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Physico-Chemical Characteristics of Water from Bore Wells of an Industrial Town Bhilwara, Rajasthan: A Correlation Study

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Physico-chemical characteristics of water samples from 35 bore wells in the industrial town Bhilwara were studied. The values of 'r' (> 0.90) show significant positive correlation between electrical conductivity, total hardness, total dissolved solids, chloride and magnesium. The experimental values for parameter magnesium and total dissolved solids agree with predicted values and thus the correlation may be used for groundwater quality monitoring.

INTRODUCTION

Groundwater is a major source of fresh water and fulfils about 97% of freshwater requirement. The groundwater contains a high degree of minerals, which varies according to the quality of soil and rocks. Due to ecological factors and industrialization, certain variations in groundwater quality have been noticed. Efforts have been made to prevent groundwater pollution through awareness programs in sensitive areas of human settlement. In urban environment of developing countries like India, release of industrial and domestic waste to water bodies without treatment is one of the major reasons of water pollution. The industrial and domestic waste not only affects the waterbodies of the area but also exerts an impact on the physicochemistry of groundwater. Therefore, continuous periodical monitoring of water quality is necessary particularly in the area of industrial settlement[1]. As reported earlier a correlation may exist among water quality parameters of various samples of the same area. If the correlation exists, it may facilitate the task of rapid monitoring of pollution and also be helpful in predicting the quality parameters by analyzing only a few parameters[2,3]. During the last fifteen years, many towns in Rajasthan have grown up as industrial cities. Rapid growth of industries along with urbanization has not only decreased the water availability but also deteriorated the quality of both surface and groundwater. Various studies[4–6] carried out in previous years have clearly shown that groundwater is being contaminated with hazardous substances, particularly in industrial zones. Intake of this polluted water can result in serious health problems[7,8]. Bhilwara, the southwest city of Rajasthan, has grown up as a 'Textile

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City' of India. This industrial growth of Bhilwara has created the problem of drinking water for expanding population. The only surface source of drinking water for the city is *Maja Dam*, which could not meet the entire demand of water supply to the city. To a greater extent, effluents from textile industries may affect the ground water quality. The present study deals with the physico-chemical characteristics of water from bore wells of Bhilwara along with correlation between different parameters.

EXPERIMENTAL

In all 35 groundwater samples from bore wells located in different areas were collected in properly washed poly-propylene bottles with necessary precaution[9]. The pH and electrical conductivity (EC) were estimated at sampling sites. While total alkalinity (TA), total hardness (TH), nitrate (NO_3^-), fluoride (F^-), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}) and total dissolved solids (TDS) were analyzed in the laboratory as per standard methods[10]. Karl Pearson's coefficient of correlation (r) was calculated between two variables of all possible pairs using the following equation:

$$r = \frac{N\Sigma(x \cdot y) - \Sigma x \cdot \Sigma y}{[N\Sigma(x^2) - (x)^2] \cdot [N\Sigma(y^2) - (y)^2]^{1/2}} \quad \ldots (1)$$

where N is total number of samples, x and y being the two parameters of water quality.

The parameters having values of $r > 0.9$ were selected for developing linear correlationships by the formula:

$$Y = AX + B \quad \ldots (2)$$

$$A = \frac{N\Sigma(x \cdot y) - \Sigma x \cdot \Sigma y}{[N\Sigma(x^2) - (x)^2]} \quad \ldots (3)$$

$$B = \frac{1}{N}\{\Sigma y - A\Sigma x\} \quad \ldots (4)$$

Putting the values of A and B, linear equations were developed for various parameters.

RESULTS AND DISSCUSION

The values of correlation coefficient among physico-chemical parameters were found positive as well as negative (Table-1). Data reveal that only ten pairs of physico-chemical parameters show high degree of positive correlation (> 0.9), *i.e.*, TH-Cl (0.95), TH-Mg (0.97), TH-TDS (0.93), TH-EC (0.93), Cl-Mg (0.91), EC-Cl (0.98), EC-Mg (0.91), EC-TDS (0.99), TA-Mg (0.97), Cl-TDS (0.98). The significant positive correlation (> 0.90) of EC with Cl, Mg, TDS and TH is due to the fact that these ions are responsible for changes in electrical conductivity of water[2]. Total hardness is positively and significantly correlated with calcium (0.77) and magnesium (0.96). This shows that there is a great influence of calcium and magnesium over total hardness. On the other hand 12 pairs of parameters

showed negative correlation. pH shows negative correlation with almost all parameters except for total alkalinity and fluoride. The values of correlation coefficient for magnesium with TDS, TA, TH, Cl and EC are highly significant (> 0.90). The present study reveals that correlation of total hardness and EC with Cl, Mg, and TDS is highly significant which has also been reported by Krishna *et al.*[11], Sulochana *et al.*[12] and Sharma *et al.*[3] For the pair of parameters having correlation coefficient > 0.9 a linear relationship was calculated by using equations (2), (3), (4) (Table-2). The linear relationship between these parameters may be used to get the values of Cl, Mg, TDS, EC and TH by the determination of either TH or EC. The experimental values of Mg and TDS as shown in Table-3 agree with the predicated values, which are calculated as a function of TH within the limits of significance.

TABLE-1
CORRELATION (r) MATRIX FOR WATER QUALITY PARAMETERS

Parameters	pH	EC	TA	TH	NO_3^-	F^-	Cl^-	Ca^{2+}	Mg^{2+}	TDS
pH	1	–0.3609	0.1474	–0.3048	–0.0686	0.1812	–0.3488	–0.3010	–0.2850	–0.3580
EC		1	0.0383	0.9342	0.4988	–0.2772	0.9803	0.6976	0.9125	0.9998
TA			1	0.0316	0.2010	0.2263	0.0561	–0.9750	0.9704	0.0392
TH				1	0.5436	–0.2250	0.9482	0.7777	0.9681	0.9348
NO_3^-					1	0.2637	0.4712	0.4449	0.5394	0.4983
F^-						1	0.2956	0.1131	–0.202	–0.2780
Cl^-							1	0.7502	0.9063	0.9807
Ca^{2+}								1	0.6302	0.6900
Mg^{2+}									1	0.9121
TDS										1

TABLE-2
LEAST SQUARE FITTING OF THE LINEAR RELATION Y = AX + B AMONG DIFFERENT PARAMETERS

X	Y	r	A	B
TH	Cl^-	0.9482	1.0278	256.43
TH	Mg^{2+}	0.9681	0.1795	–9.118
TH	TDS	0.9348	2.8463	–185.495
TH	EC	0.9342	4.0690	–267.090
Cl	Mg^{2+}	0.9063	0.1246	38.247
EC	Cl^-	0.9803	0.3035	–141.92
EC	Mg^{2+}	0.9125	0.0388	17.647
EC	TDS	0.9998	0.6960	2.8039

TABLE-3
PREDICTED AND OBSERVED VALUES OF TOTAL DISSOLVED SOLIDS AND MAGNESIUM AS FUNCTION OF TOTAL HARDNESS

Total hardness mg/L	Total dissolved solid mg/L		Magnesium mg/L	
	Predicted	Observed	Predicted	Observed
600	1522	1680	98	86
550	1380	1330	89	94
750	1949	1750	125	103
400	953	1050	62	55
680	1750	1680	113	106
470	1152	1400	75	68
670	1721	1610	111	137
870	2290	1890	147	156
820	2148	1870	138	130
1090	2917	2870	186	183

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