

QUALITY OF GROUNDWATER IN PARTS OF UPPER CATCHMENT OF BETWA RIVER BASIN IN CENTRAL INDIA

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ABSTRACT

During the course of the groundwater survey and exploration in parts of Upper Catchment of Betwa River Basin in Central India, 68 water samples have been collected from the dug-wells and also from the exploratory boreholes to assess the quality of groundwater. Most of the area is underlain by Deccan Traps whereas the rest of the area is covered by Vindhyan Sandstone. The shallow groundwater is neutral to slightly alkaline in nature with a maximum EC of $2082 \mu\text{S}/\text{Cm}$. With depth, water changes from alkaline earth bicarbonate to sodium chloride type with low NO_3 and K. Fluoride concentration increases with depth reaching a maximum value of 10.25 mg/l. Deep groundwaters show low values of tritium ranging from 2.8 ± 2 TU to 3.2 ± 2 TU indicating insignificant turnover during the last 35 years whereas the shallow groundwater records tritium value of 44.3 ± 2 TU and represents recent recharge.

INTRODUCTION

Betwa, with $20,600 \text{ km}^2$ catchment area, is one of the most important perennial rivers in Central India which flows from south to north and eventually joins Yamuna. Nion, an important right bank perennial tributary of Betwa river, covers an area of about 1100 km^2 and flows from southeast to the northwest. The lowland plain covering 90% of the Nion-basin is developed on the weathering products of several basalt flows comprising black cotton soils and yellow clay with varying thickness ranging from a few to 26 m and rests on the weathered basalt. The drainage pattern of the basin is dendritic in nature.

The southern and eastern margins of the basin are surrounded by Vindhyan Sandstone (Cambrian age) and Deccan Traps (Upper cretaceous) hillocks with elevation ranging from 400-600 m amsl. The central and western parts are generally flat with sporadic occurrence of hills covered with deep vegetation of deciduous trees and 85% of the area comes under rainfed cultivation. During the course of the groundwater survey and exploration, 68 water samples have been collected from dug wells of depth range 3 m to 22 m bgl and also from the exploratory boreholes upto a maximum depth of 210 m bgl.

Climate

The area is humid to subhumid with three distinct type of climates: Summer, Monsoon and Winter. The average rainfall and potential evapotranspiration values are around 1230 mm and 1624 mm respectively.

Geology

The basin is underlain by two distinct hard rocks: Vindhyan Sandstone and Deccan Traps (basalts). Sandstone in the form of low flat topped hillocks, occupies very small area. It is mostly quartzitic in nature, hard, compact and massive with well developed joints. On the other hand, the Deccan Traps occupy the extensive flat sloping land and rest directly on the Vindhyan. Petrological studies of Trap reveal the presence of plagioclase, augite and volcanic glass which weathers to black cotton soils rich in montmorillonite (Smectite) with traces of feldspar, quartz and calcite. The red soils, found in the upland, comprises of kaolinite and illite with goethite, quartz and secondary minerals.

EXPERIMENTAL

The filtered water samples (0.45 m μ , Millipore, USA) collected during field traverse in March, 1980 were subjected to chemical analysis as per standard procedures. Values of pH, EC, HCO₃ and Ca were determined in-situ.

DISCUSSION OF THE RESULTS

The group ionic composition of the groundwater samples is shown in the table-I. This is arranged in 5 groups according to their Electrical Conductivity values such as 0-500, 501-1000, 1001-1500, 1501-2000 and >2000 μ S/cm. The average value of EC

is $600 \mu\text{S}/\text{cm}$ with highest value of $2082 \mu\text{S}/\text{cm}$. However, very few water samples have EC values greater than $1000 \mu\text{S}/\text{cm}$. HCO_3 is predominant among the anions forming bicarbonate type of water. The Cl concentration is very low with an average value around 18 mg/l. Relatively high values occur sporadically and may be due to local contamination. In most of the well waters, the concentration of SO_4 is very low with average value of 10 mg/l.

About 30% of the water samples analysed so far contain nitrate more than 20 mg/l. As such, possibilities of developing methemoglobinaemia can not be ruled out. However, high NO_3 occurs sporadically and is associated with high values of Cl, SO_4 and EC. The analytical results indicate that the highly populated villages have greater contamination with respect to this ion, particularly whenever the dug-wells are located in the near proximity of the villages. It may, therefore be inferred that human and animal excreta may be considered as the main sources of nitrate in groundwater.

Ca and Mg are remarkably high and in some instances the concentration of Mg is greater than Ca and/or Na, arising from weathering of the ferromagnesian silicates. All waters are of alkaline-earth bicarbonate type as revealed from Piper plotting. The highest concentration of Ca and Mg ions are 173 mg/l and 90 mg/l respectively. The calculation of chlorine-alkali disequilibrium indices indicates some base exchange during the movement of groundwater. It is also seen that the values of Ca and Mg increase with the increase of salinity, but Mg/Ca equivalent ratio decreases with salinity. Potassium concentration is also normally below 5 mg/l. All shallow groundwater samples record fluoride below 1 mg/l indicating free from occurrence of dental carries.

TABLE 1
Group ionic composition of groundwater samples

No. of samp.	EC in $\mu\text{S}/\text{cm}$	pH	Concentration in meq/l							
			HCO_3	Cl	SO_4	NO_3	Ca	Mg	Na	K
2	<500	6.81	3.70	0.70	0.08	0.09	2.75	0.98	0.43	0.10
60	500-1000	7.20	6.72	0.73	0.14	0.16	3.60	0.49	1.56	0.07
4	1000-1500	7.10	6.42	2.56	0.72	1.43	5.35	3.29	1.73	0.08
1	1500-2000	7.30	8.70	3.89	2.37	1.41	4.20	6.08	3.78	0.17
1	>2000	7.05	7.29	8.99	1.93	3.22	8.65	7.39	5.00	0.10

The percentage of saturation of the shallow groundwater with respect to calcite, dolomite, gypsum and fluorite have been computed using Fortran-IV computer programme. It appears that almost all waters are either saturated or supersaturated with respect to calcite and dolomite. However, in few water samples, cases of undersaturation is observed. The shallow groundwater is also undersaturated with respect to gypsum and fluorite.

There is a tendency of deep groundwater to increase its salinity with depth having low NO_3 and K. In unconfined aquifers the Mg/Ca equivalent ratio is normally less than unity which with depth, increases with the availability of Mg from weathering of basalt. At a greater depth the ratio of Mg/Ca decreases with an increase of Na/Ca+Mg forming NaCl type of water. Deep groundwater also records high fluoride and a value as high as 10.25 mg/l has been obtained at a depth of 156.5 m bgl. Computation of saturation indicates that the water from different aquifer zones are either below saturation or near to saturation whereas the same from the well waters at Jetpura, Begumganj and Dehgaon, are saturated with respect to fluorite. The source of fluoride in deep groundwater is attributed to the presence of fluorite mineral (CaF_2) as evident from the petrological studies of the aquifer materials. Few water samples appear to be saturated with respect to both calcite and fluorite minerals. Tritium analysis of the deep aquifer waters indicates the presence of low values in the range of 2.8 ± 2 to 3.2 ± 2 TU indicating the water is likely to be originated (> 90%) from pre-bomb storage with a possible trace of modern contamination, possibly due to well construction. Shallow groundwater shows tritium value around 44.3 ± 2 TU representing recent recharge during the last few years.

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