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Research Article

APPRAISAL OF GROUND WATER QUALITY FOR IRRIGATION IN OUTER PLAINS OF KATHUA DISTRICT, J&K, INDIA

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ABSTRACT
The objective of this research was assessment of quality of shallow ground water of the Outer Plains of Kathua District for its suitability for irrigation and other uses. About 23 samples were collected from the dugwells of coarse grained formation Kandi belt and fine grained Sirowal belt of Outer Plains. Samples were investigated for Sodium Adsorption Ratio, Magnesium Adsorption Ratio, Kelley's Ratio, Residual Sodium Bi-Carbonate, and alkalinity hazard and Permeability Index. The preferential order of cations and anions in the study area is $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$ and $HCO_3^{2-} > Cl^{-} > NO_3^{-} > SO_4^{2-}$ respectively. Results of chemical analysis revealed a pH of mean value 7.4, E.C of 564 µS/cm, Ca of 54.45 mg/l, Mg of 21.74 mg/l, and Na of 27.45 mg/l, K of 13.14 mg/l and anions having mean values of HCO3 of 232.4 mg/l, Cl of 37.76 mg/l, SO4 of 13.68 mg/l, NO3 of 20.92 mg/l, F of 0.22 mg/l and Fe of 0.92 mg/l. SAR, SSP, MAR, PI indicate that majority of the water are suitable for irrigation. Kelley's Ratio shows that 57% of the water samples are above permissible limit of good irrigation waters while 43% fall within. Calculated SAR and EC classify 73.9% of the samples into medium salinity to low sodium hazard (C2S1), 8.6% within low salinity and low sodium hazard (C1S1) and 17.39% within the high salinity and low hazard (C3S1). The groundwater qualities satisfy the condition for use in agriculture as well as other uses.

Keywords: *Groundwater, Chemical Parameters, Sodium Adsorption Ratio (SAR), Permeability Index (PI), Kelley's Ratio (KR), Magnesium Adsorption Ratio (MAR)*

INTRODUCTION
Groundwater is extensively used for drinking, irrigation and industrial purposes. Many factors like leachate from landfill sites, irrigation return flow and domestic and industrial wastes can change the groundwater quality. The various land use practices, geology, rainfall patterns, climatological factors affect the groundwater use.

In the recent past many studies have reported focusing on the groundwater quality issues. The hydrogeochemical aspects and studies on groundwater quality with respect to irrigation purposes have been carried out and reported in India (Niranjan *et al.*, 1997; Subba *et al.*, 1999; Dhiman, 2005; Thirumala *et al.*, 2005; Subba, 2006; Jayalakshmi *et al.*, 2009; Ravikumar *et al.*, 2011).

Water quality analysis is one of the most important aspects in groundwater studies. The hydrochemical study reveals quality of water that is suitable for drinking, agriculture and industrial purposes. Chemical analysis forms the basis of interpretation of the quality of water in relation to source, geology, climate, and use. Water being an excellent solvent, it is important to know the geochemistry of dissolved constituents and methods of reporting analytical data. The present paper is an attempt to assess the quality of shallow ground water for suitability in irrigation and other uses of the Outer Plains of Kathua District.

Study Area
Kathua district is the gateway to the State of Jammu and Kashmir, covers an area of 2651 sq. km. constituting 1.9 percent of the total area of the State. The district shares its boundary with Himachal Pradesh in the east, Punjab in the south, Udhampur district in the north and Jammu district in the west. The south western boundary is contiguous with the international border with Pakistan.

The study area lying on the south western part of the district at the foot of outer most Siwalik hill is called as Outer Plain. This plain tract is underlain by the sediments of Recent to sub-Recent age, laid down by the present day streams in the area. On the basis of the sediment size, the plain can further be divided in

two parts viz. the Kandi in north and Sirowal in the south. The Kandi belt comprised of heterogenous coarse clastic sediments and it imperceptibly merge with the Sirowal belt. There is a general decrease in the particle size in the area thus the Sirowal belt comprised of finer sediments

Sub-tropical climate prevails in the study area where summers are very hot and winters are cold and dry. The summer season starts from April to June; the southwest monsoon usually arrives in the first week of the July and remains active till September The month October and November, although generally dry, are most pleasant part of the year. The area experiences rainfall in winter season also which is due to western disturbances. Ravi River along with its tributaries namely Ujh, Tarnah and Bein drains the district from east to west.

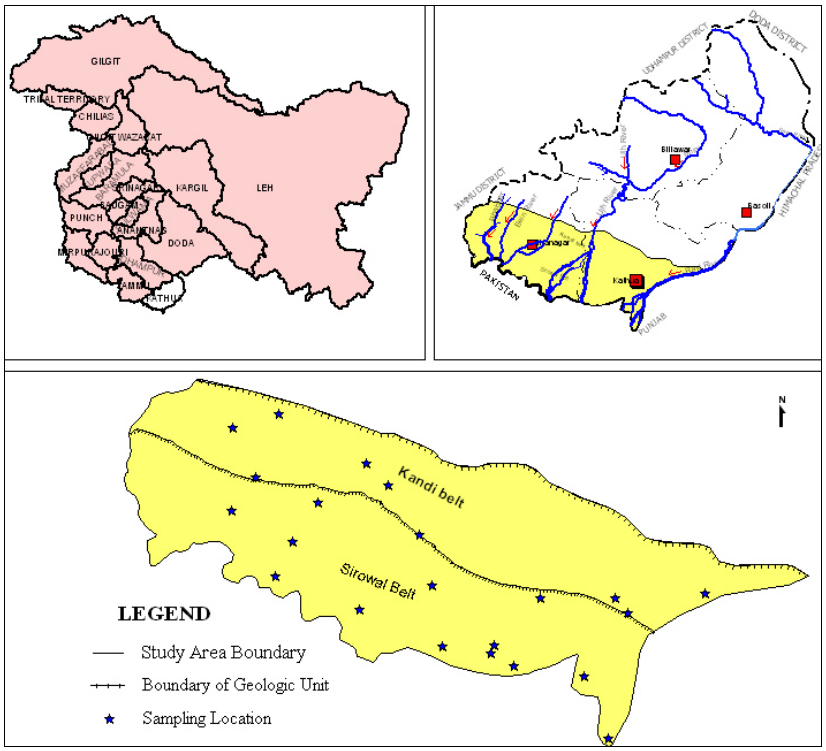

Figure 1: Sampling Location Map of the Study Area

Hydrogeology

In the study area, which is about 50 km in length and 10-20 km in width, groundwater occurs as a regional groundwater body. Depth to water table is deep in Kandi belt and here ground water occurs under water table conditions and in Sirowal belt water table is quite shallow and ground water occurs under both water table as well as confined conditions.

MATERIALS AND METHODS

Methodology

Twenty three water samples were collected from dug wells of Kandi and Sirowal Belts of Kathua District and subjected to chemical analyses. Sample locations and numbers are plotted in Figure 1, to display their spatial distribution in the study area. The samples were collected in 1000 ml plastic bottles. They were then carefully sealed, labeled and taken for analyses. Chemical analyses were performed in the laboratory employing standard methods of APHA (1998). Ions were converted from milligram per liter to mill equivalent per liter and anions balanced against cations as a control check of the reliability of the analyses results. The analytical results were compared with the standards specification (BIS, 2006) for drinking.

The quality analysis for irrigation was revealed after calculating SAR, SSP, PI, MAR and KR and comparing them as per standards.

The Sodium Adsorption Ratio (SAR) was calculated by the following equation given by Richards (1954) as:

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

where all the ions are expressed in meq/L.

The Soluble Sodium Percentage (SSP) was calculated by the following equation (Todd, 1980):

$$SSP = \frac{(Na^{+}+K^{+}) \times 100}{(Ca^{++}+Mg^{++}+Na^{+}+K^{+})}$$

where, all the ions are expressed in meq/L.

The Permeability Index (PI) was calculated according to Doneen (1964) employing the following equation:

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

where, all the ions are expressed in meq/L.

The Magnesium Adsorption Ratio (MAR) was calculated using the following equation (Raghunath 1987):

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

where, all the ionic constituents are expressed in meq/L.

The Kelly's Ratio was calculated by employing the following equation as:

$$KR = \frac{Na^{+}}{Ca^{++}+Mg^{++}}$$

where, all the ionic constituents are expressed in meq/L.

RESULTS AND DISCUSSION

Table 1: Chemical Parameters compared with BIS Standards

Parameters	BIS Limits		Dugwells		
	Desirable Limit	Permissible limit	Min	Max	Mean
pH	6.5-8.5	No relaxation	6.55	7.9	7.44
EC µmhos/cm at 25°C	500	2000	182	2010	564
CO_3 (mg/l)	-	-	0	0	
HCO_3 (mg/l)	-	-	75	427	232.86
Cl^- (mg/l)	250	1000	7	163	37.76
NO_3^- (mg/l)	45	100	0.1	265	20.91
F^- (mg/l)	1	1.5	0.01	0.8	0.223
SO_4^{2-} (mg/l)	200	400	0	60	13.68
Ca^{2+} (mg/l)	75	200	24	172	54.45
Mg^{2+} (mg/l)	30	100	5	80	21.73
Na^+ (mg/l)	-	-	7.7	97	27.427
K^+ (mg/l)	-	-	0.9	132	13.14
Fe (mg/l)	0.3	1	0	7.5	0.92
TH as $CaCO_3$ (mg/l)	300	600	82	760	224.31

Assessment of Chemical Parameters of Groundwater for Drinking Purpose

Geochemical properties and principles that govern the behavior of dissolved chemical constituents in groundwater are referred to as hydro-geochemistry. The dissolved constituents occur as ions, molecules or solid particles, these constituent not only undergo reactions but also redistribution among the various ionic species or between the liquid and solid phases. The chemical composition of groundwater is related to the solid product of rock weathering and changes with respect to time and space. Therefore, the variation on the concentration levels of the different hydro-geochemical constituents dissolved in water determines its usefulness for domestic, industrial and agricultural purposes. However, the use of water for any purpose is guided by standard set by the Bureau of Indian Standards (BIS) and other related agencies. In this study, the results of the analyzed chemical parameters in the study area were correlated with those of the BIS (2006) for drinking purpose (Table 1).

The pH of ground water in the study area ranged from 6.55 to 7.59. The average pH for these 23 samples is 7.35. The average EC is 555.76 µS/cm, the minimum EC of ground water was observed 182 µS/cm at Ghagwal and maximum EC is 896 µS/cm at Sherpur Bala. Dugwell at Jandi has the highest EC value of 2010 µS/cm.

Cations

The dominant cation is Calcium, followed by Magnesium and Sodium. Calcium and Magnesium along with their Carbonates, Sulphates and Chlorides make the water hard. The average values for Calcium and Magnesium are 53.41 mg/l and 21.05 mg/l and minimum and maximum values ranged from 24 to 172 mg/l and 5 to 80 mg/l respectively. The concentration of Sodium in the study area varies from 8.3 to 84 mg/l. Potassium is an essential element for all living beings and derived in food chain mainly from vegetation and soil. Its concentration in ground water of the study area varies from 1 to 7.5 mg/l of minimum and maximum respectively. The order of dominance of cations in the ground water of the study area is $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$.

Anions

The presence of Carbonates, Bicarbonates and Hydroxides are the main cause of alkalinity in natural waters. Bicarbonates represent the major form since they are formed in considerable amount from the action of Carbonates upon the basic materials in the soil. It is the dominant anion and its value in the ground water samples of the study area varies from 75 to 427 mg/l. The concentration of Chloride varies from 7 to 163 mg/l. The average minimum and maximum values for Sulphate concentration in the ground water samples of the study area are 0 and 46 mg/l respectively. Nitrate content in drinking water is considered important for its adverse health effects. In the study area it is well within the permissible limits of BIS viz. 45 mg/l, except for one sample of Jandi area where it is 265 mg/l which may be due to some localized pollution. The Fluoride values ranged from 0.01 to 0.8 mg/l. The presence of Iron in ground water is due to the processes involved during rock formation. The concentration limits of Iron in water samples ranges between 0 mg/l and 7.5 mg/l. Six samples has Iron values above 0.3 mg/l. The highest value of Iron is found in a sample from dugwell of Nagri -I (7.5 mg/l). The order of dominance of anions in the ground water of study area is $HCO_3^{2-} > Cl^{-} > NO_3^{-} > SO_4^{2-}$.

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

Hardness as $CaCO_3$ (ppm)	Water class	Water samples
0-75	Soft	0
75-150	Moderate Hard	6 (82-150)
150-300	Hard	15 (175-290)
>300	Very hard	2 (305-760)

Total 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 Outer Plains, the total hardness varies between 82 to 760 ppm. According to Sawyer *et al.*, (2003) classification for hardness, none of the

samples fall under soft class and 06 samples fall under moderately hard class whereas 15 samples fall under hard and 2 samples under very hard class for water samples. The hardness classification is given in Table 2.

Assessment of Chemical Parameters of Groundwater for Irrigation Purpose

The suitability of the shallow groundwater for irrigation has been qualified according to irrigation indices (SAR, SSP, Salinity Hazard, PI, MAR and KR). The statistics of water samples for SAR, SSP, KR and MAR values is given in Table 3.

Table 3: Statistics for Irrigation Indices.

Parameter	Range	Water Class	Number of samples
SAR	<10	Excellent	23
	10-18	Good	-
	18-26	Doubtful	-
	>26	Unsuitable	-
SSP	<50	Good	23
	>50	Bad	-
KR	<1	Good	10
	>1	Unsuitable	13
MAR	<50	Good	23
	>50	Unsuitable	-

SAR

A better measure of the Sodium hazard for irrigation is the Sodium Adsorption Ratio (SAR) which is used to express reactions with the soil. During pre –monsoon 2012, the SAR values of all 23 samples were found to be less than 10 and are classified as excellent for irrigation. Calculated SAR and EC classify 73.9% of the samples into medium salinity to low sodium hazard (C2S1), 8.6% within low salinity and low sodium hazard (C1S1) and 17.39% within the high salinity and low sodium hazard (C3S1).

Irrigation water having high SAR levels can lead to the build-up of high soil sodium levels over time, which in turn can adversely affect soil infiltration and percolation rates due to soil dispersion.

Soluble Sodium Percentage (SSP)

Soluble Sodium Percent is an important factor for studying Sodium hazard. High percentage Sodium water for irrigation purpose may stunt the plant growth and reduces soil permeability (Joshi *et al*., 2009). In the study area SSP ranges between 0.97 and 13.82. All the twenty three samples (100%) have SSP values less than 50 which indicate good quality water for irrigation.

Kelly's Ratio (KR)

Water having KR more than one indicates an excess level of Sodium (Kelly, 1946). As discussed, excess sodium levels make water unsuitable for irrigation. The KR values of water samples of the study area ranged between 0.41 and 6.58. Ten samples fall within the permissible limit of 1.0 making water suitable for irrigation purpose and thirteen samples have KR >1 indicating the unsuitable water quality for irrigation.

Permeability Index (PI)

The soil permeability is affected by the long-term use of irrigated water and the influencing constituents are the total dissolved solids, Sodium Bicarbonate and the soil type. In the present study, the permeability index values range between 1.15 and 13.89 meq/l. The above result therefore suggests that water samples fall within Class I and can be categorized as good irrigation water.

Magnesium Adsorption Ratio (MAR)

Generally, Calcium and Magnesium maintain a state of equilibrium in water. More Magnesium in water will adversely affect crop yields as the soils become more saline (Joshi *et al*., 2009). The values of the Magnesium Adsorption Ratio of shallow groundwater in present study vary from 0.47 to 6.74% and all the samples have MAR less than 50% indication good quality of water for irrigation.

Conclusion

The suitability of shallow groundwater in Outer Plains of Kathua district was investigated for irrigation and other usability status. The chemical parameters and calculated indices such as SAR, SSP, KR, PI and MAR were employed to determine its suitability for irrigation and other purposes. Results indicated that calcium is the dominant metal in the analyzed samples. However, the groundwater revealed low sodium hazard and alkalinity hazard. Majority of the groundwater samples satisfy the required quality needed for irrigation and other agricultural uses. In general, most of the water from shallow wells in Outer Plains is suitable for domestic, industrial and irrigation purposes.

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