ASSESSMENT OF CHEMICAL QUALITY OF GROUNDWATER IN THE EQUIVALENTS OF BHABHAR AND TARYAI BELTS OF JAMMU DISTRICT, J&K

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ABSTRACT

The Kandi and Sirowal belts are the equivalents of Bhabhar and Taryai Belts of Indo Gangetic Plains in the State of Jammu and Kashmir. These belts together comprise the outer plains of Jammu and Kashmir which extends throughout Jammu and Kathua districts. In Jammu district Kandi and Sirowal belts occupy more than 75% of the area of district viz 2000 sq.km.

This paper deals with the study of results of chemical analysis of 44 Water samples collected during pre-monsoon of 2009. The analysis of these water samples reveals there is predominance of Ca and Mg ions which not only makes the water hard but also contributes to the Ca-Mg-HCO3 type of water in the Kandi and Sirowal Belts of the district. Except for nitrate and fluoride at some places all other constituents are found to be in the permissible limits of BIS. The suitability of ground water for irrigation purpose suggests that water from about 28 dugwells is suitable as these falls in C2S1 category, 16 are under doubtful class and 1 sample is unsuitable.

Key Words: Kandi belt, Sirowal, Sirowal belt, ground water .

INTRODUCTION

Jammu district lies between 32°33'07" & 33° 07'30" North latitudes and 74°27'00" & 77°21'00" East longitudes and is covered by Survey of India degree-sheet no 43L and 43P. The district has a total geographical area of 3165 sq km out of which 1165 sq km is covered by hilly terrain and 2000 sq km is the outer plains, which comprises of *Kandi* and *Sirowal* belts.

The Kandi Belt is equivalent to the Bhabhar and Sirowal Belt is equivalent to Taryai belt of Indo-Gangetic plains in the State of Jammu and Kashmir. In Jammu district, these two belts together covers an area of 2000 sq.km, and are bounded by the Siwalik hills on the northeastern edge and by the International Border with Pakistan on the southwestern side. These are located at the foot of the outer most Siwalik hills and have an altitude varying between 280 and 400 m. above the mean sea level. Innumerable seasonal nalas traverse the area.

The *Kandi* tract has got steep topographic slopes ranging between 1:90 and 1:120. General altitude of the *Kandi* ranges between 320 to 400 m. above the mean sea level. Water levels are deep, resulting into very less number of ground water structures i.e. dug wells and tube wells. The *Kandi* imperceptibly merges with the *Sirowal* southwards.

The *Sirowal* tract having altitude less than 300 m. above the mean sea level occupies the southern plainest tract of the district. Topographic gradient is reduced and become very gentle i.e.1:250 to 1:300. The contact between the *Kandi* in north and the

Sirowal in the south is marked by Spring Line

Two major perennial rivers coming from the hills viz. Chenab and Tawi drains the area and enters Pakistan territory in the southwest. Basantar River and Aik nala also follows the same trend of the major rivers. (Fig. 1) Apart from these, several seasonal nalas traverse the area, which are boulder laiden and have broad shallow channels, having water only for short time after the rains

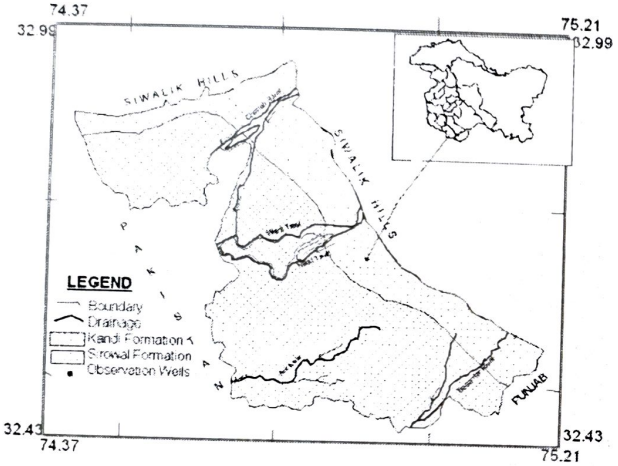

Fig 1. Location Map of the study area

MATERIAL AND METHODS

The results of analysis of 44 water samples, collected during pre-monsoon viz. May 2009 were studied for the assessment of water quality of Kandi and Sirowal Belts of Jammu District. The samples were analysed for the most commonly occurring variables viz. specific conductance, pH, Ca, Mg, Na, K, Cl, SO_4, HCO_3, NO_3, and F using standard methods of Bureau of Indian Standards (BIS). The ground water is classified through trilinear diagrams and the variation in the quality was predicted.

Geological Setting

Kandi formation lies at the foothills of Siwalik formation brought by the streams deposited as alluvial fans. It consists of boulders, cobbles, gravels, sand, silt and clay. Near the Siwalik, the sediments are coarse and vary in size form boulder to pebble with varying percentage of silt and clay. While gravel and sand with silt and clay exist away from the hill. The width of this formation varies from 4 km in the southeast to 10 km at the central region

Southern part of the outer Jammu plain is covered by Sirowal which lie south of the Kandi. A topographic contour of 300 to 320 m amsl demarcates the Sirowal belt form the Kandi. The Sirowal sediments are well stratified and its grain size is generally finer than Kandi. This belt comprises alternating layers of gravels, sand and clay. The swampy conditions emerge at places due to out flow of water along the spring line where ever clay beds comes in contact of surface, giving rise to the spring line.

Groundwater Flow

Groundwater occurs both under water table and confined conditions in the Sirowal and under unconfined conditions in *Kandi* belt. It occurs in the saturated parts of alluvium sediments in the pore spaces. The flow direction of groundwater is broadly form north to south and corresponds roughly with the topographic slope. (Fig. 2) Rainfall is the main sources of ground water replenishment in Kandi area whereas seepage from canal system, return flows from surface and ground water irrigation also contributes to a large quality of water

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to the aquifer system.

The water level of *Kandi* belt is deeper than in Sirowal belt. The depth to water level increases towards Siwalik formation and decreases towards Sirowal formation. It is as shallow as *1.0 mbgl in Sirowal* and as deep as *35.0 mbgl* in *Kandi* belt. The hydraulic gradient in Kandi belt is between 1:90 and 1:120 and between 1:200 and 1:250 in *Sirowal* belt. Water level fluctuation varies between 0.50 m and 4.50 m in *Kandi* belt and between 0.20 m and 2.00 m in *Sirowal* belt. Average fluctuation in the entire area is 1.50 m.

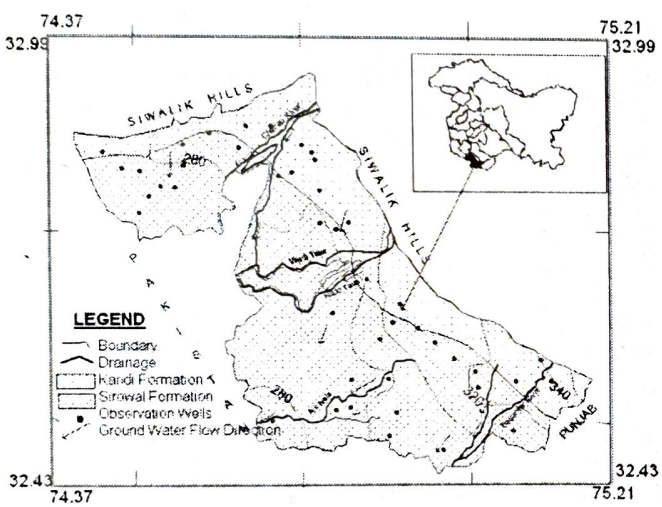

Fig. 2 Water Table Contour and locations of DW

RESULTS AND DISCUSSION

Ground Water Quality

The ground water quality is a dynamic parameter keeps on changing with time. The change in the quality is the resultant of all the processes and reactions that have acted on the water. For a particular use, the quality of water is very important to be determined.

The chemical analysis of ground water samples collected from 44 dugwells of Kandi and Sirowal viz. Outer Plains of Jammu area revealed the following :

pH

pH may be defined as negative logarithmic of Hydrogen ion concentration. The pH of ground water was observed in the range of 7.0 to 8.05. The average pH for these 44 samples is 7.41. The pH values for all the samples are well within the limits prescribed by BIS (1991) and WHO (1996) 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 substance in water and may also be related to problems of excessive hardness and/or other mineral contamination. The average EC is 795. µS/cm, the minimum EC of ground water was observed 305 µS/cm and maximum EC is 3240 µS/cm.

Major Ionic Constituents

In natural waters, dissolved solids consists mainly of inorganic salts such as carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron etc. and small amount of organic matter and dissolved gases. In the present study the values of total dissolved solids (TDS) in the ground water varied from 186.2 to 1495.5 mg/l.

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 the value in the ground water varied from 122-

1379 mg/l. during the present study.

The dominant cation is calcium, followed by magnesium and sodium. Calcium and magnesium along with their carbonates, sulphates and chlorides make the water hard (Fig. 3). The average values for calcium and magnesium are 61.2 mg/l and 33.7 mg/l and minimum and maximum values ranged from 14 to 152 mg/l and 6 - 112 mg/l respectively.

The concentration of sodium in the study area varies from 4 to 220 mg/l. The Bureau of Indian Standards has not included sodium in drinking water standards. But ground water with high sodium is not suitable for irrigation purpose due to sodium sensitivity of crops/plants. Potassium is an essential element for humans, plants and animals and derived in food chain mainly from vegetation and soil. The concentration of potassium in ground water of the study area varies from 0.9 to 320 mg/l of minimum and maximum respectively.

The concentration of chloride varies from 7.1 to 277 mg/l in the ground water of the outer plains. The average minimum and maximum values for sulphate concentration in the ground water of the study area are 0 and 100 mg/l respectively. Nitrate content in drinking water is considered important for its adverse health effects. The nitrate content in the study area varies from minimum of 1.6 to maximum 188 mg/l indicating that all the samples of the study area falls within the desirable limit of 45mg/l except for 7 samples which have NO_3 concentrations higher than the prescribed limits because of anthropogenic causes viz. use of nitrogenous fertilizers, irrigation practices and cattle area. The fluoride values ranged from 0 to 1.76 mg/l.

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 135.9 to 840 ppm. According to Sawyer and McCarthy's (1967) classification for hardness (Table 1), 2 samples fall under moderately hard class and 29 samples fall under hard and 13 under very hard class for water samples.

Table 1: Classification of water based on hardness by Sawyer and McCarthy 1967

Hardness as $CaCO_3$ (ppm)	Water class	Water samples
0-75	Soft	0
75-150	Moderate Hard	2 (135.9-140.7)
150-300	Hard	29 (152.3-299.5)
>300	Very hard	13 (329.7-840)

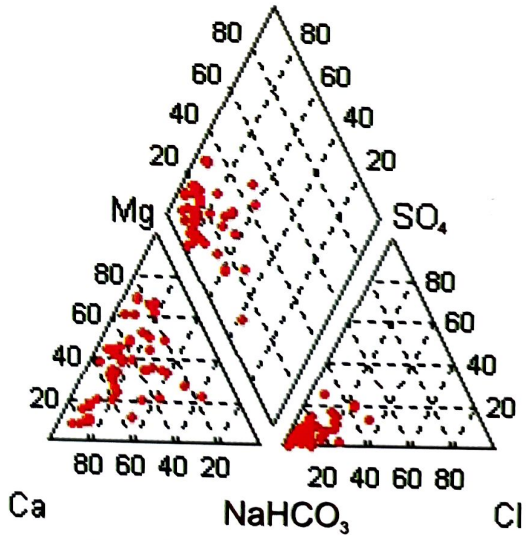

Fig. 3 Paper linear diagram showing different water types

Classification Of Ground Water

The analytical data of major cations and anions such as Na+, K+, Ca_2+, Mg_2+, HCO_3-, $CO_3^{(2-)}$), $SO_4^{(2-)}$ and Cl- was plotted in hydro chemical trilinear Hill-Piper diagram to identify the facies.

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Facies are recognizable parts of different characters belonging to any genetically related system (Sadashivaiah. *et al.*, 2008). In the present study HCO_3 is the dominant anion with calcium and magnesium ions and the combination of these cations resulting in Ca-Mg-HCO_3 type and Mg-Ca-HCO_3 type of facies followed by Na and K ions. Only few samples have mixed type of water(Fig.3).

The dominance of alkaline earth metals viz. Ca and Mg followed by alkali metals viz. Na and K can be related to the presence of clay and silt in the Outer Plains. The alkaline earth metals thus not only contributes to the major type of water in the area but also is a cause of hardness of water.

Suitability for Irrigation

The graphical plot of values of SAR (Sodium absorption ratio) and specific conductance of water on the US salinity (USSL) diagram, enables to classify water for irrigation purposes. The US salinity plot of these 44 samples reveals that the groundwater of Kandi and Sirowal Belts is in general Ca-Mg-HCO_3 type. About 98% of the samples are grouped within C2S1 and C3S1 classes, except for the one that falls in C4S1 category. The water falling in C4S1 category is suitable for irrigation purposes only after getting treated or by applying typical agricultural practices.

SAR

A better measure of the sodium hazard for irrigation is the SAR which is used to express reactions with the soil. During Pre monsoon 2009, the SAR value of all the samples are found to be less than 10 (0.4 4.8), and are classified as excellent for irrigation

Table 2. Suatibility for Irrigation

Sodium Hazard class	SAR in Equivalents per mole	Remark on quality
S1	10	Excellent 0.14- 4.89 (All Samples)
S2	10 – 18	Good
S3	18-26	Doubtful
S4 and S5	>26	Unsuitable

Salinity Hazard

For the purpose of diagnosis and classification, the total concentration of soluble salts (salinity hazard) in irrigation water can be expressed in terms of specific conductance. It is found from the EC value, only 1 sample of (Bengular) was found to be unsuitable for irrigation purposes (Table 3)

Table. 3. Salinity hazard criteria for water samples

Salinity hazard Class	EC in(µmohs/cm)	Remark on quality	no. of samples
C1	100-250	Excellent	- No samples
C2	250-750	Good	305-742 (28 samples)
C3	750-2,250	Doubtful	775-1350 (15 samples)
C4 & C5	>2,250	Unsuitable	3240 (1 sample)

CONCLUSIONS

The inference drawn from the study of ground water chemistry of shallow aquifer of outer plains of Jammu indicates that :

1. The type of water that predominates in the study area is Ca-Mg-HCO_3 type based on the hydrochemical facies (May 2009).
2. The dominance of Ca and Mg results in the hardness of water in 65% of water samples from the outer plains.
3. Though the suitability of water for irrigation is determined based on SAR and Salinity hazard, it is only an empirical conclusion.
4. In addition to water quality, other factors like soil type, crop type, crop pattern, frequency and recharge (rainfall), climate, etc. have an important role to play in

determining the suitability of water.

5. About 98% of the samples are grouped within C2S1 and C3S1 classes.

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