

A STUDY ON MAJOR ION CHEMISTRY OF GROUNDWATER IN RELATION WITH DOMESTIC AND AGRICULTURAL USE IN AND AROUND SRINAGAR CITY, KASHMIR

Khurshid Ahmad Lone[†], M. I. Bhat, and Gh. Jeelani

Post Graduate Department of Geology & Geophysics. University of Kashmir, Srinagar- 1900 06
lonekhurshid@yahoo.co.in

ABSTRACT

The present study on groundwater chemistry would generate baseline information about groundwater resources in both rural as well as urban areas of Srinagar. To ascertain the suitability of groundwater for drinking and public health purposes, hydrochemical parameters were compared with the established standards recommended by the World Health Organization (WHO, 1993) and ISI (1983). Groundwater of the area is classified as "freshwater" and moderately hard to very hard. Based on the analysis of certain parameters like electrical conductivity, salinity hazard, and sodium adsorption ratio (SAR), integrated SAR and EC have been calculated for evaluating irrigation water quality. The interpretation of the physico-chemical characters on the basis of the available data indicated that groundwater of Srinagar can be considered suitable for drinking and irrigation purposes.

Keywords: Groundwater chemistry, Freshwater, Hard water, Salinity hazard, Sodium adsorption ratio, Srinagar.

INTRODUCTION

The quality of water plays a prominent role in promoting both the standards of human health and agricultural production. Humans and agriculture require not only sufficient water for growth and development but also the reliable quality of water. Any deterioration in water quality affects the sustainable development. Whether groundwater of a given quality is suitable for a particular purpose depends on the

standards of acceptable quality for the intended use (US EPA, 1976). Besides being chemically safe for human consumption, water should be free of undesirable physical properties such as colour or turbidity and should not have unpleasant taste or odour. Harmful microorganisms should be absent; however, they are not usually considered in ordinary chemical analysis (Hem, 1985). Hence, determination of physico-chemical characteristics of water is essential for assessing the suitability of water for drinking and household uses, agricultural purposes, and industrial applications as well.

According to an estimate of the World Health Organization, around eighty percent of the diseases and one-third of the total deaths in the developing countries are caused by the consumption of contaminated water (Earth Summit, 1992). In developing countries like India, the quality standards are not followed strictly, mostly because of the ignorance about water quality conditions, hence large number of health related problems are identified (Niranjan Babu *et al.*, 1997). The suitability of groundwater for irrigation is contingent on the effects of the mineral constituents of water on both the

plants and the soil (Wilcox, 1955). High concentration of salts may harm plant growth physically by limiting the uptake of water through modification of the osmotic processes, or chemically by metallic reactions (Todd, 1980). The US Salinity Laboratory of the Department of Agriculture adopted certain techniques based on which the suitability for agriculture is explained (US Salinity Laboratory, 1954).

In view of the widespread and large-scale tapping of groundwater in and around Srinagar, it becomes imperative to study the major ion chemistry of groundwater to obtain the first hand information about its usefulness and

suitability (in terms of major ions) for drinking and other domestic purposes.

STUDY AREA

Srinagar district comprising both urban and rural areas lies between the latitude $34^{\circ} 3' - 34^{\circ} 20' N$ and the longitude $74^{\circ} 42' - 75^{\circ} 0' E$, covering a geographical area of about 2,228 km², with the mean altitude of about 1586 m amsl. The most important drainage network is the river Jhelum and its tributaries- Sindh, Dudhganga and Telbal, besides some land-locked water bodies being dotted in the form of lakes (Dal, Nageen and Anchar) (Fig. 1).

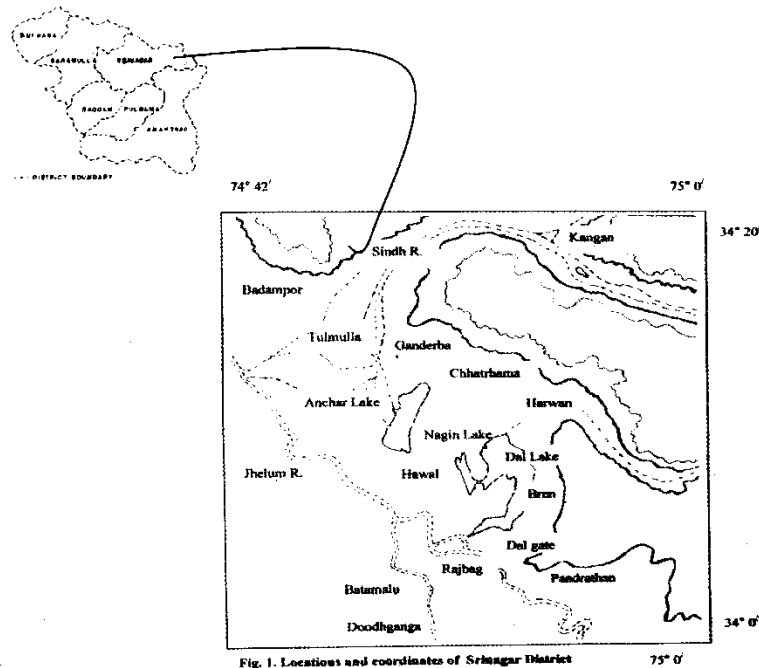


Fig. 1. Locations and coordinates of Srinagar District

Srinagar experiences by and large temperate to Mediterranean type of climate (Husain, 2005). The winters are cold (with min. temp. mostly below freezing point) and summers hot (max. temp. 37° C, in July-August). The average rainfall is 661 mm (based on the data of Srinagar observatory) most of which falls in spring, that is from March to May.

MATERIALS AND METHODS

Representative groundwater samples were collected from 70 sampling stations (bore wells, springs and dug wells) during November-December, 2004. Groundwater samples were collected in clean polyethylene bottles of one liter capacity, which were first cleaned with 10 % HNO₃ followed by rinsing with distilled water. Prior to sample collection, bore wells were flushed for about 5-10 minutes to obtain the representative groundwater samples. The physico-chemical analysis was carried out as per the standard methods (Trivedy and Goel, 1984; APHA, 1998). EC and pH were determined with the help of digital water analyzer kit. Total dissolved solids (TDS) was calculated from EC; Ca²⁺, Mg²⁺ and hardness were determined by volumetric method; Na⁺ and K⁺ ions by flame photometric method (flame photometer Systronics 130); Cl⁻ was estimated by titration with

AgNO₃ and HCO₃⁻ with HCl (0.01N). Nitrate and sulphate were determined using spectrophotometer method.

RESULTS AND DISCUSSION

The quality of groundwater as determined by its chemical constituents is of great importance in determining the suitability of a particular groundwater for a certain use. The physico-chemical characters of groundwater play a significant role in classifying and assessing water quality. The statistical overview of results of physico-chemical parameters is given in Table 1.

DRINKING WATER CRITERIA

The results of various parameters obtained were interpreted by comparing them with the established standards as recommended by the WHO (1993) and the ISI (1983) for drinking and domestic purposes, Table 2.

The groundwater samples were found to be odorless and free from any visible impurity or turbidity. The range and the mean of various parameters as given in Table 1 indicated that the concentration of various constituents fall well within the guidelines established by the WHO (1993) and the ISI (1983) for drinking and domestic purposes. The groundwater showed alkaline (basic) nature (pH: 7.10 - 8.30) with alkaline-earths (Ca-Mg) exceeding alkalis (Na-K) and weak acids (HCO₃-CO₃) exceeding over

strong acids (Cl-SO₄). The values of TDS (107 mg/L - 710 mg/L) and EC (168 μS/cm - 1110 μS/cm) indicated freshwater nature, and low to slightly-high-salinity category. The range of

hardness (86 mg/L - 410 mg/L) indicated moderately hard to very hard water types (> 300 mg/L) (Sawer and MaCarty, 1967).

Table 1: Statistical overview of hydrochemical characteristics of groundwater in Srinagar District.

Parameter/ Constituent	Overall Range	Overall Mean
pH	7.10-8.30	7.62
Temp. (°C)	11-15	13.06
EC (μS/cm)	168-1110	587.65
TDS (mg/L)	107-710	382.21
Ca ²⁺ (mg/L)	20-127	72.09
Mg ²⁺ (mg/L)	5-35	17.34
Na ⁺ (mg/L)	3-80	28.28
K ⁺ (mg/L)	0-9	3.67
Cl ⁻ (mg/L)	7-120	39.7
HCO ₃ ⁻ (mg/L)	95-455	299.87
SO ₄ ²⁻ (mg/L)	1.5-5.0	3.15
NO ₃ ⁻ (mg/L)	0.5-8.5	2.7
Hardness (mg/L)	86-410	247.64
Sodium Adsorption Ratio	0.15- 1.79	1.50

Table 2: Summary of results of physico-chemical characters and their permissible limits

Parameter	Range	WHO (1993)		ISI (1983)	
		Acceptable level	Max. Permissible level	Acceptable Level	Max. Permissible Level
Temperature °C	11.0-15.0	-	-	-	-
TDS mg/L	107-710	500	1500	500	3000
Conductivity µS/cm	168-1110	-	1600	800	4800
pH	7.10-8.30	7-8.5	6.5-9.2	6.5-9.2	9.2
Ca ²⁺ (mg/L)	20-127	75	200	75	200
Mg ²⁺ (mg/L)	5-35	<30 (if SO ₄ is 250 mg/L)	150 (if SO ₄ is 250 mg/L)	30	100
Na ⁺ (mg/L)	3-80	-	200	-	-
K ⁺ (mg/L)	0-9	-	12	-	-
Cl ⁻ (mg/L)	7-120	200	250	250	1000
HCO ₃ ⁻ (mg/L)	30-455	-	-	-	-
SO ₄ ²⁻ (mg/L)	1.5-6.61	200	400	150	400
NO ₃ ⁻ (mg/L)	0.5-8.5	-	50	45	-
Hardness (mg/L)	86-410	100	500	300	600

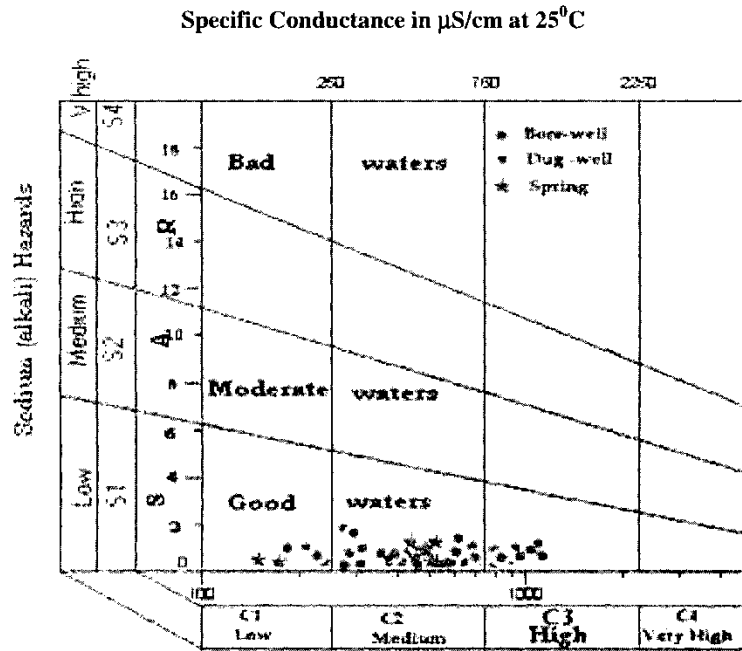
IRRIGATION CRITERIA

The sodium or alkali hazard of water for irrigation is determined by the relative concentration of cations and is expressed in terms of SAR and it can be estimated by the formula:

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

There is a significant relation between SAR values of irrigation water and the extent to

which sodium is adsorbed by the soils. If water used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of the clay particles. The calculated values of SAR in the groundwater samples of Srinagar ranged from 0.15 to 1.79 with the mean value of 1.50.



The plotting of the data on the US Salinity diagram (Fig. 2) indicated that most of the groundwater samples fall in the category C_2S_1 and a few samples in C_3S_1 - indicating low to slightly-high salinity, and low alkali hazard. Hence, groundwater tapped in Srinagar can be applied for irrigation purposes in most soils and crops with little danger of development of exchangeable sodium and salinity hazard.

CONCLUSION

The present study revealed that groundwater in the aquifers of Srinagar is fresh and alkaline in nature. Ca^{2+} and Mg^{2+} are the dominant cations and bicarbonate as the dominant anion.

The excess of alkaline-earths impart hardness to the groundwater of the area. The quality assessment of groundwater showed its suitability for drinking and domestic purposes. The calculated parameter of SAR integrated with the EC indicated that the subsurface water tapped in Srinagar can be applied for irrigation purposes without any threat of imposition of any hazard (salinity and alkali hazards).

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