Asian Journal of Chemistry Vol. 18, No. 1 (2006), 485–490

Dependence of Groundwater Quality on Rainfall

JESIAMMA JOSEPH† and GEETHA PARAMESWARAN*
Department of Chemistry, University of Calicut, Calicut-673 635, India
E-mail: geethapara1@rediffmail.com

Like weather forecast, quality forecast is also of vital importance for the management of groundwater resources. An attempt has been made to relate quality variation with rainfall by correlation analysis. Linear relationship model has been developed using the rainfall and chemical characteristics observed since 2001 in different wells of Calicut town area. Mixed trend of variation is found.

Key Words: Correlation analysis, Quality fluctuation, Rainfall.

INTRODUCTION

Groundwater is a replenishable source and also an economical resource. The interesting advantage of groundwater over surface water is its wide distribution, negligible evaporation loss, low risk of pollution and relatively free from harmful bacteria. The chemical composition of groundwater depends upon the soluble products of rock weathering and decomposition in addition to external polluting agents and changes in space and time. The quality of ground water is described by its physical, chemical and microbiological properties. These characteristics are interlinked. Therefore, interpretation of coefficient between water quality parameters gives a good idea about the quality of water and facilitates rapid monitoring methods.

Kumar *et al.*[1] studied quality and correlationship among water quality parameters of groundwater samples from different parts of India and developed linear regression equations for different water quality parameters. Similar studies were also carried out for Musnur Mandal[2] and Reddigudem Mandal[3] in Krishna district of Andhra Pradesh.

As weather forecast, quality forecast is also of vital importance for the management of groundwater resources. Rainfall is the chief external contribution to the groundwater storage and has influence on the quality[4].

In Kerala rainfall is received by south-west monsoon during June to September followed by north-east monsoon in the months of October and November. Major portion is received in the former case with a few torrential showers during April and May.

Here an attempt has been made to relate quality variation with rainfall by correlation analysis. Linear relationship model has been developed using the

†Department of Chemistry, Providence Women's College, Calicut, India.

rainfall and chemical characteristics observed since 2001 in different wells of Calicut town area.

EXPERIMENTAL

Calicut is situated in the nothern part of Kerala between 11°10′–11°15′ north latitude and 75°45′–75°52′ east longitude. It has a total area of 2344 km^2 and a population of 26.2 lakhs, which is about 9% of the total population of the state. The relative areas of the different physiographic units in the district are lowland –362.8 km^2, midland –1344.7 km^2 and highland –625.8 km^2. Calicut city is spread over an area of 84.2 km with a human population of about 419831. It is situated on the Malabar Coast. The area falls under the midland area of Kerala, with the highest elevation being approximately 65 m above sea level.

The soil is typically lateritic. It is deep red in colour and is observed mainly in the tropics. It has developed on bedrock of mafic igneous rock. A soil horizon associated with laterite soils is iron-rich, humus and a poor mixture of clay, quartz and other diluents. This material, called plinthite, dries irreversibly with repeated wetting and drying with strong sunlight. The hard, dried rock-like material is hardened plinthite and is commonly referred to as ironstone or laterite[5].

Most of the people depend on homestead open wells for domestic purposes. The density of open wells in the district is 258 per km^2. It is estimated that 50% of the population of the city depends on wells[6]. A detailed ground water survey of the location of wells was conducted and some were selected in different parts of Calicut district. All the wells served the purpose of drinking water source. The observation wells are placed 5–15 km apart. The chemical analysis was done as prescribed in APHA[7].

RESULTS AND DISCUSSIONS

Geological factors seldom undergo changes over a period of time and space. The rainfall is the space and time dependent factor, and is the external contributor to the ground water storage system. So it is assumed that the fluctuation in concentration of chemical constituent has direct relationship with the rainfall.

It can be stated as

$$C_i = C_{i-1} + \Delta C_i \quad (1)$$

where C_i = concentration of a chemical parameter at the end of the ith year,

C_{i-1} = concentration of the chemical parameter at the end of the (i – 1)th year (that is, beginning of ith year).

ΔC_i = change during ith year.

The change in concentration (ΔC_i), either dilution or denseness, is related with annual rainfall (R) assuming that there is no inter-basin transfer.

$$\Delta C_i = A^*R + B \quad (2)$$

where A and B are constants and R is the total rainfall during ith year in monsoon.

The equation is applicable only to a particular area because A and B stand for soil cover complex and geological formations.

The annual quality fluctuation is the difference in quality during the pre-monsoon and post-monsoon. The annual quality change, parameter-wise corresponding to annual rainfall in the wells of seven different places, is given in Table-1. Positive values represent the increase and the negative values reflect the decrease in concentration. A and B are reckoned from the observed change in concentration of chemical parameters and the corresponding annual rainfall by regression analysis. Determined values of correlation coefficients A, B and standard error of estimate are given in Table-2.

TABLE-1
RAINFALL AND FLUCTUATIONS IN CHEMICAL PARAMETERS IN mg/L (2000–03)

Year	Rainfall	pH	EC	Alk	Cl^-	NO_3^-	SO_4^{2-}	DO	TDS	HT	CaH	Mg^{2+}	Ca^{2+}	Fe
VELLAYIL														
00–01	2507.7	–0.6	0.30	2	–2	–1.99	–10	0.72	53	36	–9	6.20	–40.10	–0.09
01–02	2423.3	0.1	0.70	4	–2	0	10	1.44	–77	8	39.46	30.50	15.82	0
02–03	1886.2	0.8	0.03	100	–2	0.20	0	0.64	–31	–12	–33	–7.52	–13.20	0
NADAKKAVU														
00–01	2507.7	0.6	0.29	50	–4	0	–10	–0.80	3	62	49.06	0	–20.04	0.40
01–02	2423.3	0.7	0.03	38	–18	0	10	12.80	31	40	–34.80	17.9	–14.04	1.49
02–03	1886.2	1	0.08	40	4	0.01	70	3.36	–111	28	51.91	2.60	4.76	0
VENGERI														
00–01	2507.7	0	0.09	0	4	–0.30	0	–0.94	37	36	0.006	1.92	0	0
01–02	2423.3	0.1	–0.01	2	4	–0.01	0	–1.44	–19	2	–4.003	–0.74	–1.60	0
02–03	1886.2	0.4	0.01	5	0	0.10	0	0.08	–17	12	–2.008	–1.22	–0.80	0
ERANHIPALAM														
00–01	2507.7	0	0.17	2	4	1	0	0	41	36	3	3.89	–3.42	0
01–02	2423.3	0.4	–0.10	–12	2	0	0	0.96	15	2	0.99	1.96	0.39	0
02–03	1886.2	0.4	–0.12	–28	4	0.50	0	–0.32	–64	–10	–2.98	0.91	–1.19	0
BORE WELL														
00–01	2507.7	0.2	–0.01	10	22	0	–5	–0.84	–12	58	6.01	–0.47	–7.80	0
01–02	2423.3	0.3	–0.14	–32	6	0	0	2.72	–72	–12	6	–0.14	73.40	0.20
02–03	1886.2	0	0.01	–22	20	0.01	0	0	–52	–16	–11.99	–2.53	–4.80	1

TABLE-2
RELATION BETWEEN RAINFALL AND FLUCTUATION IN QUALITY

Parameter	A	B	r	S.D.
		VELLAYIL		
pH	4.449593	–0.0019141	–0.921803	0.571547
EC	0.338635	–0.00020344	–0.132607	0.42227
Alk	410.71313	–0.1651908	–0.99421	45.73352
Cl^-	0	0	0	0
NO_3^-	–1.65438	0.000270674	0.279563	0.98861
SO_4^{2-}	8.43824	0.00371336	–0.12518	8.16496
DO	–0.461816	0.000613954	0.46974	0.35975
TDS	–146.5446	0.05642109	0.288537	53.8227
HT	–132.42752	0.0629705	0.880434	19.6843
CaH	–166.626271	0.07295	0.66277	30.13824
Mg^{2+}	–79.90999	0.039445	0.690649	15.72064
Ca^{2+}	–36.45143	0.015432	0.188514	22.8347
Fe^{3+}	0.1817258	–9.31728	–0.60477	0.4226
		NADAKKAVU		
pH	2.1602763	–0.00061328	–0.99315	0.16996
EC	–0.285259	0.000184207	0.4501136	0.11264
Alk	22.158938	0.009024699	0.47321	5.24933
Cl^-	46.011647	–0.022888	–0.6929	9.09212
NO_3^-	0.049145	–1.6992E-05	–0.992133	4.714045
SO_4^{2-}	–285.17878	0.1152285	0.93302	33.99346
DO	–142.25716	0.0585946	0.571577	5.6899
TDS	–568.66146	0.243352	0.99357	67.41579
HT	–54.756232	0.0431356	0.843895	14.07914
CaH	159.57945	–0.060518	–0.44146	40.22056
Mg^{2+}	–10.133032	0.007466275	0.260237	7.8969
Ca^{2+}	–16.932203	–0.0381559	–0.9941219	10.5645
Fe^{3+}	–2.558945	0.00140338	0.613459	0.62965
		VENGERRI		
pH	1.560276	–0.00061328	–0.99315	0.169967
EC	–0.1280707	6.95419E-05	0.44303	0.0432
Alk	18.6219399	–0.00716802	–0.96018	2.0548
Cl^-	–12.4376108	0.006622102	0.99112	1.8856
NO_3^-	1.03695939	–0.00048713	–0.794704	0.18798
SO_4^{2-}	0	0	0	0
DO	3.926095	–0.02065113	–0.89865	0.63252
TDS	–123.68483	0.054578	0.579103	25.4401

Parameter	A	B	r	S.D.
HT	–24.7067142	0.0182069	0.351254	14.2673
CaH	–3.72979365	0.000760485	0.1278	1.63667
Mg^{2+}	–8.12438359	0.003569376	0.71139	1.38104
Ca^{2+}	–1.47505936	0.000297069	0.12518	0.65319
Fe^{3+}	0	0	0	0
		ERANHIPALAM		
pH	1.2076706	–0.0004141	–0.604477	0.18856
EC	–7.080956	0.000305006	0.6410668	0.130985
Alk	–107.380935	0.0416802	0.936031	12.2565
Cl^-	6.3507047	–0.00132783	–0.3876566	0.94281
NO_3^-	0.07808	0.000185668	0.12518	4.0825
SO_4^{2-}	0	0	0	0
DO	–2.47058	0.001181095	0.597718	0.54389
TDS	–368.86637	0.16115107	0.99345	44.6492
HT	–116.98635	0.05558866	0.78537	19.48218
CaH	–19.7208	0.008826567	0.977807	2.48465
Mg^{2+}	–6.341266	0.003782168	0.845539	1.23413
Ca^{2+}	1.45572	–0.00125963	–0.221831	1.5629
Fe^{3+}	0	0	0	0
		BORE WELL		
pH	–0.756441	0.00040622	0.8965	0.12472
EC	0.226686	–0.00012029	–0.497904	0.14617
Alk	–74.860126	0.026488	0.407018	17.91337
Cl^-	32.41658	–7.224335	–0.279359	7.11805
NO_3^-	0.041945	–1.6991707	–0.99213	4.714045
SO_4^{2-}	10.095882	–5.1762671	–0.604477	2.35702
DO	–1.50085	0.000936242	0.169605	1.579415
TDS	–109.260016	0.0281317	0.3104	24.94438
HT	–170.120476	0.079264	0.64206	33.98038
CaH	–69.47976	0.030578	0.99219	8.48292
Mg^{2+}	–9.498595	0.00371938	0.968101	1.05749
Ca^{2+}	–90.655025	0.048812	0.3574	37.5908
Fe^{3+}	–0.23507	0.000132783	0.38765	0.43204

S.D. = Standard deviation

At Vellayil, positive r values are shown by NO_3, DO,TDS, HT, CaH, Mg and Ca. Highest positive r value is that of HT (0.880) and lowest is that of Ca (0.1885). The correlation between rainfall and fluctuation is HT, CaH and Mg fall above 0.53 and they are dependent on rainfall. The highest negative fluctuation is shown by alkalinity (–0.994) and those having r value above 0.53 are pH, alkalinity and Fe.

At Nadakkavu, EC, alkalinity, SO_4, DO, TDS, HT, Mg and Fe have given positive r values. Highest value is that of TDS (0.994) and the lowest is that of Mg (0.260). It is clear that SO_4, DO, TDS, HT and Fe are dependent on rainfall. Negative r value varies between –0.994 (Ca) and –0.414 (CaH). Those showing negative r values above 0.53 are pH, Cl^-, NO_3^- and Ca.

At Vengerri, positive coefficient of correlation varies from 0.991 (Cl) to 0.125 (Ca) and that of chloride, TDS, Mg fall above 0.53 and show an increasing tendency with rainfall. Negative r values are given by pH, alkilinity and nitrate and dissolved oxygen and the r values are above 0.53 and show a decreasing trend with the annual rainfall.

At Eranhipalam, except pH (–0.604), Cl^- (–.388), and Ca (–0.222) all show positive r value. Highest positive r is shown by total dissolved solids and lowest by nitrate. The correlation coefficient values of electrical conductivity, alkalinity, dissolved oxygen, TDS, total hardness, calcium hardness, Mg and pH fall above 0.53 and they show dependency on rainfall. pH shows a decreasing trend while others show an increasing trend.

A comparative study was made with parameters of the bore well also. In this case positive correlation with rainfall is given by pH, alkalinity, DO, TDS, HT, CaH, Mg, Ca and Fe. Among these, except HT CaH and Mg all are independent of rainfall as seen from the correlation coefficient value. The highest r is that of CaH (0.992) and lowest is that of DO (0.1696). The highest negative r value is given by nitrate (–0.9921). Only nitrate has negative r values greater than 0.53.

The study reveals that there is correlation between fluctuations in some of the parameters and rainfall. The coefficient of correlation (r) between rainfall and pH fluctuation was found to be negative for all the wells, *i.e.*, pH has a decreasing trend with rainfall. The coefficients of correlation between rainfall and total hardness, electrical conductivity and total dissolved solids fluctuation were found to be positive for all the wells, *i.e.*, these parameters have an increasing trend with annual rainfall. In the case of bore well such trend was absent, may be because the rain water takes longer time to reach the water table of the bore well.

REFERENCES

1. S. Kumar, N. Garg and K. Gopal, *Indian J. Environ. Prot.*, **14**, 595 (1994).
2. K.S. Rao, and B.S. Rao, *Indian J. Environ. Prot.*, **14**, 528 (1994).
3. J.S.R. Krishna, K. Rambabu and C. Rambabu, *Indian J. Environ. Prot.*,**15**, 914 (1995).
4. P. Mariappan, V. Yegnaraman and T. Vasudevan, *Indian J. Environ. Prot.*, **21**, 1012 (2001).
5. S.P. Raychaudhuri, Land and Soil, National Book Trust of India (1996).
6. Karma, Civic Amenities in Calicut Corporation: Findings of a Social Survey, Kozhikode, India (1994).
7. APHA, Standard Methods for the Examination of Water and Waste Water, 20th Edn., AWWA WPCF (1998).

(*Received*: 19 March 2005; *Accepted*: 3 October 2005) AJC-4428