 0.402 mg/l and the maximum permissible concentration based on BIS 2012 standards is 0.3 mg/l. At four locations viz. Swankha, Raiyan, Birpur and Didyal, the ground water samples have iron concentrations above the maximum permissible limit. Map showing the spatial distribution of Iron concentration in the ground water samples of the study area is shown in figure 7.

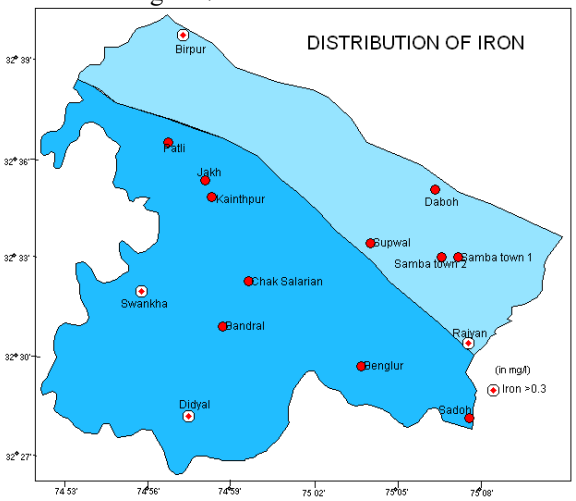

Figure 9: Distribution of Iron in the Study Area

6. Conclusions

The ground water quality of Samba area was assessed for its domestic suitability. The ground water samples collected during May 2012, from 15 locations tapping unconfined zone were analysed and compared with the quality standards of Bureau of Indian Standards for drinking.

The results of the analysis indicate Nitrate pollution at four locations (Samba Town 1, Samba Town 2, Patli and Bengular with values 78, 80, 58, 113 mg/l respectively. Overall Nitrate values ranges 2.45 to 113 mg/l which can be attributed to fertilizer applications, human and animal waste. Iron contamination is observed at four locations viz. Swankha, Raiyan, Birpur and Didyal with value as 1.44, 1.65, 0.8 and 0.55 mg/l respectively. Iron concentration ranges from 0.00 to 1.65 mg/l. The results of hydrochemical analyses also indicate that all other parameters viz. pH, EC, CO_3, HCO_3^{2-}, Cl^-, SO_4^{2-}, F^-, Ca^{2+}, Na^+, Mg^{2+}, K^+ and TH fall within the recommended limits of Bureau of Indian Standards (BIS, 2012) and thus largely suitable for domestic purposes. Eight water samples fall in hard category and seven fall in very hard category. The major ions are in the preferential order of $Ca^{2+}>Na^+>Mg^{2+}>K^+$ and $HCO_3^{2-}>Cl^-$ $>NO_3^{2-}>SO_4^{2-}$.

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Author Profile

Priya Kanwar is an Assistant Hydrogeologist in Central Ground Water Board, Ministry of Water Resources, Jammu. She has 15 years of experience in the field of Ground Water with expertise in Exploratory Drilling, Ground Water Monitoring, Artificial Recharge Projects, Groundwater Quality Issues and Quantifying Groundwater Resources. Currently, she is working on a national project on Aquifer Mapping of in the State of J&K State. 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. She has been conferred with the **Gold Medal,** for meritorious performance and MERIT SCHOLARSHIP' sponsored by Government of Madhya Pradesh in M. Tech, 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. She has authored 22 research papers, 15 technical reports and has attended number of national and international conferences and seminars in different parts of the country and has presented papers.

Dr. Pragya Khanna is an Associate Professor in Zoology at Govt. College for Women, Parade Ground, Jammu (J&K). She has over forty research papers, more than 1500 popular articles published in local Newspapers, magazines and websites, four books and five monographs to her credit. She has been awarded sixteen times by different scientific, academic and allied agencies/societies for her research/scholastic work at State, National and International levels. She is the recipient of prestigious **SWARNA JAYANTI PURUSKAR** by The National Academy of Sciences, India, **YOUNG SCIENTIST AWARD** by All India Congress of Zoology twice for two consecutive years, **OUTSTANDING RESEARCH AWARD** by the Zoological Association, Kurukshetra University, Kurukshetra, **HONORARY FELLOWSHIP** of 'The Society of Life Sciences', Madhya Pradesh for outstanding contributions in the field of Life Sciences, **HONORARY MEMBERSHIP OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, HONORARY FELLOWSHIP** by the Institute of Applied Sciences, Allahabad, Nominated as **INTERNATIONAL EDUCATOR FOR THE YEAR 2009** by the **International Biographical Centre, Cambridge, England, INNOVATIVE SCIENCE TEACHER AWARD-2011** by the J&K State Council for Science and Technnology, Dept. of Science and Technology, J&K besides receiving other awards and recognitions. She is **Member, Board of Councillors,** Indian Journal of Environmental Sciences, Green Earth Foundation, Rajasthan, **Associate Editor, Science Bulletin,** 'The Society of Life Sciences', Satna, Madhya Pradesh, **Honorary Member** of the Zoological Association of Kurukshetra University, Kurukshetra, **Reviewer** of 'African Journal of Agricultural Research', Nairobi, South Africa, **Member, Editorial Board** 'Journal of Food and Agricultural Sciences', Bowie, Maryland, United States, **Reviewer, '**Greener Journal of Biological Sciences', International Greener Journals, Ikeja, Lagos, Nigeria, **Reviewer, '**Environment Monitoring and Assessment', a **Springer Verlag Journal.** She has attended over 50 conferences/seminars in different parts of India and has presented papers, delivered invited talks/guest lectures and has chaired sessions. She is Life Member of Member, Indian Science Congress Association, Kolkata, The National Academy of Sciences, India, Allahabad, Society of Cytologists and Geneticists, Bangalore, Karnataka, All India Congress of Cytology and Genetics, West Bengal, International Society of Applied Biology, Lucknow, The Society of Life Sciences, Madhya Pradesh, Green Earth Foundation, Rajasthan. She has 17 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. Dr. Khanna has reported 14 new species of an insect called *Chironomus* from Jammu and Kashmir, out of which 7 form the first time reports from the world.