

RESEARCH NOTES

Geochemistry of underground irrigation waters of Dharwar District, Karnataka

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Abstract

Groundwaters from two important lithological units of the Archaean complex consisting of schists and granite gneiss were analysed for major cations and anions. The cation and anion relation with respect to total dissolved solids suggests atmospheric precipitation, rock dominance and evaporation as the mechanisms that control the chemistry of groundwaters.

The groundwater from schistose aquifer is less saline as compared to water from granite and granite gneiss aquifer.

Introduction

Adequate information on groundwater composition in relation to lithology of the aquifer is not available. Consequently, hydrogeochemical studies relevant to water quality on a large area delineated by the local geology were undertaken in an attempt to establish the relationship of water composition to aquifer lithology. Such known relationships would help to explain the origin and distribution of the dissolved constituents and elucidate the factors controlling the chemistry of groundwaters.

Materials and methods

Six hundred sixty-seven water samples were collected from wells located in several talukas of Dharwar District. The sampled areas represent the two important lithological units of the Archaean complex consisting of schists, granites and granitic gneisses.

Selected chemical characteristics such as electrical conductivity and Na, K, Ca, Mg, Cl and HCO_3 ion contents in the water were determined according to methods of Richards (1954).

Results and discussion

The mean values of the electrical conductivity (EC) and Na, K, Ca, Mg, HCO_3 and Cl contents of the well waters are presented in Table I. The average EC of the water samples 1.96 mmhos/cm and Na, K, Ca, Mg and HCO_3 and Cl are 17.3, 1.8, 6.4, 11.9 and 7.4 and 17.6 meq/litre respectively.

From the data presented in Table I, it is apparent that salinity and sodium hazards in well waters are encountered in Naragund followed by those in Ron, Hubli, Mundargi, Shirahatti and Gadag Talukas. This apparently indicated that salinity of groundwaters increased in the northeastern direction of Dharwar district which is considered to be arid. Salinity decreased with abundant rainfall in the western and southern parts of the district.

The average chemical composition of waters in different groups of EC range shown in Table II reveals that sodium is the dominant cation followed by Mg, Ca and K. Thus, waters are of Na-Mg-Ca-K type. An increase in concentration of Na-Mg-Ca and K is observed with an increase in salinity. However, sodium

increased relatively more than magnesium and calcium. Potassium is present in small amounts ranging from 0.28 to 4.07 meq/litre. The high potassium content in 8.5 per cent of the samples could be due to the presence of biotite mica which is a less stable K phase mineral than either muscovite or orthoclase. It could also be due to local irrigation practices. In relation to anions, the waters in the EC range of 0-2 mmhos/cm are of $\text{HCO}_3 - \text{Cl}$ type and in the EC range greater than 2 mmhos/cm waters are of $\text{Cl} - \text{HCO}_3$ type.

TABLE I. Average Chemical Composition of underground irrigation waters in some talukas of Dharwar district

Talukas	Number of Samples	EC. mmhos/cm.	Na	K	Ionic Constituents, meq/litre		HCO_3	Cl.
					Ca	Mg		
Byadagi	38	1315.06	8.35	0.15	4.62	4.76	5.75	6.42
Dharwar	88	1472.10	5.53	0.71	4.32	4.98	5.92	7.20
Haveri	56	1408.62	5.91	0.20	4.20	4.29	5.52	5.53
Hirekerur	14	1562.20	6.59	1.24	3.05	5.87	5.43	8.19
Hubli	33	3158.90	18.57	2.81	5.03	13.88	5.91	19.77
Kundagol	12	2386.00	7.17	1.89	5.84	8.35	8.01	8.80
Ranebennur	27	2155.50	9.63	0.96	4.54	6.32	5.10	13.98
Savanur	53	1147.26	5.06	0.14	2.65	3.49	6.33	5.33
Shiggaon	41	1456.90	6.75	0.55	4.29	6.35	6.92	7.54
Naragund	18	4039.40	17.58	0.56	11.19	16.96	6.56	21.46
Gadag	67	1029.86	5.98	0.41	2.88	4.27	5.19	3.57
Ron	58	3233.80	18.72	0.14	6.72	11.67	6.86	15.24
Mundargi	10	1709.40	16.74	0.24	1.82	3.93	6.68	4.52
Shirahatti	109	1367.94	8.70	0.43	2.75	4.98	7.30	5.99

TABLE II. Average distribution of cations and anions in relation to electrical conductivity of waters in Dharwar district

Electrical conductivity, micromhos/cm	% of Total Samples	No. of Samples	Na	K	Ca meq/litrs	Mg	HCO_3	Cl
Less than 1000	40.5	270	3.92	0.47	2.55	3.27	5.49	3.36
1001 - 2000	38.1	254	7.82	0.28	3.45	4.99	7.31	6.03
2001 - 4000	12.91	86	12.71	1.01	5.55	8.93	6.96	13.65
4001 - 6000	4.6	31	23.06	3.25	9.68	18.97	9.05	26.80
6001	3.9	26	39.22	4.07	11.05	23.55	8.14	38.24

The increase in sodium and magnesium with increase in salinity in groundwaters are a consequence of CaCO_3 precipitation from solution. The process of precipitation is further supported by Ca : Mg below 1 in the present study (Table II). Result similar to this has been reported by Jones (1966). The enrichment of Mg in groundwaters is possibly due to the fact that magnesium has a very long residence time as

compared to calcium. The long residence time for magnesium shows that it precipitates less readily than calcium and thereby leaving the water rich in magnesium (Barth, 1961).

The chemical analysis of water samples as related to source rock type is illustrated by bar graphs in Fig. 1. Water from schistose formation is less saline as compared to waters from granite gneiss along with other fine grained materials.

A plot of the ratio of $\text{Na}/\text{Na}+\text{Ca}$ on X-axis and the variation in the total dissolved salts (TDS) on the Y-axis (Fig. 2) shows a distinct linear relationship as reported by Gibbs (1970). An ordered arrangement such as a high $\text{Na}/\text{Na}+\text{Ca}$ ratio and low TDS, low $\text{Na}/\text{Na}+\text{Ca}$ ratio to medium TDS and low $\text{Na}+\text{Ca}$ ratio, medium TDS to high $\text{Na}/\text{Na}+\text{Ca}$ and high TDS is observed. This ordered arrangement suggests that atmospheric precipitation, rock dominance and evaporation as mechanisms that control groundwater chemistry (Ramesam and Barua, 1973).

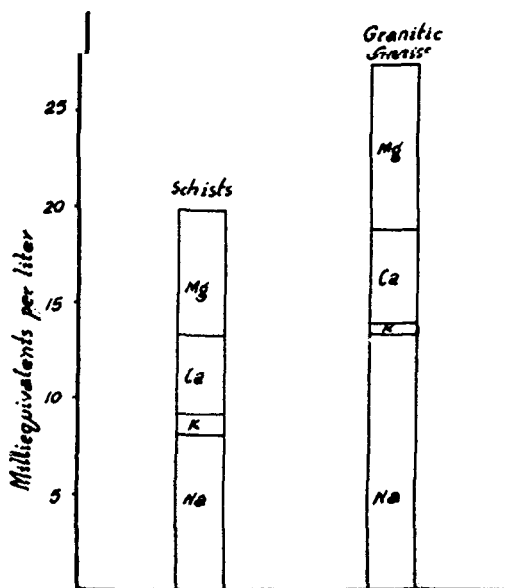


Figure 1. Composition of groundwater in relation to aquifer lithology.

As a result, the water will be low in dissolved solids since concentrations reached are likely to be a function of contact time and area of solid surface exposed to water.

The precipitation control zone is one end member of a series. The opposite end member is comprised of waters of high salinity with dissolved salts furnished by the rocks and soils of the aquifer. This grouping defines the second mechanism controlling water chemistry as rock dominance. The waters of this rock dominated end member include groundwaters of Naragund, Ron, Gadag, Mundargi and Shirahatti. The groundwater of this region appears to be very much related to relief, climate and composition of rock and soil. The source for the dissolved salts is the prevailing granites and granite gneiss and aridity in these areas.

The third major mechanism that controls the chemical composition of the groundwaters is evaporation. Groundwaters of Dharwar district belong to Mg-rich, low salinity end member. The high salinity end members are located in hot, arid regions

The first of these mechanisms is atmospheric precipitation. The chemical composition of low salinity waters are controlled by the amount of dissolved salts furnished by precipitation. These include well waters of Dharwar, Hubli, Shiggaon, Haveri, Byadagi, Ranebennur, Hirekerur and Savanur. The total salinity ranges from 0-2000 micro-mhos per cm. The amount of rainfall is high in these talukas and much greater in proportion to the low amount of dissolved salts from the rocks.

In addition, the lithological unit prevailing in the low salinity area is schist. The crystalline schist is metamorphic in origin and is dense. Further, groundwater originating in areas where schists are exposed is low in dissolved solids because the weathering attack on schist is slow. There is lesser opportunity for the groundwater to participate in reactions with the rock minerals. As

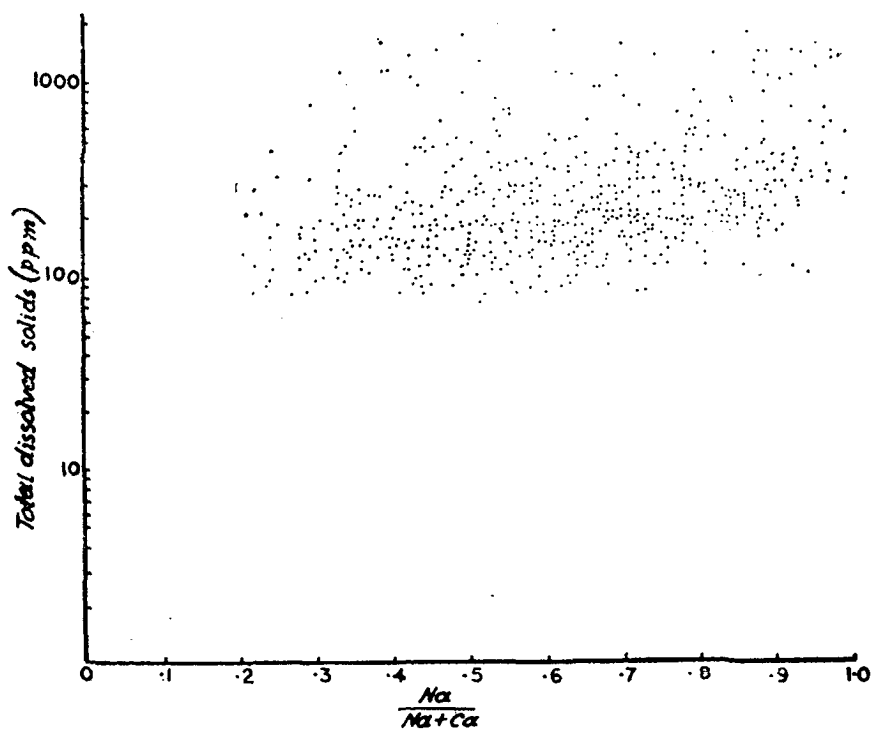


Figure 2. Variation of $Na/Na+Ca$ as a function of total dissolved solids.

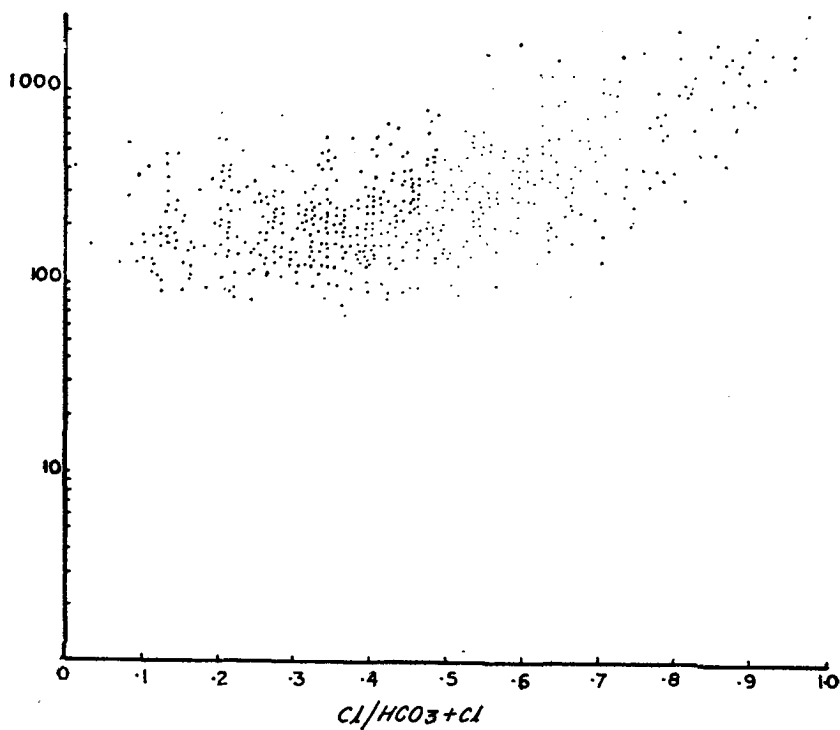


Figure 3. Variation of Cl/HCO_3+Cl as a function of the total dissolved solids.

and in the northeastern part of the district. This change in composition along the northeastern sector of Dharwar district is due to evaporation and precipitation of calcite from solution resulting in an increase in the relative proportion of Na to Ca in groundwaters.

A plot of the anion ratio $\text{Cl}/(\text{Cl} + \text{HCO}_3)$ to total dissolved solids (Fig. 3) shows a trend remarkably similar to those for cations and provides support for the mechanisms postulated by Gibbs (1970) and Ramesam and Barua (1973).

The factors that control the chemistry of groundwaters of Dharwar district are precipitation, rock dominance and evaporation. The source for the dissolved salts in high salinity waters is granite and granite gneiss and soils dominated by smectite group of clay minerals in the aquifer.

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