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CORRELATION COEFFICIENT OF BORE WELL WATER SAMPLES FROM DROUGHT PRONE AREA OF MAHARASHTRA INDIA

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ABSTRACT
A detailed study was conducted to evaluate the bore well water quality from a drought prone area of Maharashtra (Parner Tahsil, Dist. Ahmednagar) to evaluate the ground water quality. Groundwater samples from bore wells of thirteen sampling stations were analyzed for different physico-chemical parameters. The analytical results shows higher concentration of electrical conductivity, alkalinity and hardness at some sampling stations indicate signs of deterioration but values of pH, total dissolved solids, chloride, calcium, magnesium, sulphate and sodium are within permissible limit as per WHO standards. The correlation co-efficient has been reckoned for the water quality parameters have been obtained which can be used for rapid monitoring of water quality parameters. SAR and % Sodium indicated that ground water is safe and excellent to good for irrigation.

KEYWORDS: Bore well water quality, Physico-chemical parameters, Correlation co- efficient, Drought prone area.

INTRODUCTION
Ground water is one of the earth's most important resources. It is also adversely affected both qualitatively and quantitatively by all kinds of human activities. The fresh water is contaminated by inorganic and organic substances such as dissolved solids, metals, detergents, pesticides etc. The quantity of utilizable water decreases due to over exploitation and also by pollution. This is a major environmental problem.

During the last few decades, disposal without proper treatment of sewage wastes from urban areas and of effluents from industries, excess use of chemical fertilizers and pesticides in agriculture has been the cause of deterioration in the quality of ground water.

Industrialisation brings with it the attendant problem of waste disposal. The effluents discharged from industries variously introduce into ground water undesirable. Colour, odour and taste, organic matter and dissolved salts, which may include arsenic, cadmium and cyanine, in toxic concentrations.

Ramanaiah *et al.* (2006) monitored fluoride concentration in ground water in eight villages of Prakasham district and their correlation with physico-chemical parameters. Ghandour *et al.* (1985) studied the distribution of carbonates, bicarbonates, and pH values of ground water of the Nile Delta region, Egypt. Prajapati and Mathur (2005) analysed statistically the ground water from Sheopurkalan (Madhya Pradesh). Durgude (1999) worked on analysis of soil, water and plants. Raghunath (1968) interpreted on the composition of ground water and chemical reactions with the soil. Nikumbh (1997), Pawar and Nikumbh (1999) studied geochemistry of ground water trace elements from Nashik district.

Correlation coefficient of various parameters give an idea of the bearing that a single parameter analyzed has other parameters. These correlation coefficient values can be used in estimating the values of other parameters at the particular place without actually measuring them (Mishra *et al*., 2003). The specific objective of this study are (1) find out the suitability of groundwater for irrigation and drinking purposes and (2) establish significant correlation amongst various water quality parameters.

MATERIALS AND METHODS

The Ahmednagar district is located between 18^0 49' 40" N. and 19^0 21' 13" N. Latitude and 74^0 10' 22" E. and 74^0 38' 34" E. Longitude in the western part of Maharashtra State. The samples were analyzed for physical parameters pH, electrical conductivity (EC), temperature, total dissolved solids (TDS) (using water quality analyzer) and chemical parameters such as alkalinity, hardness, chlorides, calcium, magnesium (using titrimetric method), phosphate, sulphate (using spectrophotometer) and sodium and potassium (using flame photometer). Analytical techniques as described in Trivedi and Goel (1986) are adopted for physico-chemical analysis. As there is some inter-dependence between the physico-chemical parameters, they may be related by the method of least square principle. All the results are compared with standard limits recommended by APHA-AWWA (1995) and World Health Organization (WHO, 1983).

Correlation

The relationship between the two variables is such that a change in one variable results in a change in the other variable is known as correlation. There are three kinds of correlations: Positive, zero and negative correlations.
The equation for the correlation coefficient is,

$$\gamma_{xy} = \frac{Cov(X,Y)}{\sigma_x . \sigma_y}$$

Where, $-1 \leq \gamma_{xy} \leq 1$

$$Cov\ (x, y) = \frac{1}{N}\sum_{i=1}^{N}(X_i - \mu_x)(y_i - \mu_y)$$

T -Test

Verification of significance of correlation coefficient is given by t- test. Correlation coefficient (r) gives a measure of the degree of relationship between the two variables of a sample.

The formula of t- test is,

$$t = \frac{r\sqrt{N-2}}{\sqrt{1-(r)^2}}$$

Regression analysis

As there is some interdependence between the physico-chemical parameters, they may be related by method of least square principle. While keeping one parameter as independent variables (X), remaining parameters are treated as dependence variables (Y). And they can be related as given below,

$$Y = AX + B$$

Where, A and B are constants.

Values of A and B can be calculated with the help of following equations,

$$A = \frac{\sum xy}{\sum x^2}$$

Where, $x = X - \overline{X}$

Where, $y = Y - \overline{Y}$

$$A = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sum X^2 - \frac{(\sum X)^2}{N}}$$

$$B = \overline{Y} - A\,\overline{X}$$

The degree of fitness of the equation is determined by the factor, correlation coefficient (r). From the correlation coefficient of the parameters, certain important linear relationship can be proposed between the various parameters. From the linear relationship, standard error Y of estimate is calculated (Prasad, 2004).

RESULTS AND DISCUSSION

The mean values of physico-chemical parameters with standard deviation (σ), %CV, variance are given in Table 1. 92.3% water samples from the study area indicates high alkaline nature of water. Electrical conductivity values of the study area shows that all the water samples except in one (1420µs/cm) are below permissible limit. Hardness concentration in 15% water samples were found to exceed the limit of potability of water (WHO, 1983). This might be due to leaching of effluents driven out by sugar factory nearby area of the sampling station.

Table 1: Statistical parameters.

Sr. No.	Parameter	Mean	Std. Devn.	% CV	Variance
1	Temp.	25.7	2.3	8.9	5.2
2	pH	8.6	0.6	7.1	0.4
3	EC	868.8	304.9	35.1	92966.3
4	TDS	433.4	163.4	37.7	26687.6
5	Alkalinity	360.8	231.1	64.1	53425.7
6	Hardness	355.2	145.9	41.1	21274.2
7	Chlorides	99.2	69.8	70.4	4878.6
8	Ca^{++}	83.0	43.2	52.1	1867.0
9	Mg^{++}	37.6	22.0	58.7	485.3
10	PO_4^{---}	0.2	0.3	140.4	0.1
11	SO_4^{--}	20.3	19.4	95.6	376.2
12	Na^{+}	13.2	7.4	56.1	54.7
13	K^{+}	6.0	16.6	275.7	275.8

Total dissolved solids, chlorides, calcium, magnesium, sulphate and sodium, potassium values are less than prescribed standards and is fit for drinking purposes (WHO, 2006). 30%water samples were found to exceed the limit which might be due to improper or faulty applications of irrigation water and over use of chemical fertilizers. The obtained results are in support of the

results obtained by Auti (2007). SAR and % sodium of the study area shows that ground water is excellent too good for irrigation purposes.

A strong correlation was observed between EC and TDS, EC and sulphate, TDS and sulphate, hardness and chlorides, hardness and calcium, hardness and magnesium, chlorides and sodium and TDS and sodium. A good correlation of water samples was observed between EC and chlorides, EC and calcium, EC and sodium, TDS and chlorides, hardness and sodium, chlorides and calcium, chlorides and sulphate, chlorides and sodium, magnesium and potassium, sulphate and sodium (Table 2).

Table 2: Correlation coefficient matrix among water quality parameters.

Parameter	Temp.	pH	EC	TDS	Alkalinity	Hardness	Chlorides	Ca++	Mg++	PO4-	SO4-	Na+	K+
Temp.	1.00												
PH	0.42	1.00											
EC	-0.11	-0.04	1.00										
TDS	-0.10	0.06	**0.99**	1.00									
Alkalinity	-0.12	-0.33	0.37	0.34	1.00								
Hardness	0.14	-0.06	0.45	0.44	0.38	1.00							
Chlorides	0.05	0.10	**0.57**	**0.61**	0.40	**0.71**	1.00						
Ca++	-0.35	-0.19	**0.57**	**0.56**	0.17	**0.72**	**0.57**	1.00					
Mg++	0.53	0.19	0.13	0.13	0.38	**0.74**	0.53	0.09	1.00				
Po4-	0.21	0.36	0.25	0.18	-0.23	0.02	-0.05	0.03	0.05	1.00			
So4-	0.08	-0.12	**0.89**	**0.87**	0.44	0.35	**0.57**	0.40	0.11	0.10	1.00		
Na+	0.07	0.11	**0.60**	**0.66**	0.33	0.48	**0.93**	0.37	0.38	0.16	**0.64**	1.00	
K+	0.20	0.16	0.23	0.19	0.03	**0.63**	**0.60**	0.29	**0.64**	0.20	0.21	0.41	1.00

From the correlation coefficient of the water quality parameters, important linear relationship can be proposed between various parameters. As there is some interdependence between the physico-chemical parameters, they may be related by the method of least square principle. Least square fitting of the relation Y= AX+B are presented in Table 3.

Table 3: Least square fitting of the relation Y = AX + B.

Sr. No.	Y	X	A*X	B	Std. Error of Y Estimate
1	TDS	EC	0.5283*EC	-25.55	27.18
2	Chlorides	EC	0.1316*EC	-15.15	57.17
3	Calcium	EC	0.0811*EC	12.59	37.31
4	Sulphate	EC	0.0565*EC	-28.79	5.92
5	Sodium	EC	0.0145*EC	0.56	8.91
6	Chlorides	TDS	0.2622*TDS	-14.46	55.17
7	Calcium	TDS	0.1469*TDS	19.33	58.3
8	Sulphate	TDS	0.1035*TDS	-24.58	9.5
9	Sodium	TDS	0.0299*TDS	0.22	2.71
10	Chlorides	Hardness	0.3405*hardness	-21.77	35.57
11	Calcium	Hardness	0.2138*hardness	7.05	15.88
12	Magnesium	Hardness	0.1121*hardness	-2.27	13.26
13	Potassium	Hardness	0.0715*hardness	-19.37	5.55
14	Calcium	Chlorides	0.3512*Chlorides	48.18	12.92
15	Sulphate	Chlorides	0.1594*Chlorides	4.48	49.11
16	Sodium	Chlorides	0.0985*Chlorides	3.41	29.9
17	Potassium	Chlorides	0.1432*Chlorides	0.14	14.75
18	Potassium	Magnesium	0.4846*Magnesium	0.48	12.72
19	Sodium	Sulphate	0.2458*Sulphate	8.2	5.65

Keeping one parameter as independent variable (X) and remaining parameters are treated as dependent variables (Y) from the pairs of significant variables. They can be related as Y= AX+B where A and B constants such that A is slope of fitted line and C is the intercept of fitted line. Standard error of Y intercept was also calculated. Table 4 illustrates significance of the correlation coefficient.

Table 4: T-Test for the significance of the correlation coefficient.

Parameter	Temp.	pH	EC	TDS	Alkalinity	Hardness	Chlorides	Ca^{++}	Mg^{++}	PO_4^{---}	SO_4^{--}	Na^{+}	K^{+}
Temp.	1.00												
PH	1.52	1.00											
EC	0.36	0.12	1.00										
TDS	0.33	0.20	**19.66**	1.00									
Alkalinity	0.40	1.16	1.34	1.20	1.00								
Hardness	0.47	0.20	1.67	1.61	1.38	1.00							
Chlorides	0.18	0.35	**2.33**	**2.58**	1.43	**3.35**	1.00						
Ca^{++}	1.26	0.64	**2.31**	**2.22**	0.59	**3.46**	**2.29**	1.00					
Mg^{++}	2.05	0.64	0.43	0.45	1.37	**3.68**	2.05	0.29	1.00				
PO_4^{---}	0.71	1.28	0.84	0.59	0.79	0.07	0.16	0.09	0.17	1.00			
SO_4^{--}	0.27	0.39	**6.41**	**5.91**	1.64	1.23	**2.32**	1.44	0.35	0.33	1.00		
Na^{+}	0.25	0.35	**2.48**	**2.92**	1.17	1.79	**8.43**	1.32	1.34	0.54	**2.80**	1.00	
K^{+}	0.67	0.52	0.78	0.63	0.10	**2.68**	**2.50**	1.00	**2.78**	0.67	0.71	1.49	1.00

The correlation co-efficient has been reckoned for the water quality parameters have been obtained which can be used for rapid monitoring of water quality parameters.

CONCLUSION

This study was carried out to check the suitability of groundwater for irrigation and drinking purposes and establish significant correlation amongst various water quality parameters. The correlation co-efficient has been reckoned for the water quality parameters have been obtained which can be used for rapid monitoring of water quality parameters. Verification of significance of correlation coefficient is given by t- test. From the correlation coefficient of the water quality parameters, important linear relationship between 19 parameters has been proposed between various physico-chemical parameters. These parameters are related by the method of least square principle by the relation Y= AX+B.

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