ijCEPr

International Journal of Chemical, Environmental and Pharmaceutical Research

Vol. 2, No.2-3, 146-151
May-December, 2011

Correlation Analysis of Groundwater Quality of Bichhwal Industrial Area, Bikaner

Rajdeep Kaur and R.V. Singh*
Department of Chemistry University of Rajasthan, Jaipur-302004, India
*E-mail: rvsjpr@hotmail.com

Article History:
Received: 1 August 2011
Accepted: 20 October 2011

ABSTRACT

With the rapid growth of industries, pollution in natural waters by industrial wastes has increased tremendously. Due to lack of treatment and improper modes of disposal of wastes, the water bodies are polluted and they carry deadly substances. The present work aims at studying the nature of effluent from different industries and hence to make a comparison of the quality of effluent water that are discharged into the water system. Quality of ground water of 16 stations of Bikaner City has been studied. Important parameters have been checked and compared with the prescribed standards for drinking water**.** The parameters studied were pH, Total Alkalinity, Total Hardness, Calcium Hardness, Magnesium Hardness, Carbonate and Non- Carbonate Hardness, Chloride, Fluoride and Total Dissolved Solids. Suitable correlation studies have been carried out among all possible pairs of 16 physico-chemical ground water quality parameters of various groundwater samples collected from Industrial Area of Bikaner City (Raj.) India. All the correlations indicate that different parameters are strongly interrelated with each other. The correlations provide an excellent tool for the prediction of parameter values within reasonable degree of accuracy. The result shows that the ground water from some sampling sites are within permissible limit according to WHO.

Keywords: Groundwater, Bikaner, Physico-Chemical Parameters, Correlation and Regression Analysis.

INTRODUCTION

Ground water is the principal source of drinking water in our country and indispensable source of our life. The problem of ground water quality is acute. Groundwater is particularly important as it accounts for 88 % of the drinking water in rural areas [6]. The quality is the function of the physical, chemical and biological parameters, and could be subjective as it depends on a particular intended use [19]. Water is also essential raw material for photosynthesis and therefore it is important for crop production [17]. Almost 70% of water in India has become polluted due to the discharges of domestic sewage and industrial effluents in to natural water sources [13]**.**

The analysis of trace heavy metals like lead, chromium, copper, iron and zinc in the water samples of the tube wells of five different locations has also been done systemically. The quality of the groundwater varies from place to place with the depth of water table. The classification, modeling and interpretations of monitoring data are the most important steps in the assessment of water quality. Water quality parameters interact with each other. To define the resource water quality many researchers treated water quality parameters individually by describing the seasonal variability and their causes. It is a very difficult and laborious task to regularly monitor all the parameters even if adequate manpower and laboratory facilities are available. For this reason, in recent years an easier and simpler approach based on statistical correlation, has been developed using mathematical relationship for comparison of physicochemical parameters [4, 15,16].

Life is not possible on this planet without water. It exists in three states namely solid, liquid and gas. It acts as a media for both; chemical and biochemical reactions and also as internal and external medium for several organisms [8]. According to Central Pollution Control Board, 90% of the water supplied in India to the town and cities are polluted, out of which only 1.6% gets treated. Therefore, water quality management is fundamental for the human welfare [3, 10].

The statistical regression analysis has been found to be a highly useful tool for correlating different parameters. Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables. If the correlation coefficient is nearer to +1 or –1, it shows the probability of linear relationship between the variables x and y . This way analysis attempts to establish the nature of the relationship between the variables and thereby provides a mechanism for prediction or forecasting [2, 7, 11, 14]**.**

MATERIALS AND METHOD

Study sites There are three industrial area in Bikaner city i.e. Bichhwal, Karni and Rani Bazaar industrial areas. For groundwater quality investigations we have selected Bichhwal Industrial Area, which is highly industrialized area of Bikaner City. Here industrial waste waters are dispose through the open drains and ponded to open land.
Total twelve bore well water samples were collected from Bichhwal industrial area. Four water samples were also collected from the holy Kolayat Lake.

Geography of the Study Area

The Bikaner city has geographical location of East Longitude 28^o 1' and North Latitude 73^{o}19', situated at an average altitude of 797 feet, Bikaner witness extreme temperatures. The summer in Bikaner is unbearably hot with temperatures rising above the 48^o centigrade mark. In the winters, the temperatures come down near 4^o centigrade. The soil type of the area is basically alkaline. Its total area is about 27,244 square kilometers which is about 7.96 percent of the total area of Rajasthan state of India. The total population of the district is approx. 1.7 millions out of which 35.84 percent constitutes the work force .Bikaner is leading Carpet Yarn Manufacturing Centre in the World and is Asia's Biggest Wool Market. It is also known for its Bikaneri Bhujia and sweets and having Asia's biggest camel Farm.

Preparation of Water Samples

The samples were collected in clean polythene bottles without any air bubbles. The bottles were rinsed before sampling and tightly sealed after collection and labeled in the field. The temperatures of the samples were measured in the field itself at the time of sample collection.

Analysis of Water Sample

Analysis was carried out for various water quality parameters such as temperature, pH, total dissolved solids, total hardness, calcium and magnesium hardness, carbonate and non-carbonate hardness, total alkalinity, calcium, chloride and fluoride as per standard procedures.

Statistical Analysis

The statistical analysis has been performed using standard methods [1]. Statistical studies have been carried out by calculating correlation coefficients between different pairs of parameters.

Coefficient of Correlation (r):

Let x and y be any two variables (Water quality parameters in the present case) and (x_i , y_i) be n pairs of observed values of these variables (i=1,2,3,--------,n). Then the correlation coefficient r between the variables x and y is given by the well known relation –

$$r = \frac{n\sum x_i y_i - (\sum x_i)(\sum y_i)}{\sqrt{n\sum x_1^2 - (\sum x_i)^2}\sqrt{n\sum y_1^2 - (\sum y_i)^2}} --- \quad (1)$$

Where, the summations are taken over 1 to n (n= number of observations). The values empirical parameters a and b were calculated with the help of equations (2) and (3),

$$b = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_1^2 - (\sum x_i)^2} --- \quad (2)$$

$$a = \frac{\sum y_i - b\sum x_i}{n} --- \quad (3)$$

Keeping the above observations in mind a linear relationship (regression line) is proposed-

$$y=a+bx \qquad (4)$$

The correlation among the different parameters will be true when the value of correlation coefficient (r) is high and approaching to one. Correlation, the relationship between two variables, is closely related to prediction. The greater the association between variables, the more accurately we can predict the outcome of events [5, 9, 12].

RESULTS AND DISCUSSION

The ground water from the study areas had no color, order and turbidity. The results of the physicochemical analysis of the groundwater samples B1toB16 are presented in Table 1**.** Values of correlation analysis are shown in Table 2.

Colour

The colour of a small water sample is caused by both dissolved and particulate material in water, and is measured in Hazen Units [HU]. Colour in water may be caused because of the presence of natural metallic ions (iron and manganese) humus and planktons. The presence of colour in water does not necessarily indicate that the water is not potable. Colour is not removed by typical water filters; however, slow sand filters can remove colour, and the use of coagulants may also succeed in trapping the colour causing compounds within the resulting precipitate. In the present study water is almost colourless.

Odour

When minerals, metals and salts from soil come in contact with water, they may change its taste and odour. Analyzed water samples are found odourless.

pH

pH is an important parameter in water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes. The pH values fluctuated between 7.1 to 8.1 (Table 1). A pH range from 7.0 to 8.5 is desirable concentration as per guided by ICMR. The pH shows slightly alkaline trend. Generally pH of water is influenced by geology of catchments area and buffering capacity of water.

Temperature

The temperature was found to be in the range between 22.1 to 29.0^{o}C. However, the variation of the water temperature affects directly or indirectly all life processes.

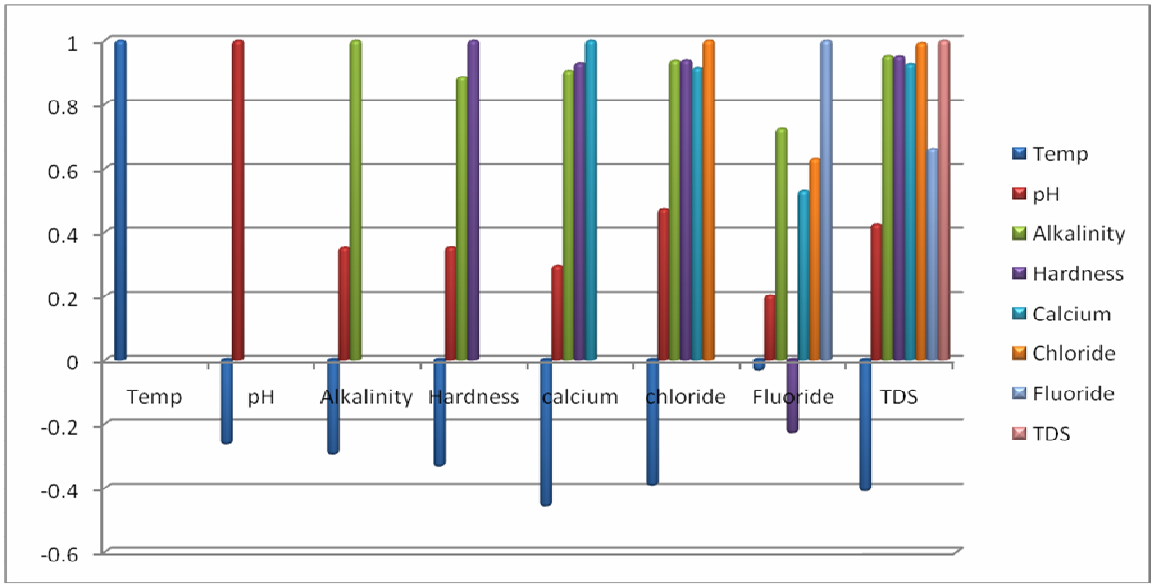

Fig-1: Average values of Linear Correlation Coefficient of water sample

Total alkalinity

The desirable limit of total alkalinity is 200 mg/L (ICMR). The maximum permissible level is 600 mg/L. The value of alkalinity in water provides an idea of natural salts present in water. The cause of alkalinity is the minerals which dissolve in water from soil. The various ionic species that contribute to alkalinity include bicarbonate, hydroxide, phosphate, borate and organic acids. These factors are characteristics of the source of water and natural processes taking place at any given time**.** The value of study area is ranged from 60 to 310 mg/L. Alkalinity in itself is not harmful to human being, but in large quality, alkalinity imparts bitter taste to water.

Chloride

Chlorides are important in detecting the contamination of ground water by waste water. The maximum permissible concentration of chloride is 1000 mg/L. (ICMR). The chloride contents of water samples are in limit. It varies from 30 mg/L. to 680 mg/L.

Total Hardness (TH)

The maximum limit of hardness in drinking water is 600 mg/L (ICMR). Regarding total hardness fluctuating trends in its value were observed in all stations. The observed total hardness values were well within the limits. Total hardness is measured in grains per gallon (gpg) or parts per million (ppm). If water contains less than 3.5 gpg, it is considered soft water. If it contains more than 7 gpg, it is considered hard water. The total hardness value ranged in the studied area from 90 to 360 mg/L.

Total Dissolved Solids (TDS)

The TDS values of water samples of points 1-4, 6-8 and 10-12 ranging from 1280-1790 mg/L. Since these values exceed the desirable limit as per ICMR so from TDS point of view quality of water samples of these points is poor. However, the TDS values of water samples of points 9, 13- 16 ranging from 175-230 mg/L. These values are within desirable limit Prescribed by ICMR.

Calcium Hardness

A measure of the amount of calcium in water measured in ppm. High levels can cause scale buildup. Low levels can cause etching and equipment corrosion. Calcium hardness is sometimes confused with the terms water hardness and total hardness. Too little calcium hardness and the water are corrosive. Too much calcium hardness and the water are scale forming. The maximum permissible limit of calcium hardness is 200 mg/L (ICMR). The value of sampling stations ranged from 40 to 185 mg/L.

Magnesium Hardness

Magnesium salts have a laxative and diuretic effect. The maximum permissible limit of magnesium hardness is 150 mg/L (ICMR). Mg hardness value in studied area ranged from 35 to 200 mg/L.

Table-1: The physico-chemical characteristics of various collected water samples

S. No.	Parameters	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8
1	pH	7.2	7.7	7.8	7.6	7.7	7.5	7.6	8.1
2	Turbidity (NTU)Y	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
3	Temperature (^oC)	27.1	24.2	26.3	25.4	26.7	24.2	27.4	24.2
4	Colour (Hazen Units)	None	None	None	None	None	None	None	None
5	Odour	aqreable	aqreable	aqreable	aqreable	aqreable	aqreable	aqreable	aqreable
6	Total Alkalinity (as $CaCO_3$)	270	240	300	300	210	300	310	300
7	Total Hardness (as $CaCO_3$)	269	360	310	270	285	272	300	245
8	Calcium (As $CaCO_3$)	155	160	130	145	158	165	170	160
9	Magnesium(As $CaCO_3$)	114	200	180	125	127	107	130	85
10	Carbonate (As $CaCO_3$)	269	240	300	270	210	272	300	245
11	Non-Carbonate (As $CaCO_3$)	Nil	20	10	Nil	75	Nil	Nil	Nil
12	Chloride	550	660	600	680	510	590	580	570
13	Fluoride	1.5	1.5	1.8	1.2	0.5	1.0	1.4	1.5
14	Total Dissolved solids	1475	1750	1715	1790	1280	1648	1496	1488
15	Residual Chlorine	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table-1, Cont…

S. No.	Parameters	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16
1	pH	7.5	7.7	7.2	7.1	7.3	7.2	7.3	7.3
2	Turbidity (NTU)Y	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
3	Temperature (^oC)	22.1	25.8	23.9	24.0	27.4	29.0	28.7	28.0
4	Colour (Hazen Units)	None	None	None	None	None	None	None	None
5	Odour	aqreable	aqreable	aqreable	aqreable	aqreable	aqreable	aqreable	aqreable
6	Total Alkalinity (as $CaCO_3$)	60	260	290	290	130	120	100	120
7	Total Hardness (as $CaCO_3$)	90	310	300	310	140	120	120	124
8	Calcium (As $CaCO_3$)	55	170	185	190	50	40	60	50
9	Magnesium(As $CaCO_3$)	35	140	115	120	90	80	60	74
10	Carbonate (As $CaCO_3$)	60	260	290	290	130	120	120	120
11	Non-Carbonate (As $CaCO_3$)	30	50	10	20	10	Nil	Nil	04
12	Chloride	40	480	500	510	50	40	40	30
13	Fluoride	0.4	1.1	1.3	1.4	0.9	0.9	1.0	0.9
14	Total Dissolved solids	175	1412	1515	1520	220	200	229	230
15	Residual Chlorine	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table-2: Average values of Linear Correlation Coefficient of water sample

Corre. Coeff.	Temp	pH	Alkalinity	Hardness	Calcium	Chloride	Fluoride	Total Dissolved Solids
Temp.	1	-0.268	-0.299	-0.338	-0.461	-0.396	-0.038	-0.414
pH	-0.268	1	0.352	0.353	0.296	0.473	0.203	0.424
Alkalinity	-0.299	0.352	1	0.886	0.906	0.937	0.724	0.951
Hardness	-0.338	0.353	0.886	1	0.929	0.938	-0.232	0.950
Calcium	-0.461	0.296	0.906	0.929	1	0.915	0.531	0.927
Chloride	-0.396	0.473	0.937	0.938	0.915	1	0.630	0.993
Fluoride	-0.038	0.203	0.724	-0.232	0.531	0.630	1	0.662
TDS	-0.414	0.424	0.951	0.950	0.927	0.993	0.662	1

Carbonate and Non-Carbonate Hardness

Carbonate hardness is often called "temporary hardness" because it can be removed by heating the water. When the water is heated, the insoluble carbonates will precipitate and tend to form bottom deposits in water heaters. Carbonate hardness also known as KH, refers to the concentration of bicarbonate (HCO_3^-) and carbonate (CO_3^-) dissolved in water. It is usually expressed either as parts per million (ppm or mg/L). The carbonate hardness value ranged from 60-300 mg/L. The maximum permissible limit for carbonate hardness is 200 mg/L (ICMR).
Non-carbonate hardness is called permanent hardness, because it is not removed when the water is heated. It is much more expensive to remove non-carbonate hardness than carbonate hardness. Non-carbonate hardness is caused primarily by calcium and magnesium nitrates, chlorides, and sulphates. The value of non-carbonate hardness ranged from nil to 75 mg/L.

Fluoride

Result showed that fluoride content in samples at all sites were within the permissible limit (1.5 mg/L). Nevertheless, fluoride causes health hazards at both the lower and higher concentration. Lower concentration of fluoride (< 0.5 mg/L) causes dental carries, while higher concentration (beyond 1.5mg/L) causes dental and skeletal fluorosis [18].

CONCLUSIONS

The results of present investigation clearly indicate that the ground water quality of nearby Bichhwal industrial area of Bikaner is unsatisfactory in the study area and there is indication of increasing pollution due to their higher values of Ca, total hardness and chloride as per ICMR standards. Therefore, constant monitoring of this water is required to prevent health hazards in the area. The correlation and regression study of the physico-chemical parameters of underground water reveals that all the parameters are more or less correlated with each other. The linear correlation is very useful to get fairly accurate idea of the quality of the ground water by determining just a few examples experimentally and then predicting the remaining from correlation equation.

REFERENCES

1. APHA standard methods for examination of water and waste water, American Public health Association, Washington D.C. (1998).
2. Draper N.R. et al., (1966), Applied Regression Analysis Wiley, New – York.
3. Gupta S.C., Indian J. Environ. Hlth., **33(3)** (1991) 341.
4. Iyer,C.S et al., J. Environ. Monit**., 5,** (2003) 324.
5. Khattab M.F., Iraqi Journal for Earth science, **4(1)** (2003) 98.
6. Kumar A., Water Pollution. Nisha Enterprises, New Delhi,. (2004) 1.
7. Kumar J. et al., Indian J. Env. Prot., **25(5)** (2005) 405.
8. Kumar Rajesh, and Yadav S. S., Int. J. Chem. Sci.: **9(1)** (2011) 440.
9. Mazlum N. et.al., J. of Engineering and Environmental Science, **23** (1996) 19.
10. Madhuri U. et al., Poll. Res., **23(3)** (2004) 565.
11. Mulla J.G. et al., Int. J. Chem. Sci., **5(2)** (2007) 943.
12. Praus P., Water SA., **31(4)** (2005) 417.
13. Radhakrishan R., et al., J. Environ. Bio., **28(1)** (2007) 105.
14. Snedecor G.W. et al., (1967). Statistical Method, The Lowa State University Press, Ames, 6 th Ed.
15. Shihab A.S., Application of Multivariate Method in the Interpretation of Water Quality Monitoring Data of Saddam Dam Reservoir, (1993).
16. Sarkar Mitali et al., J. Indian Chem. Soc., **83** (2006) 1023.
17. Smitha, P.G. et al. , J. Environ. Bio., **28(3)** (2007) 591.
18. Thangarajan M., et al., (2007). Regional groundwater chemical modeling: A case study in Kodaganar river basin, Tamil Nadu, India, Proceedings of Internation Ground Water Conference, IGC-2007, Coimbatore, India.
19. Tatawat R. K. et al., Environ. Monit. Assess, **143,** (2008) 337.

[IJCEPR-182/2011]