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PRIMARY ARTICLE

Ground Water Quality Assessment Of Buldhana District, Ms, India

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ABSTRACT

Buldhna District is located in the northern part of Maharashtra State. Physiographically the study area is divided into Deccan Trap and Purna valley. The Deccan Trap consists of hard & massive basaltic rocks and Purna valley is a rift valley having in situ salinity. Ground water quality in the study area needs to pay attention as the people are dependent on it for drinking and irrigation purposes. It is also noted that people from this area are suffering form renal disorders. Therefore physico-chemical parameters of 27 samples from shallow aquifer and 35 samples from deeper aquifer were randomly collected and analyzed using different statistical techniques.

Keyword: Deccan Trap, Basaltic Rocks, Ground Water Quality, Aquifer.

Study Area

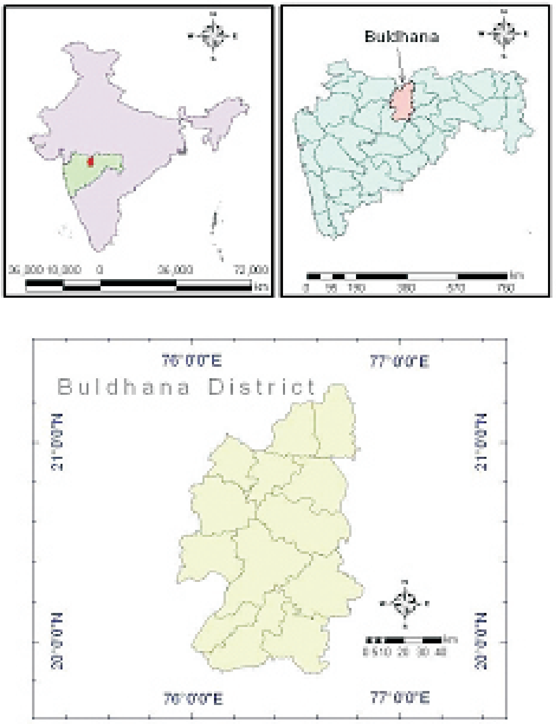

Figure 1. Location Map

Geographically Buldhana district lies between 19° 51´North to 2°17´ North latitude and 75° 57´ to 76° 59´ East longitude (Fig l). Total geographical area of the district is 9661 sq. km. The topography is undulated terrain with intermingling of hills and valleys and bare rocky outcrops facilitating rapid erosion. The northern part of the district forms the plain area and southern part is covered by Deccan trap. Major part of the study area covered by hard and massive basaltic rocks. Purna and Penganga are the major rivers flowing through the district. Groundwater in the district occurs under the water table condition in the weathered basalt rocks, joints, cracks and crevices of the basement rock. Major part of rainfall is lost through surface run off and evapo-transpiration and remaining becomes part of ground water.

Material and Methods

The ground water samples have been collected from the observation wells established by NHNS, Ground water Survey and Development Agency (G.S.D.A.) and few samples are collected during field work. Chemical analysis done by C.G.W.B and in the college laboratory is used for study. 35 samples from deeper aquifer and 27 from shallow aquifer were randomly collected from the existing tube/ bore/ open wells during pre and post monsoon season of 2008 and analyzed for 13 parameters like pH, Electrical conductivity, total dissolved solids, alkalinity, Chloride, total hardness, calcium, magnesium, Sodium, fluoride, nitrate, sulphate and bicarbonate.

Principal Component Analysis

Principal component analysis (PCA) is a multivariate technique that analysis a data table in which observations are described by several inter - correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components and to display the pattern of similarity of the observation (Jolliffe, 1995) Mathematically, PCA depends upon the eigen decomposition of positive semi definite matrices and upon the singular value decomposition (svd) of rectangular matrices. FA and PCA are not much different than canonical correlation in terms of generating canonical variates from linear combinations of variables. Correlated variables are grouped together and separated from other variable with low or no correlation.

Results and Discussion

Factor analysis has been used to condense large amount of original data into four factors from shallow aquifer and five factors from deeper aquifer to identify physico-chemical parameters which influence the quality of groundwater samples. Data from physical and chemical parameters of ground water samples have been interpreted with regard to quality of water using factor analysis. From pre-rotated eigen values, four physico-chemical factors from shallow and five from deeper aquifer were found suitable to explain the physical and chemical data. Based on these factor derived and the analysis, a relatively high percentage of the total variance of the data with a few components and its loadings are interpreted on the basis of environmental phenomena(K. L. Prakash 2006).

Shallow Aquifer

The data on inter-correlation among 13 parameters are shown in Table 1. The inter-correlations between explanatory variables distort the parametric estimates and significance tests. Statistically, substantial conclusions can be drawn when the estimates are distorted. For this purpose ' Principal Component Matrix' was adopted and is computed in Table 2. For analysis only those components that explain a significant potion of the variance in original variables are considered important. There is strong positive correlation among EC with TH, Mg and Cl, TDS with Na and SO4. TDS is positively correlated with Mg, Cl and SO4. Also Mg show strong positive correlation with Cl. On the basis of eigen values, the principle components that explains 82.9% of variance of the physico-chemical components are chosen for further analysis.

The first eigen value is equal to 5.137 and accounts for 39.5% of the variance. The 2nd, 3rd, and 4th eigen values are 2.843, 1.637 and 1.155 which accounts for 61.4%, 74.0% and 82.9% of the total variance respectively (Table 3). The first four components contribute to 82.9% of the total variance. The components are interpreted as follows:

Component 1 : TH, Mg, Cl, SO4, EC
Component 2 : Na, F, NO3, TDS,
Component 3 : Ca, pH, K
Component 4 : F, pH

The first component has highest positive loading on total hardness factor followed by magnesium, chloride, sulphate and EC which accounts for 39.5% of the total variance. It is interpreted, total hardness indicates probable involvement of Mg, Cl, SO4 etc. ions (Jayakumar, 1993; Verma et al,2003). The hardness in water is because of natural accumulation of salts from contact with the soil and geological formations (Garg et al, 2003). Hardness in water is caused by dissolved calcium and, to a lesser extent, magnesium. It is usually expressed as the equivalent quantity of calcium carbonate (WHO 2004). The hardness of water reflects the nature of the geological formations with which it has been in contact (Sawyer and Mccarty 1978).

Water shows significant conductivity when dissolved salts are present. Over most ranges, the amount of conductivity is directly proportional to the amount of salts dissolved in the water.

The second component is loaded on sodium, fluoride, nitrate and total dissolved solids, which accounts for 21.9% of the total variance. Total dissolved solids may be high because of the dissolution of the ions from geological formulations and the ions coming in water from the fertilizers added to soil. Here sodium, fluoride and nitrate ions may be responsible for increase of TDS in water. The major sources of fluorides in ground water are fluoride bearing rocks such as fluorspar, cryolite, fluorspatite, etc.

The nitrate concentration in groundwater and surface water is normally low but can reach high levels as a result of leaching or runoff from agricultural land or contamination from human or animal wastes as a consequence of the oxidation of ammonia and similar sources (WHO 2004). During recent years, the problem of groundwater contamination by nitrates has been studied thoroughly all over the world (Hudak 1999, 2000; Vinten and Dunn 2001; Levallois et al 1998; TSE 1997; Nas and Berktay 2006; Fytianos and Christophoridis 2004). The primary health concern regarding nitrate and nitrite is the formation of methemoglobinemia, the so-called bluebaby syndrome. The release of nitrate is due to direct oxidation of nitrogen or ammonia as the fertilizer.

The third component has a positive loading on calcium, pH and potassium, which accounts for 12.6% of total variance. The pH values imply that water is alkaline in nature. Potassium may be because of fertilizers applied to the soil.

The fourth component accounts for 8.9% of total variance with a strong positive contribution for the variables like fluoride and pH. Both of these values also occur in third and fourth components respectively.

Table 1: Simple Correlation among 13 variables (Shallow Aquifers)

PH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
1.000												
-0.297	1.000											
-0.251	0.367	1.000										
-0.420	0.808	0.573	1.000									
0.255	0.146	0.269	0.349	1.000								
-0.479	0.819	0.552	0.982	0.191	1.000							
-0.244	0.216	0.722	0.144	-0.123	0.175	1.000						
0.311	0.145	0.240	-0.147	0.231	-0.201	0.258	1.000					
0.183	-0.326	0.185	-0.330	0.006	-0.327	0.296	0.433	1.000				
-0.454	0.816	0.459	0.940	0.241	0.938	0.116	-0.163	-0.312	1.000			
-0.190	0.576	0.788	0.759	0.295	0.743	0.387	0.032	-0.188	0.729	1.000		
-0.386	-0.049	0.392	0.015	0.051	-0.026	0.533	0.242	0.336	0.036	0.023	1.000	
0.123	-0.209	0.434	-0.199	-0.272	-0.173	0.560	0.194	0.135	0.258	0.239	0.272	1.000

`Table 2. Principal Component Matrix

	Component			
Factor Components	**1**	**2**	**3**	**4**
pH	-0.214	0.007	0.536	0.395
EC	0.365	-0.088	0.092	-0.034
TDS	0.306	0.376	0.065	0.105
TH	0.426	-0.104	0.058	-0.043
Ca	0.121	-0.024	0.595	-0.201
Mg	0.423	-0.109	-0.037	-0.005
Na	0.153	0.479	-0.173	0.063
K	-0.03	0.322	0.453	-0.136
HCO_3	-0.129	0.359	0.176	-0.345
Cl	0.411	-0.139	0.012	-0.067
SO_4	0.373	0.115	0.116	0.313
NO_3	0.049	0.393	-0.187	-0.495
F	-0.025	0.422	-0.162	0.549

Table 3. Eigen Values Based on Correlation Matrix

Component category	Eigen Values	Percentage of Variance	Cumulative percentage
1	5.137	39.5	39.5
2	2.843	21.9	61.4
3	1.637	12.6	74.0
4	1.155	8.9	82.9

Deeper aquifer

The data on inter-correlation among 13 parameters from deeper aquifer are shown in Table 4. As per the ' Principal Component Matrix' shown in Table 5, there are strong positive correlations among EC with TDS, Na, Cl and CO3; TDS with TH, Na and Cl. TH is positively correlated with Ca, Mg, Cl and NO3. Also Ca show strong positive correlation with Mg, Cl and NO3. On the basis of eigen values, the principle components that explain 89.2% of variance of the physico-chemical components are chosen for further analysis.

The first eigen value is equal to 6.5156 and accounts for 46.5% of the variance. The 2nd, 3rd, 4th and fifth eigen values are 2.1095, 1.6285, 1.2628 and 1.0934which accounts for 15.1%, 11.6% , 9.0% and 7.0% of the total variance respectively (Table 6). The first five components contribute to 89.2% of the total variance. The components are interpreted as follows:

Component 1 : EC, TDS, Cl, Na
Component 2 : F, TH, Ca, Mg
Component 3 : CO3, HCO3, SO4, NO3, F
Component 4 : pH, HCO3
Component 5 : pH, K, F

The first component has highest positive loading of total dissolved solids factor followed by chloride, electrical conductivity and sodium which account for about 46.5% of the total variance. High values of TDS accounts for the dissolved salt which may be because of sodium and chloride ions. These ions are also responsible for increase in electrical conductivity.

The second component has positive loading with fluoride and calcium and negative loading with magnesium and total hardness which accounts for 15.0% of the total variance.

The third component has a positive loading on carbonate, bicarbonate and nitrate & negative with sulphate and fluoride which accounts for 11.6% of total variance.

The fourth component has loading on pH and bicarbonate contributing to about 9.0 % of the total variance. The fifth component is negatively loaded on pH, potassium and fluoride.

Table 4. Simple Correlation Among 13 Variables (Deeper Aquifer)

	pH	EC	TDS	TH	Ca++	Mg++	Na+	K+	Co3--	HCo3--	Cl	So4--	No3-	F-
pH	1.000													
EC	-0.129	1.000												
TDS	0.273	0.904	1.000											
TH	0.189	0.550	0.666	1.000										
Ca++	0.175	0.588	0.675	0.896	1.000									
Mg++	0.212	0.362	0.494	0.873	0.597	1.000								
Na+	0.238	0.806	0.861	0.206	0.252	0.085	1.000							
K+	0.192	0.394	0.428	0.286	0.304	0.178	0.345	1.000						
Co3--	0.178	0.663	0.624	0.101	0.173	-0.025	0.755	0.418	1.000					
HCo3--	0.393	0.354	0.491	0.353	0.251	0.413	0.440	0.107	0.397	1.000				
Cl-	0.198	0.888	0.949	0.576	0.633	0.364	0.844	0.414	0.600	0.255	1.000			
So4--	0.122	0.554	0.663	0.429	0.349	0.413	0.596	0.053	0.108	0.019	0.690	1.000		
No3-	0.156	0.633	0.635	0.545	0.620	0.321	0.451	0.671	0.565	0.312	0.559	0.056	1.000	
F-	0.106	-0.007	0.059	-0.208	-0.115	-0.298	0.198	0.013	-0.041	-0.328	0.165	0.252	-0.142	1.000

Table 5. Principal Component Matrix

	Component				
Factor Component	**1**	**2**	**3**	**4**	**5**
pH	0.107	-0.042	0.131	0.679	-0.483
EC	0.351	0.135	-0.044	-0.23	0.263
TDS	0.385	0.075	-0.072	0.069	0.056
TH	0.29	-0.426	-0.142	-0.062	-0.078
Ca++	0.289	-0.311	-0.107	-0.167	-0.16
Mg++	0.222	-0.482	-0.139	0.111	0.032
Na+	0.308	0.378	0.003	0.167	0.16
K+	0.203	0.07	0.297	-0.27	-0.497
Co3--	0.247	0.334	0.363	0.004	0.139
HCo3--	0.194	-0.136	0.35	0.475	0.296
Cl-	0.361	0.162	-0.167	-0.035	0.003
So4--	0.23	0.089	-0.545	0.135	0.096
No3-	0.287	-0.044	0.328	-0.291	-0.24
F-	-0.011	0.387	-0.387	0.077	-0.463

Table 6. Eigen Values Based on Correlation Matrix

Component category	Eigen Values	Percentage of Variance	Cumulative percentage
1	6.5156	46.5	46.5
2	2.1095	15.1	61.6
3	1.6285	11.6	73.2
4	1.2628	9.0	82.2
5	1.0934	7.0	89.2

Conclusion

The quality of ground water in Bhuldana district was statistically analyzed by applying factor analysis technique. Based on factor analysis, four factors from shallow aquifers and five from deeper aquifers were found responsible for total variance in the quality of groundwater. These factors account 82.9% and 89.2% of the total variance respectively. Among the parameters, total hardness, total dissolved solids, electric conductivity, fluoride, nitrate, calcium, magnesium were found to be dominant that determine the quality of groundwater in the district. Hence, Factor analysis has enabled the interpretation of the dependent variables affecting the ground water quality.

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