GROUNDWATER QUALITY AND STABLE ISOTOPIC COMPOSITION IN SOUTH-WEST, PUNJAB

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Abstract: The study is carried out mainly in the Bhatinda district of Punjab. The district comprises of 7 blocks (Bhatinda, Nathana, Rampura,Phool, Talwandi sabo, Sangat, Maur) and out of which 4 blocks namely Rampura, Phool, Nathana, Maur are over exploited. The random samples were collected from 20 sites covering the entire 7 blocks of the Bhatinda district. Electrical conductivity ranged from 470 to 6000 μS/cm at 25°C. Around 83% of the district area has been found to have EC value more than 1000 μS/cm at 25°C out of which 30% of the district area is having EC value more than 3000 μS/cm at 25°C. The southern and western parts are showing high values of EC. The fluoride (F) values range from 0.6 mg/l to 4.4 mg/l and some areas in the district especially in north, central and small patches in south-western and eastern parts showing high values of fluoride exceeding the permissible limit of 1.5 mg/l for drinking water standards. The total hardness varies from 151 mg/l to 1468 mg/l and the water belongs to the category of very hard water. The -18O values ranged from -5.85 to -11.26‰ with an average of -8.61‰. The enriched values are found in the eastern and western parts of the district, while southern and northern parts are showing highly depleted values.

***Keywords:** Groundwater, quality, isotopic composition, southwest Punjab*

INTRODUCTION

Groundwater has emerged as most preferred source of water to meet the requirements of various user sectors in India due to its near universal availability, dependability and low capital cost. Ground water has made significant contributions to the growth of India's economy and has been an important catalyst for its socio-economic development. The increasing dependence on ground water as a reliable source of water has resulted in its large-scale and often indiscriminate development in various parts of the country, without due regard to the recharging capacities of aquifers and other environmental factors.

The unplanned and non-scientific development of ground water resources, mostly driven by individual initiatives has led to an increasing stress on the available resources. The adverse impacts can be observed in the form of long-term decline of ground water levels, de-saturation of aquifer zones, increased energy consumption for lifting water from progressively deeper levels and quality deterioration due to salinity. There are areas in the country, where ground water development is still at low-key in spite of the availability of sufficient resources, similarly the canal command areas suffer from problems of water logging and soil salinity due to the gradual rise in ground water levels.

The groundwater quality is controlled by various factors such as soil characteristics, climate, topography, interaction with aquifer minerals, or internal mixing among different groundwater along flow paths in the subsurface (Domenico 1972; Wallick and Toth 1976; Reghunath et al. 2002; Singh et al. 2010).

The Punjab plains in the past 3-4 decades witnessed a boom in groundwater use and many authors have studied this problem of depleting water quality and fall in water tables (Dhawan 1995; Sondhi et al. 2001; Ambast et al. 2006). Many districts of Punjab show 100% or even greater levels of exploitation and the same is exhibited by

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lar decline in pre-monsoon water tables except for remely wet years.

The water-logging and deteriorating ground water quality of southwest Punjab, India has affected an area exceeding 200 km^2. The reasons for this are considered to be due to inadequate drainage system, excess application of irrigation water, non-exploitation of groundwater resource and excessive use of pesticides. The increasing groundwater salinity is reducing the availability of fresh water for drinking and irrigation needs. More than 75 km^2 area has become saline. This is also affecting the crop production. The origin of salinity in soils and in groundwater in shallow and deeper aquifers and its growth in space and time is not well understood.

In the present study, the groundwater quality of Bhatinda district was evaluated from various deep (tube wells) and shallow aquifers, i.e., hand pumps along with the isotopic data to understand groundwater quality and conditions.

STUDY AREA

The study is carried out mainly in the Bhatinda district of Punjab. The district covers an area of 3369 sq. km and comprises of 7 blocks (Bhatinda, Nathana, Rampura,Phool, Talwandi sabo, Sangat, Maur). The study area is situated between 29°33 and 30°36 North latitude and 74°38 and 75°46 East longitudes in the southern part of Punjab (Fig. 1). It is nearest to the Thar Desert of Rajasthan and far away from the major rivers that run through the state. The monsoon is scanty and meager. The average rainfall is 410 mm. The district is situated within the Satluj-Ganga plain.

METHODOLOGY

The random groundwater samples were collected from 20 sites (fig. 1) covering the entire 7 blocks of the Bhatinda district using standard protocol. Sampled wells/tubewells were selected to represent different geological formations as well as land use pattern and different depths of the aquifer.

All water samples were collected in the pre-washed polyethylene bottles. At the time of sampling, bottles were thoroughly rinsed two to three times with groundwater to be sampled. Each hand pump was properly flushed at least for five minutes before taking the sample.

Samples were monitored carefully for electrical conductivity (EC) measurement using in-situ probe and when this parameter reached to constancy, samples were collected. The sampling bottles were carefully filled just to overflowing and ensuring no air bubble is trapped inside the sample container. The samples were brought to the laboratory and stored in a cold room at 4 °C.

The sample sites location with latitude & longitude was noted properly in the notebook using Garmin global positioning system (fig. 1). The samples were properly labelled and then immediately transported to the laboratory. All samples were filtered to separate the suspended sediments and the analysis was carried out as early as possible in the laboratory.

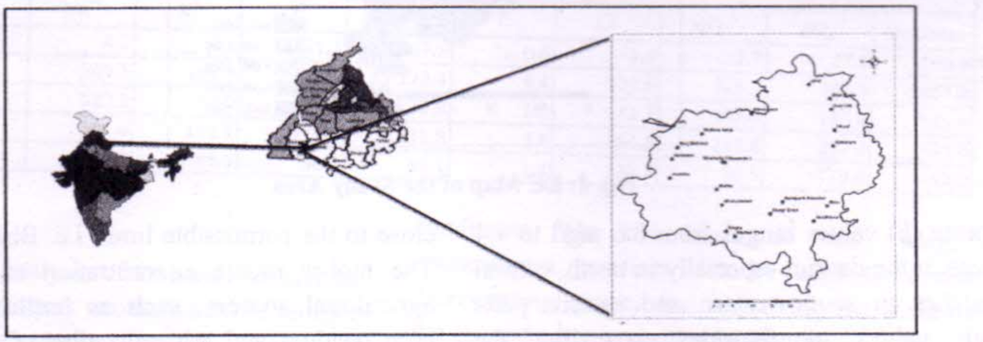

Fig. 1: Study Area with Sampling Points

The samples were analysed for major anions F^-, Cl^-, NO^-_3 and cations Ca^{++}, Mg^{++}, Na^+, K^+ using Dionex Ion Chromatograph ICS-5000 and stable isotope ($\delta^{18}O$) was measured using DI-IRMS at Nuclear Hydrology Laboratory, National Institute of Hydrology, Rookree. For analysis of anions and cations before performing the analysis, Ion Chromatograph was calibrated using anion mixture standard and cation mixture standard. Total permanent water hardness was calculated as sum of calcium and magnesium hardness. After calculating the hardness, the hardness has been classified as per Table 1.

Table 1: Hardness classification for water

Class	Range of Total Hardness (mg/l)
Soft	0-60 mg/l
Moderately hard	61-120 mg/l
Hard	121-180 mg/l
Very hard	> 180 mg/l

RESULTS AND DISCUSSION

Electrical conductivity ranged from 470 to 6000 µS/cm at 25^0C. Around 83% of the district area has been found to have EC value more than 1000 µS/cm at 25^oC out of which 30% of the district area is having EC value more than 3000 µS/cm at 25^oC (fig. 2). The southern and western parts are showing high values of EC. The increase in EC may be due to rise in water levels and possibly due to comparatively more temperature in summers in the areas closer to the desert. This increases the evaporation and salts in soils rise towards surface thus causing salinity.

Table 2 provides that the sodium (Na^+) values range from 4.7 mg/l to 509.1 mg/l and the potassium (K^+) values range from 8.2 mg/l to 199.3 mg/l. The highest Na^+ (509.1 mg/l) was found in Ramgarh and also exceeding the permissible limit (200 mg/l) of WHO, 2008.

The total hardness varies from 150.6 mg/l to 1467.8 mg/l and the water belongs to the category of very hard water.

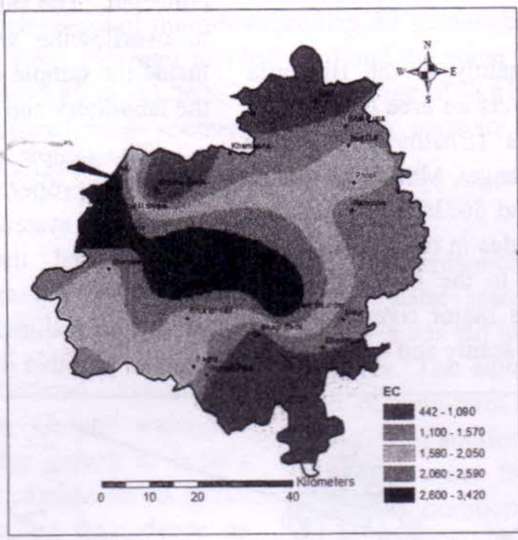

Fig. 2: EC Map of the Study Area

The fluoride (F) values ranges from 0.6 mg/l to 4.4 mg/l some areas in the district especially in north, central and small patches in south-western and eastern parts showing high values of fluorides exceeding the permissible limits of 1.5 mg/l for drinking water standards (WHO, 2008).

The chloride (Cl^-) values range from 7.3 mg/l to 501.6 mg/l and the nitrate (NO_3^-) values range from 2.7 mg/l to 216.5 mg/l.

The sulphate (SO_4^-) values ranged from 27.1 mg/l to 784.3 mg/l. The concentration of nitrate exceeding the permissible limit (50 mg/l) of WHO (2008) was observed in Mehta, Phul, Bhatinda, Rama, Ablu and Ramgarh with the highest being in Balluana (216.5 ppm). There were some other sites from where nitrate concentrations were close to the permissible limit, i.e. Bhikianwali (46 ppm). The higher nitrate concentration can be attributed to agricultural sources, such as fertilizers, animal waste, crop residues and mineralization of soil organic nitrate and on the other hand non-agricultural sources such as septic tanks, effluents containing nitrogen discharged from industries.

The $\delta^{18}O$ values ranged from -5.85 to -11.26‰ with an average of -8.61‰ (fig. 3). The enriched values are found in the eastern and western parts of the district, while southern and northern parts are showing highly depleted values. The enriched values found between the canals Bhatinda branch and Kotla branch may be attributed to evaporation from shallow water table areas.

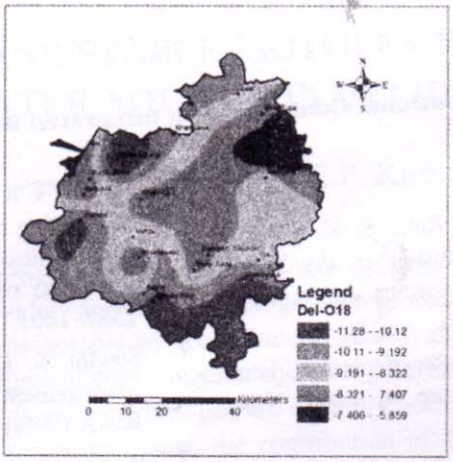

Fig. 3: Stable Isotope Composition Map

As evident from the figure 4, there is an increase in EC and enrichment in isotopic composition as observed in some samples due to the evaporation effect and in some samples the increase is EC is found but the isotopic composition remains constant indicating the increase in EC due to geogenic reasons.

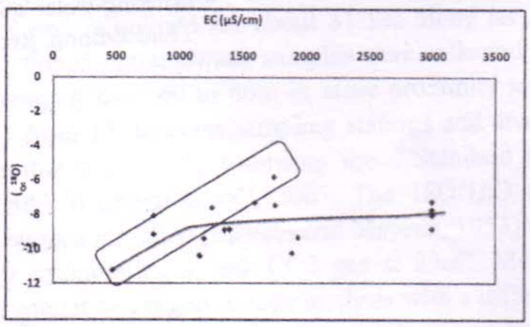

Fig.4. Relationship between EC and $\delta^{18}O$

Table: 2. Stastistical summary of Water Quality Parameters

	Ion Concentration (mg/l)								
	Na^{++}	K^{+}	Mg^{++}	Ca^{++}	F^{-}	Cl^{-}	NO_3^{-}	SO_4^{-}	Hardness
Minimum	4.7	8.2	21.3	17.5	0.6	7.3	2.7	27.1	150.6
Maximum	509.1	199.3	240.9	229.3	4.4	501.6	216.5	784.3	1467.8
Mean	120.2	42.0	81.4	77.6	1.8	131.7	47.4	192.4	541.6
Range	504.4	191.1	219.6	211.8	3.8	494.3	213.8	257.2	391.0
Standard deviation	104.1	45.3	58.3	49.1	1.1	122.7	56.5	179.8	349.0

CONCLUSIONS

The hydrochemical analysis of the study reveals that the groundwater of the study is contaminated in terms of nitrate concentration exceeding much above the permissible limits of WHO. The major cause for nitrate pollution is mainly anthropogenic. The enriched values of δ18O are found in the eastern and western parts of the district, while southern and northern parts are showing highly depleted values. An increase in EC and enrichment in isotopic composition is observed due to the evaporation effect. The integrated data of water quality and isotope is useful for interpreting the groundwater quality & conditions. On the basis of this study, suitable management practices can be used to overcome the deteriorating quality and improving the sustainability of the groundwater in southwest Punjab.

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