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Statistical approach and assessment of physico-chemical status of ground water in near proximity of South Bank Canal, Tamil Nadu, India

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ABSTRACT

The physico-chemical status of water samples from five major part of locality in Karur and Tiruchirappalli cities, Tamil Nadu was assessed. The sampling points were selected on the basis of their importance. The physicochemical parameter like, temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness (TH), calcium (Ca) magnesium (Mg), sodium (Na), potassium (K), nitrate (NO_3) sulphate (SO_4) and phosphate (PO_4) of ground water was determined. The results were compared with standards prescribed by WHO (2003). It was found that the ground water was contaminated at few sampling sites namely Mayanur, lalapet and Petavaithalai. While the sampling sites showed physicochemical parameters exceed the water quality standards and the quality of water is bad and it is not fit for drinking purpose. For the statistical analysis, correlation co-efficient (r) were also calculated for these water quality characteristics.

Keywords: Groundwater, physicochemical parameters, statistical analysis, Karur and Tiruchirappalli cities.

INTRODUCTION

Natural resources are the important wealth of our country, water is one of them. Water is a wander of the nature. *" No life without water ''* is a common saying depending upon the fact that water is the one of the naturally occurring essentional requirement of all life supporting activities [1]. However, rapid industrial development, economic growth, and population growth have intensified the requirements for a vast number of materials and products, leading to an increase in the number of factories in various places across the World. Consequently, available water resources have been reduced, while the environmental pollution of open water systems has increased. However, recently, social concerns and the requirement for environmental conservation have increased across the World, with rising economic standards, which has led to the establishment of wastewater treatment facilities near the industrial complexes for the efficient control of wastewater [2]. So its quality is likely to change day by day and from source to source. Any change in the natural quality may disturb the equilibrium system and would become unfit for designated uses. The availability of water through surface and groundwater resources has become critical day to day. Only 1% part is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal [3-5]. Traditional approaches to evaluate river water are usually based on the comparison of the parameter values monitored with the local normative. The analysis including one or some parameters grouped according to a common feature may give partial information on the overall quality of water. It is difficult in integrating many parameters via the traditional approaches to providing a global water quality of a watershed [6]. In India, most of the population is dependent on groundwater as the only source of drinking water supply. The groundwater is believed to be comparatively much clean and free from pollution than surface water. But prolonged discharge of industrial effluents, domestic sewage and solid waste dump causes the groundwater to become polluted and created health problems [7]. The rapid growth of urban areas has further affected groundwater quality due to overexploitation of resources and improper waste disposal practices. Hence, there is always a need for and concern over the protection and management of groundwater quality [8]. Heavy metals are priority toxic pollutants that severely limit the beneficial use of water for domestic and industrial application [9]. The lakes have

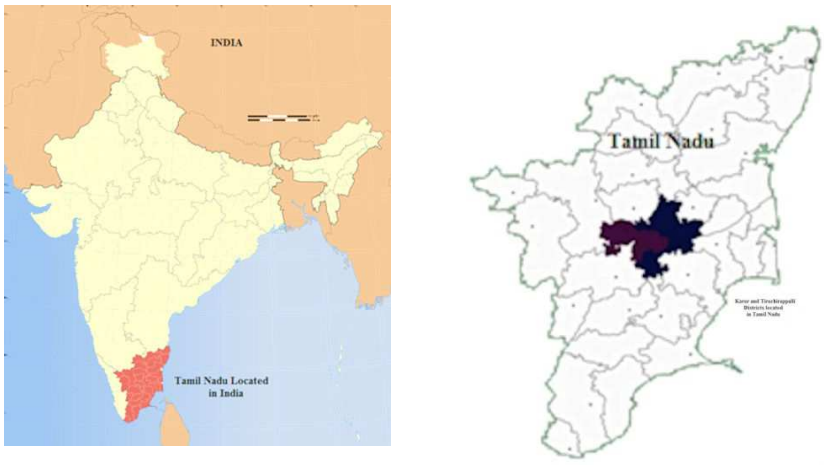
complex and fragile ecosystem, as they do not have self cleaning ability and therefore readily accumulate pollutants [10]. The physicochemical parameters and trace metal contents of water samples from Delhi were assessed [11]. The most of water bodies in India needs to be treated before using it in domestic applications by various means. Ground water contains high amount of various ions, salts etc. so if we were using such type of water as potable water then it leads to various water-borne diseases [12]. The consequence of urbanization and industrialization eads to spoil the water. For agricultural purposes ground water is explored in rural areas especially in those areas where other sources of water like dam and river or the canal is not available. During last decade, this is observed that the ground water get polluted drastically because of increased human activities [13-15]. Hence it is very essential to maintain the quality of ground water for human consumption, for the aquatic life and for other subsequent uses. Considering the above aspects of groundwater contamination, the present study was undertaken to investigate the impact of the groundwater quality of some canal water and bore well water samples in Mayanur to Petavaithalai areas of between Karur and Tiruchirappalli districts in central region of Tamil Nadu. Thus, in this research work an attempt has been made to assess the physical and chemical parameters of groundwater like, Temperature (T), pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness (TH), calcium (Ca) magnesium (Mg), sodium (Na), potassium (K), nitrate (NO_3), sulphate (SO_4) and phosphate (PO_4) of canal water and Bore well was determined. The analyzed data were compared with standard values recommended by WHO [16].

MATERIALS AND METHODS

Mayanur to Petavaithalai which is situated in the Karur and Tiruchirappalli districts is heart of the state in Tamil Nadu (central region) has become an important city because of the natural resources available around it. There are various existing industries and industrial estates. These industries use huge quantity of water for processing and release most of the water in the form of wastewater. The wastewater being generated is discharged into the nearby water resources. Similarly the geochemical and morphological structural changes due to weathering may also leaches out some chemicals/minerals from the geostatic into surface and groundwater and may change the original characteristics of water which could be rather harmful to human health after consumption. The people are using canal water, tube well water as well as municipal water for their daily need. The literature survey reveals that no water quality management studies are made in this region so far. Hence the present study was planned and undertaken. Mayanur (canal water), inner places of Mayanur & Seelapillayarputhur (bore water), lalapet (canal water), inner places of lalapet & mahendramangalam & petavaithalai (bore water), site selected were from different localities in Karur and Tiruchirappalli districts for samples collection.

The sample were collected from all the stations at 11.00 am to 12.00 noon in both the seasons for physico-chemical examinations, different methods of collection and handling were adopted based the standard procedures [17]. The samples were collected in plastic canes of five liters capacity without any air bubbles. The instruments were used of accuracy. The temperatures of the samples were measured in the field itself at the time of sample collection. The samples were kept in refrigerator maintained at $4^{o}C$.

Figure 1: Map of study area along with sampling locations



South Bank Canal located in between Karur and Tiruchirappalli Districts

Water samples from seven sampling sites were collected during a post monsoon period. The sampling locations in Karur and Tiruchirappalli districts for assessment of physico-chemical parameter status of ground water are given in Table 1and Figure 1.

Table : 1 Ground water sample location

No of samples	Water type	Area of samples	Co ordinates
1	Surface water (Canal)	Mayanur	10°56 N 78°14 E
5	Bore well (TR)	Mayanur	
5	Bore well (TR)	Lalapet	10°34 N 78°15 E
3	Bore well (TR)	Pettavaithalai	10°54 N 78°35 E
1	Surface water (Canal)	Lalapet	
5	Bore well (TL)	Seelapillayarputhur	10°94 N 78°34 E
5	Bore well (TL)	Mahendramangalam	10°56 N 78°27 E

TR - Towards Right of the canal water
TL - Towards Left of the canal water

Analysis was carried out for various water quality parameters such as Temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness (TH), calcium (Ca) magnesium (Mg), sodium (Na), potassium (K), nitrate (NO_3), sulphate (SO_4) and phosphate (PO_4) using standard method [18-20]. All The reagents used for the analysis were AR grade and double distilled water was used for preparation of solutions.

RESULTS AND DISCUSSION

The physico-chemical parameters of the above mention sites in Karur and Tiruchirappalli cities can be calculated and it is describe as bellow,

Table-2: Readings of Physico chemical parameters in Different Stations

Parameters	Se	May	La	Mah	Pet	WHO
Temp	27.5	28	29	27.6	30	-
pH	7	7.2	7.1	7.7	7.9	7-8.5
EC	735	2585	887	2989	1925	1400
TDS	2300.5	870	835.5	2582	1995	500
TH	716.5	298	423	235	140	500
DO	5.5	6.5	7.5	7.1	8.2	5
BOD	14.5	8.2	14.1	12.1	14.6	6
COD	27.8	18.9	26.4	29.5	17	10
Sul	18.2	6.9	11.4	11.7	6.5	250
Nit	3.5	5.4	2.2	3.9	2.2	50
Pos	0.5	0.4	0.6	0.6	0.3	0.1
Ca	74	120	118	113	82	100
Mg	48	40	54	81	51	150
Na	112	114	142	135	106	200
K	49	45	74	74	24	12

Se-Seelapillayarputhur *May-Mayanur* *La-Lalapet*
Mah-Mahendramangalam *Pet-Petavaithalai*
WHO-World Health Organization *Temp-Temperature*
EC-Electrical Conductance *TDS-Total Dissolved Solids*
TH-Total Hardness *DO-Dissolved Oxygen*
BOD-Biological Oxygen Demand, *COD-Chemical Oxygen Demand,*
Sul-Sulphate, *Nit-Nitrate,* *Pos-Phosphate*
Ca-Calcium *Mg-Magnesium* *Na-Sodium*
K-Potassium.

Temperature is an important biologically significant factor, which plays an important role in the metabolic activities of the organism. The temperature was ranging from 27.0°C to 30.0°C during the study period. Lowest water temperature was observed in the Seelapillayarputhur was 27.5 °C. A study increase in water temperature in the course of Mayanur was noticed i e 28.0 °C. An increase in temperature was observed from Mayanur (28.0 °C) to Pettavaithalai (30.0 °C). This might be due to presence of the effluents. Our property of water is that with change in temperature, its density varies and it becomes less with warming up and more with cooling. pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. Most of the water samples are slightly alkaline due to presence of carbonates and bicarbonates. The pH values of water samples varied between 8.0 to 7.1 and were found within the limit prescribed by WHO. The higher range of Ph indicates higher productivity of water [21]. Electrical conductivity (EC) is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts [22]. EC values were in the range of 3000 micro ohms/cm to 700 micro ohms/ cm. High EC values were observed for three sampling place namely Mayanur, lalapet and Pettavaithalai indicating the presence of high amount of dissolved inorganic substances in ionized form.

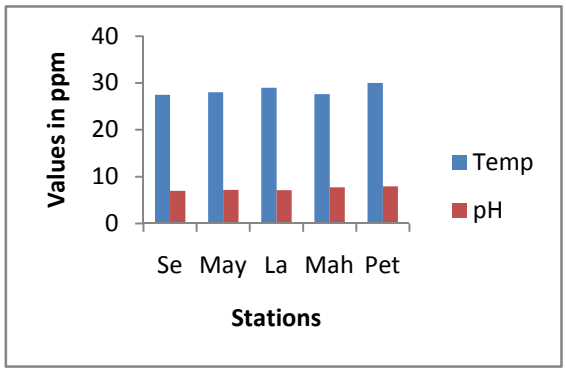
Total dissolved solids indicate the salinity behavior of groundwater. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed [21]. TDS values varied from 835.5 mg/L to 2582 mg/L. All sampling points showed higher TDS values than the prescribed limit given by WHO. Dissolved oxygen is important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. The DO values indicate the degree of Pollution in water bodies. DO values varied from 8.2 to 5.5.All sampling points showed high DO values. Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water [23]. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The hardness values shown range from 716 mg/L to 140mg/L. All sampling points were higher than the prescribed limit.

Calcium is directly related to hardness. Calcium concentration ranged between 118.00 mg/L to 74.00 mg/L. Seelapillayarputhur and Pettavaithalai are found below permissible limit of WHO, except samples from sampling point Mayanur, Lalapet and Mahendramangalam. Magnesium is directly related to hardness. Magnesium content in the investigated water samples was ranging from 81.00 mg/L to 40.0 mg/L which were found within WHO limit. Sodium concentrations were found in between 142.00 mg/L to 106.00 mg/L. All Sampling sites showed lower sodium concentration than the prescribed limit by WHO.

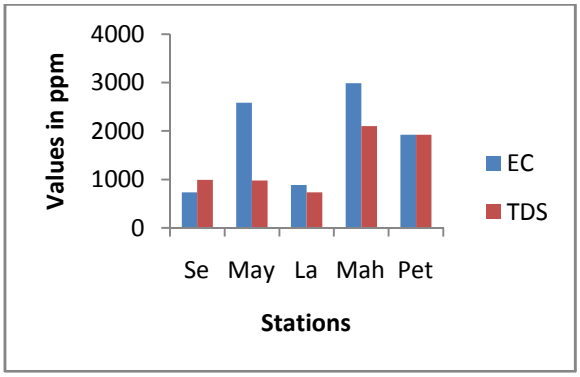
The major source of potassium in natural fresh water is weathering of rocks but the quantities increase in the polluted water due to disposal of waste water [24]. Potassium content in the water samples varied from 74.0 mg/L to 24.0 mg/L. It is found that the contents of potassium in site Lalapet and Mahendramangalam is higher i.e. 74 mg/l. Groundwater contains nitrate due to leaching of nitrate with the percolating water. Groundwater can also be contaminated by sewage and other wastes rich in nitrates. The nitrate Content in the study area varied in the range 5.4 mg/L to 2.2 mg/L and found within the prescribed limit. And Mayanur is higher value of permissible limit.

Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals [18]. Discharge of industrial wastes and domestic sewage tends to increase its concentration. The sulphate concentration varied between 18.2 mg/L and 6.5 mg/L. and found within the prescribed limit. Phosphate may occur in groundwater as a result of domestic sewage, detergents, and agricultural effluents with fertilizers. The phosphate content in the study area was found in from 0.6 to 0.3 mg/L. All the data can be summarized in *Table-2* and graphical representation of Average values of the physicochemical parameters of different sites in Karur and Tiruchirappalli district as shown in below,

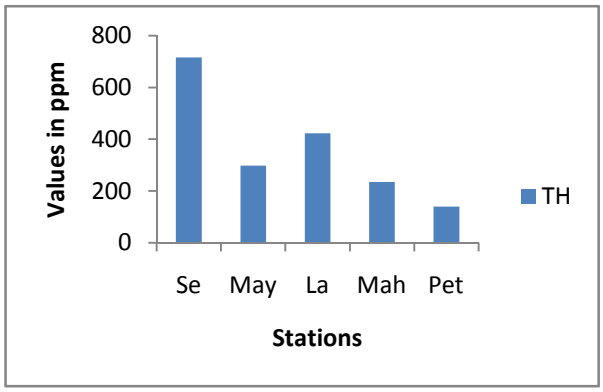
Graphically represented by Different Physico chemical parameters



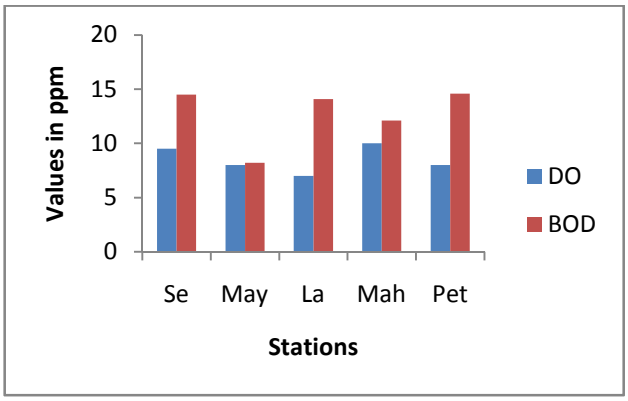
(a) Graphically represented in Temp & pH



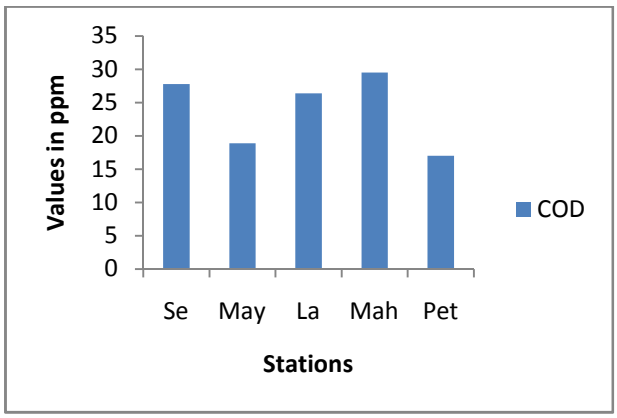
(b) Graphically represented in EC & TDS



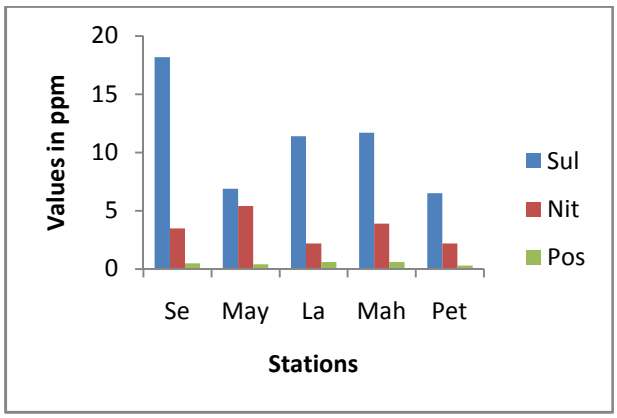
(c) Graphically represented in TH



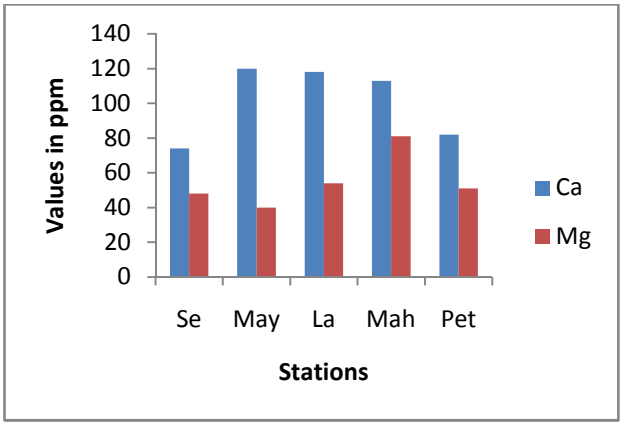
(d) Graphically represented in DO & BOD



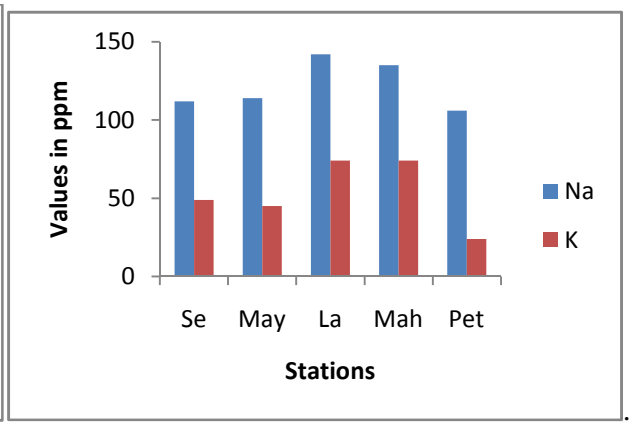
(e) Graphically represented in COD



(f) Graphically represented in Sul, Nit & Pos



(g) Graphically represented in Ca & Mg



(f) Graphically represented in Na & K

To find the relationship between two parameters x and y, the Karl Pearson's correlation coefficient, r is used and it is determined as follows

$$r = \frac{n \Sigma x y \Sigma x \Sigma y}{\sqrt{[n \Sigma x^2 - (\Sigma x)^2][n \Sigma y^2 - (\Sigma y)^2]}}$$

Here, n = number of data points ; x = values of x–variable ;
y = values of y–variable

In statistics, correlation is a broad class of statistical relationship between two or more variables. Hence, it can be considered as a normalized measurement of covariance. The correlation study is useful to find a predictable relationship which can be exploited in practice. It is used for the measurement of the strength and statistical significance of the relation between two or more water quality parameters. Hence, it is a helpful tool for the promotion of research [25-30]. It can put forward possible causal or mechanistic relationships [31-33]. The correlation coefficients(r) were calculated and correlation matrix was obtained [34-41]. Here, r is a dimensionless index which is in the range of -1.0 to +1.0 inclusive and exhibits the extent of a relation between variables. The values of correlation coefficients are listed in **Table-3.** High positive correlation was found between E.C. and TDS., Ph and E.C., SUL and TH, COD., POS and COD., K and COD., Na and POS., K and Ca, Mg, Na., while moderately high negative correlation was observed between COD and TDS., NIT and TDS, COD., Ca and T, PH, TDS., Na and EC, TDS., K and TDS, BOD., NIT and SUL., POS and NIT. Very poor positive correlation was observed between BOD and DO., NIT and TH., Ca and COD., Na and TH,BOD.,K and NIT., Very poor Negative correlation was observed between TH and PH,EC,TDS.,DO and T.,BOD and EC.,COD and T.,SUL and T.,NIT and T,BOD.,POS and T., Ca and BOD while there is almost no correlation was found between K and EC.

CONCLUSION

Deviations were observed by some groundwater samples in Karur and Tiruchirappalli. The water samples from sites Mayanur, Lalapet and Pettavaithalai showed poor water quality as compared to other water sample sites like Seelapillayarputhur, Mahendramangalam. The water samples from sites Mayanur, Lalapet and Pettavaithalai are polluted and unfit for drinking purpose. The sampling point Mahendramangalam showed high TDS, DO, BOD and COD are high attention level. Total hardness and sodium content indicating the need of some treatment for minimization of the parameters. The sampling site of Seelapillayarputhur for both open well and bore well showed physicochemical parameters within the water quality standards and Mayanur, Mahendramangalam and Pettavaithalai are the quality of water is bad and it is unfit for drinking purpose. The water should be treated properly before its usage as drinking water to avoid possible adverse effects. Therefore, public should be made aware of drinking water quality and careful Management of precious natural resources. Water quality also should be monitored continuously for the welfare of the people.

Table 3 : Statistical correlation coefficient values

	T	Ph	EC	TDS	TH	DO	BOD	COD	SUL	NIT	POS	Ca	Mg	Na	K
T	1														
PH	0.4875	1													
EC	-0.1542	0.6078	1												
TDC	0.16	0.9306	0.6521	1											
TH	0.5379	-0.8385	-0.7415	0.0509	1										
DO	-0.6907	0.1803	0.3329	0.5219	0.1973	1									
BOD	0.3934	0.1233	-0.6632	0.1184	0.2753	0.0075	1								
COD	-0.6517	-0.3468	-0.2037	-0.061	0.5357	-0.4281	0.2724	1							
SUL	-0.6136	-0.5636	-0.5792	-0.2884	0.8885	0.5156	0.4481	0.7979	1						
NIT	-0.6923	-0.2485	0.5607	-0.1062	0.0311	0.344	-0.903	-0.0513	-0.087	1					
POS	-0.537	-0.3968	-0.1407	-0.1996	0.3805	0.2348	0.1061	0.9218	0.5731	-0.0373	1				
Ca	-0.1423	-0.1152	0.4602	-0.1789	-0.3647	-0.3246	-0.6526	0.0832	-0.4176	0.3764	0.4277	1			
Mg	-0.234	0.4821	0.4341	0.6721	-0.2882	0.5646	0.1797	0.6272	0.1592	-0.1404	0.5895	0.2041	1		
Na	-0.1761	-0.1814	-0.0065	-0.132	0.0063	-0.1104	0.0457	0.6651	0.1675	-0.1817	0.8878	0.673	0.5848	1	
K	0.485	-0.3352	0.0015	-0.178	0.2189	0.1394	-0.0413	0.8298	0.3924	0.0323	0.9772	0.6055	0.5978	0.9446	1

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REFERENCES

[1] Ayibatele N.B.; First Season Environmerital Baseline Survey, *In proc. of internal. conf. on water and environ*., **1992,** 1, 4-26.
[2] Mi-Jung Bae, Jun-Su Kim and Young-Seuk Park ., *Int. J. Environ. Res. Public Health* , **2012,** 9, 1182-1200.
[3] Mishra K.R., Pradip, Tripathi; S.P, *Acta Ciencia Indica*, XXXIIIC, **2002,** 2, 179.
[4] Gupta V., Agarwal J., Sharma S.; *Asian J. of Chem.*, **2008,** 20(8), 6195-98.
[5] Tahir M.A., Rasheed H. and Malana A.; Method development for arsenic analysis by modification in spectrophotometric technique, *Drik. Water Eng.Sci. Discuss*. **2008,** 1, 135-154.
[6] Zhenghui Liu, Guoping Sun, Shaobin Huang, Wei Sun, Jun Guo, and Meiying Xu, "Water Quality Index as a Simple Indicator of Drinking Water Source in the Dongjiang River, China", *I.J.E.P*., **2012,** 2 (5),PP. 16-21.
[7] Raja R E, Lydia Sharmila, Princy Merlin, Chritopher G, Physico-Chemical Analysis of Some Groundwater Samples of Kotputli Town Jaipur, Rajasthan, *Indian J Environ Prot*., **2002,** 22(2), 137.
[8] Patil P.R, Badgujar S.R. and Warke A.M. Evaluation Of Ground Water Quality In Ganesh Colony Area Of Jalgaon City, *Oriental J Chem.*, **2001,**17 (2), 283.
[9] Petrus R and Warchol J.K., Heavy metal removal by clinoptilolite. An equilibrium studyin multi-component systems, *Water Res*., **2005,** 39, 819-830.
[10] Lokeshwari H and Chandrappa G.T, Impact of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation, *Curr Sci*., **2006,** 91(5), 584.
[11] Massod Alam, Sumbul Rais and Mohd AslamS; Hydro-chemical Survey of Groundwater of Delhi, India, *E-Jour. of Chem.* **2009,**6(2), 429-436.
[12] Arvnabh Mishra, Vasishta D. Bhatt, Nirav Sevak, Pinal Shah, Kirit Patel and Chaitanya Patel; Comparative Study of Physico-Chemical and Microbial Parameters on Lotic And Ground Waters In Selected Outlying Areas Of Central Gujarat, *J. Chem. Pharm. Res.*, **2010,** 2(4), 174-177.
[13] 13. Elizabeth K.M. and Premnath Naik L, Effect of polluted water on human health *Poll*. res., **2005,**24(2) 337-340.
[14] Vijender Singh; Physico-chemical Examination of water, Sewage and Industrial effluents, *Res. J. chem and ENV*, **2006,**10(3), 62- 66.
[15] Arunabh Mishra and Vasishta Bhatt; Physico- Chemical and Microbiological Analysis of Under Ground Water in V.V Nagar and Nearby Places of Anand District,Gujarat, India, *E-.J. Chem.*, **2008,**5(3), 487-492.
[16] World Health Organization, Guidelines for drinking water quality-I, Recommendations. *2nd Ed. Geneva WHO*. **1993**.
[17] Standard Methods for the Examination of Water and Waste Water, *20th Ed., APHA, AWWA, WEF. Washington DC*, **1998**.
[18] Standard Methods for the examination of water and waste water, *American Public Health Association, 17th Ed., Washington, DC*, **1989**.
[19] 19. Trivedy R.K and Goel P.K; *Chemical and Biological methods for water pollution studies Environmental Publication, Karad*. **1986**.

[20] 20. Manivaskam N. Physicochemical examination of water sewage and industrial effluent, *5th Ed. Pragati Prakashan Meerut.*, **2005**.
[21] 21. Khan, I.A. and Khan A.A., Physical and chemical condition in Seika Jheelat, *Aligarh, Ecol.*, **1985,** 3, 269-274.
[22] 22. Sudhir Dahiya and Amarjeet Kaur, physico chemical characteristics of underground water in rural areas of Tosham subdivisions, Bhiwani district, Haryana, *J. Environ Poll.,* **1999,** 6 (4), 281.
[23] 23. Shrinivasa Rao B and Venkateswaralu P, Physicochemical Analysis of Selected Groundwater Samples, *Indian J Environ Prot.,* **2000,**20 (3), 161.
[24] 24. Trivedy R. K. and Goel P. K.; Chemical and Biological methods for water pollution Studies, *Environmental Publication*, Karad. **1986**.
[25] 25.R. C. Ward, *J. Water Pollut. Control*, **1979,** 2291-2300.
[26] 26. C.S. Iyer, M. Sindhu, S.G. Kulkarni, S.S. Tambe, B.D. Kulkarni, *J. Environ. Monit.*, **2003,**5, 324.
[27] 27. J.R.Das, P.C. Dash, H.K.Patra, *Indian J. Environ. Prot.,* **2006,**26, 550-558.
[28] 28. C. Gajendra, P. Thamarai, *Poll. Res.,* **2003,**17(4), 679-683.
[29] 29. K. Karunakaran, P. Thamilarasu, R. Sharmila, *E. J. Chem*, **2006,**6(3), 909-914.
[30] 30. R. Reza, G. Singh, *J. American Science*, **2009,**5(5), 53-58.
[31] 31. J.L. Radgers, W.A. Nicewander, *The American Statistician*, **1988,** 42(1), 59-66.
[32] 32. J. Cohen, P.Cohen, S.G.West, L.S.Alken, Applied Multiple Regression / Correlation Analysis for the Behavioural Sciences, Hillsdale Lawrence Erlbaum Associates, 3rd edition, **2003**.
[33] 33. D. Chapman(Ed.), on the behalf of UNESCO,WHO, UNEP, Water Quality Assessments-A Guide to Use Biota, Sediments and Water in Environmental Monitoring, F & F Spon, London, Chapter-9. **1996**.
[34] 34. D.M.Joshi, N.Bhandari, Alok Kumar, N.Agrawal, *Rasayan J. Chem.,* **2009,** 2(3), 579-587.
[35] 35. V.T.Patil, P.R.Patil, *E. J. Chem*, **2010,**7(1), 111-116.
[36] 36. G.F.P.Box, W.G.Hunter, J.S.Hunter, Statistics for Experiments, An Introduction to Design, Data Analysis and Model Building, John Wiley and Sons, Toronto, **1978,** 653.
[37] 37. J. Mahadev, S.P.Hosamani, S.A.Ahmed, *World Appl. Sci. J.*, **2010,** 8(11), 1370-1380.
[38] 38. R.Shyamala, M.Shanthi, P.Lalitha, *E. J. Chem,* **2008,**5(4), 924-929.
[39] 39. R.O.Gilbert, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold Co., New York, **1987,**320.
[40] 40. V.S. Shrivastava, P.R.Patil, *Nat. Environ. Pollut. Tech.*, **2002,** 1(3), 279-283.
[41] 41. X. Zeng, T.C.Rasmussen, *J. Environ. Quali.,* **2005,**34(6), 1980-1991.