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Physico-Chemical Analysis Of Water Samples Near Industrial Area, Kurinjipadi Block, Cuddalore District, Tamilnadu, India

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Abstract : The present investigation was carried out to assess the impacts of industrial activities on the ground water quality in and around SIPCOT Industrial complex in Cuddalore District (kurinjipadi block).The quality was assessed in terms of physico-chemical parameters. Ground water and municipal water samples were collected from seven (7) villages in kurinjipadi block during December 2010- February 2011. The physico-chemical parameters such as pH, Electrical Conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), Calcium (Ca^{2+}), magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), Nitrate (NO_3^{-}), Sulphate (SO_4^{2-}) were analyzed (APHA, 1998) to know the present status of the groundwater quality. The results were compared with standards prescribed by ISI 10500-91. It was found that the underground water was contaminated at few sampling sites. The remaining sampling sites shows physicochemical parameters within the water quality standards and the quality of water is good and it is fit for drinking purpose. The correlation coefficients were calculated for water quality assessment.
Keywords : Water quality, Physico-chemical characteristics, municipal water, drinking water quality, SIPCOT.

Introduction

Ground water is one of the earth's widely distributed, renewable and most important resources. It is generally considered least polluted compared to other inland water resources, but studies indicate that ground water is not absolutely free from pollution though it is likely to be free from suspended solids. The major problem with the ground water is that once contaminated, it is difficult to restore its quality[1].

Ground water quality has become an important water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture[2]. In India, most of the population is dependent on groundwater as the only source of drinking water supply[3].

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Less than 1% of the earth's water is available for human consumption and more than 1.2 billion people still have no access to safe drinking water. Nearly 40% of global food production is attributed to irrigated abstraction, and 70% of the world groundwater withdrawals are used for irrigation purposes. In India, there are over 20 million private wells, in addition to the government tube wells[4]. Application of fertilizers, pesticides, manure, lime refuse dumps etc. is the main source of bore well water pollution in many villages[5].

Water quality is dependent on several parameters. There exist strong correlations among different parameters and a combined effect of their inter-relatedness indicates the water quality. Ground water quality in the industrial areas is determined by measuring the concentration of some physico-chemical parameters and comparing them with drinking water standards[6].

In this present study, an attempt has been made to evaluate the quality of ground water in the study area and thereby to analyse correlation and regression study of various physico-chemical parameters.

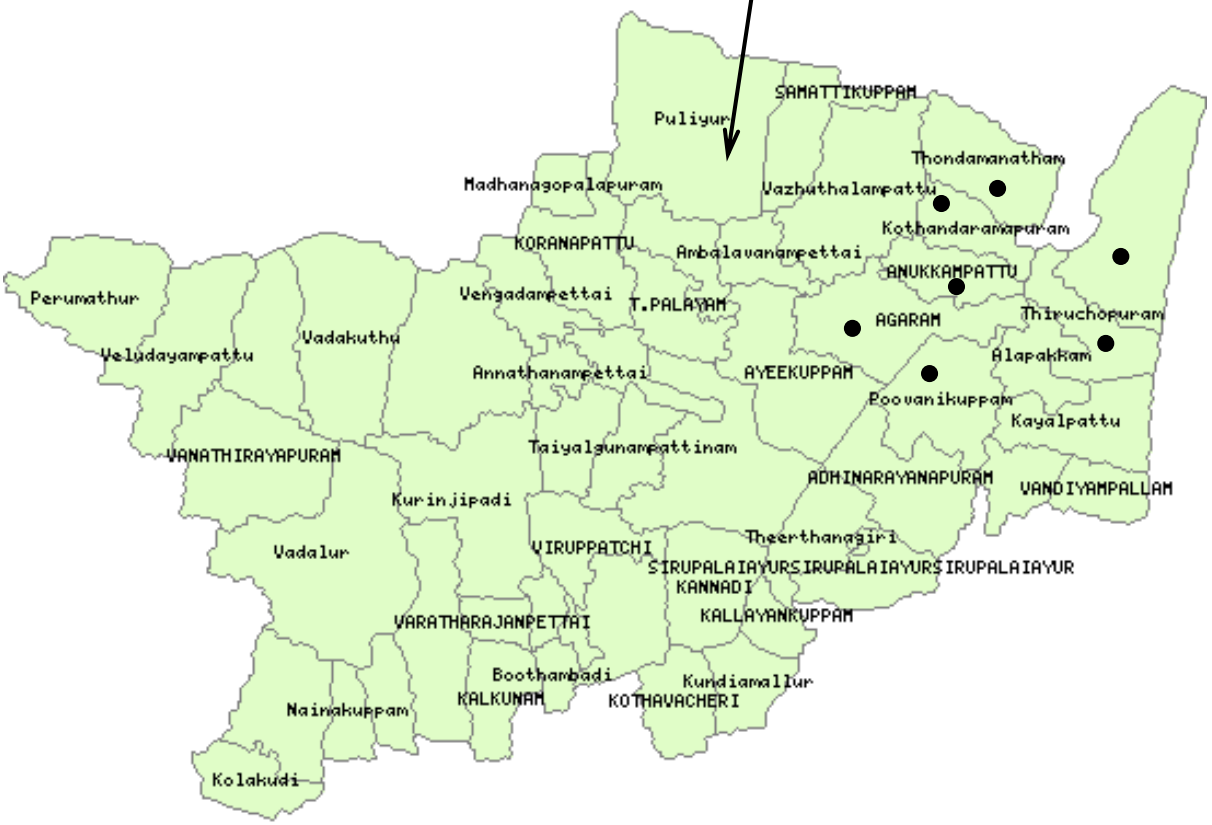
Study Area:

Cuddalore is situated at northern region of Tamilnadu state lying between latitude 11° 43' North and longitude 79° 49'east (Fig.1). Bore well water is generally using for drinking and irrigation purposes in this district. The salinity intrusion and industrial pollution of ground water are thetwo key reasons for deterioration of water quality.The ground water samples were collected in polythene bottles from bore wells and Municipal supply water of sevenpanchayat villages of Cuddaloredistrict :kurinjipadi block during December 2010 - February 2011.The sampling locations are given in Table 1.

Table 1:Name of panchayatvillages inCuddaloredistrict :kurinjipadi block used for water sampling

Villages of various region of Cuddalore district		
	Source	
Sampling locations	**Bore well**	**Municipal supply water**
Thrichopuram village	BW 1	MW 1
Agaramvillage	BW 2	MW 2
Anukkampattu village	BW 3	MW 3
Kothandaramapuramvillage	BW 4	MW 4
Thondamanathamvillage	BW 5	MW 5
poovanikuppam village	BW 6	MW 6
Thiyagavallivillage	BW 7	MW 7

Cuddalore : Kurinjipadi Block
Panchayat Villages



(Map Not to Scale)
Digital Map Source : TWAD Board, Chennai
Web Design: NIC,TNSC

Fig.1 sampling locations

Materials and Methods

Physic-chemical analysis

Samples were analyzed for different physico-chemical parameters such as, pH,electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), total alkalinity (TA) ,total hardness (TH), Calcium (Ca^{2+}), magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), Nitrate (NO_3^{-}), Sulphate (SO_4^{2-}) as per standard procedures (APHA, Standard methods)[7].The quality of ground water has been assessed by comparing each parameter with the standard desirable limit of that parameter in drinking water as prescribed by ISI 10500-91.

Statistical analysis

Interrelationship studies between different variables are very helpful tools in promoting research and opening new frontiers of knowledge. The study of correlation reduces the range of uncertainty associated with decision making. Correlation studies have also indicated the contribution of changes in land use and industrial discharge.

The simple linear correlation analysis has been carried out to find out correlation between two tested parameters. The correlation co-efficient 'r' was calculated using the equation[8].

$$r = \frac{N\sum(X_i Y_i) - (\sum X_i).(\sum Y_i)}{\sqrt{\left[N\sum {X_i}^2 - (\sum X_i)^2\right]\left[N\sum {Y_i}^2 - (\sum Y_i)^2\right]}}$$

Where, Xi and Yi represents two different parameters. N = Number of total observations. The numerical values of correlation coefficient (r) for 14 parameters are tabulated in Table 3.

The limits of r are from +1 to -1 as follows:

(a) r = +1: Perfect positive correlation, all the points on the graph on a straight line. Any increase in one variable is accompanied by the increase in other.

(b) r = 0 : No correlation, all the points on the graph are scattered irregularly.

(c) r = -1 : Perfect negative correlation, all the points on the graph on a straight line. Any increase in one variable is associated by decrease in the other.

Results And Discussion

The average results of the physicochemical parameters for water samples are presented in Table 2.

pH

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. Most of the waters are slightly acidic. The pH values of water samples varied between 6.5 to 7.3 and were found within the limit prescribed by ISI.

Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts[9]. EC values were in the range of 334 micromhos/cm to 1640 micromhos/cm. High EC values were observed for two samples BW1 and BW2 (Bore well samples) indicating the presence of high amount of dissolved inorganic substances in ionized form.

Total dissolved solids (TDS)

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[10]. TDS values varied from 110.5 mg/L to 933.4 mg/L. The samples BW6 and MW7 showed higher TDS values than the prescribed limit given by ISI 10500-91.A higher TDS level may cause corrosion of pipes and plumbing system, and therefore a water softener system with a reverse osmosis should be used[11].

Turbidity

In most waters, turbidity is due to colloidal and extremely fine dispersions. Theturbidity values varied between 0.3 to 1.7 NTU and found within the limits prescribed by ISI 10500-91.

Table 2: Water quality parameters of samples

Parameters	Water samples														ISI 10500-91
	BW1	MW1	BW2	MW2	BW3	MW3	BW4	MW4	BW5	MW5	BW6	MW6	BW7	MW7	
pH	**7.3**	6.5	**6.5**	6.6	6.8	6.6	6.6	6.7	6.5	6.9	6.6	6.9	6.8	6.7	6.5-8.5
EC	**170**	316	347	432	654	699	338	318	326	305	806	**1526**	680	1436	-
TDS	**110.5**	205.4	225.5	280.8	425.1	454.3	219.7	206.7	211.9	198.2	523.9	991.9	442	**933.4**	500
Turbidity	1.1	1.1	1.2	0.5	**0.3**	0.4	0.6	0.4	0.4	0.4	1.0	1.2	**1.7**	0.7	10
DO	4.4	**6.2**	4.7	4.2	**3.9**	4.0	4.1	4.0	4.4	5.0	4.4	6.0	4.9	6.0	5.0
TA	289	186	**136**	154	382	421	**549**	264	186	292	164	279	428	295	200
TH	108	**82**	112	100	202	218	314	324	**536**	488	204	122	144	204	300
Ca^{2+}	15.2	9.3	5.7	4.1	8.6	11.1	3.3	2.0	0.4	**0.1**	19.9	**42.4**	9.3	18.2	75
Mg^{2+}	**0.8**	1.2	3.4	2.6	2.9	4.3	2.0	3.2	**6.4**	0.9	1.6	3.8	1.7	2.0	30
Na^{+}	37.6	48.3	29.2	25.2	37.5	38.7	26.8	21.9	**21.2**	22.0	36.9	112	29.1	**127.1**	200
K^{+}	**14.7**	5.2	2.9	2.8	3.0	5.4	1.1	1.4	**0.6**	1.3	4.3	6.2	1.9	3.3	-
Cl^{-}	78	70	66	62	114	126	**54**	56	56	**54**	60	92	128	**258**	250
NO_3^{-}	22	**28**	14	19	**5**	9	14	10	6	8	7	26	16	19	45
SO_4^{2-}	84	59	18	**12**	56	44	92	**102**	34	20	46	18	23	19	200

All parameters are in mg/L except pH, EC and Turbidity. EC in micromho /cm, Turbidity in NTU

Table 3:Correlation matrix for different water quality parameters

parameters	pH	EC	TDS	Turbidity	DO	TA	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	NO_3^{-}	SO_4^{2-}
pH	1													
EC	0.047	1												
TDS	0.047	1	1											
Turbidity	0.192	0.197	0.197	1										
DO	0.019	0.522	0.522	0.475	1									
TA	0.234	0.084	0.084	-0.085	-0.238	1								
TH	-0.131	-0.256	-0.256	-0.598	-0.272	0.122	1							

Ca^{2+}	0.330	0.804	0.804	0.449	0.520	-0.036	-0.482	1						
Mg^{2+}	-0.437	0.112	0.112	-0.340	-0.240	-0.127	0.360	-0.02899	1					
Na^{+}	0.157	0.889	0.889	0.209	0.723	0.001	-0.319	0.775004	-0.026	1				
K^{+}	0.687	0.009	0.009	0.332	0.115	-0.072	-0.524	0.468932	-0.32687	0.22074	1			
Cl^{-}	0.086	0.683	0.683	0.078	0.395	0.246	-0.226	0.320261	-0.06494	0.726723	0.054803	1		
NO_3^{-}	0.222	0.242	0.242	0.568	0.705	-0.138	-0.659	0.494929	-0.34572	0.514105	0.490428	0.160249	1	
SO_4^{2-}	0.180	-0.452	-0.452	-0.213	-0.411	0.353	0.094	-0.22916	-0.16882	-0.3225	0.227064	-0.30686	-0.08374	1

Dissolved oxygen (DO)

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 3.9 to 6.2 mg/L. The samples BW3, MW3 andMW4 showed slightly low DO indicating the contamination by organic matter.

Alkalinity

Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. Total alkalinity values for the investigated samples were found to be greater than the value prescribed by ISI 10500-91 except the samples BW2, MW1,MW2,BW5 and BW6. The values varied from 136 to 549 mg/L.

Total hardness (TH)

Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water[12]. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The hardness values shown range from 82 mg/L to 536 mg/L. The values for bore well sample BW4, BW5 and municipal water supply samples MW4,MW5 were higher than the prescribed limit.

Water with hardness above 200 mg/l may cause scale deposition in the distribution system and results in excessive soap consumption and subsequent scurry formation hence it cannot be used for industrial purposes[11].

Calcium and magnesium ($Ca^{2+,}$ Mg^{2+})

Calcium and Magnesium are directly related to hardness. Calcium concentration ranged between 0.1 mg/L to 42.4 mg/L and found below permissible limit. Magnesium content in the investigated water samples was ranging from 0.8 mg/L to 6.4 mg/L which were found within the prescribed limit.

Sodium (Na^{+})

Sodium concentrations were found in between 21.2 mg/L to 127.1 mg/L. Sodium concentrations values for all the investigated samples were found within the prescribed limit.

Potassium (K^{+})

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[12]. Potassium content in the water samples varied from 0.6 mg/L to 14.7 mg/L.

Chloride (Cl^{-})

The chloride concentration serves as an indicator of pollution by sewage. Peopleaccustomed to higher chloride in water are subjected to laxative effects[9]. In the present analysis, chloride concentration was found in the range of 54 mg/L to 258 mg/L. All the values are within the limit, except the municipal water supply sample MW7.

Nitrate (NO_3^{-})

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 5.0 mg/L to 28.0 mg/L and found within the prescribed limit.

Sulphate (SO_4^{2-})

Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals[13]. Discharge of industrial wastes and domestic sewage tends to increase its concentration. The sulphate concentration varied between 12.0 mg/L and 102 mg/L and found within the prescribed limit.

Statistical analysis

Correlation analysis is a preliminary descriptive technique to estimate the degree of association among the variables involved. The purpose of the correlation analysis is to measure the intensity of association observed between two variables. Such association is likely to lead to reasoning about causal relationship between the variables. Correlation matrix between various parameters is shown in Table 3. Most of the parameters were found to bear statistically significant correlation with each other indicating close association of the parameter with each other.

Highly positive correlation is observed between the pairs,EC - TDS (0.999), EC – Na^+ (0.889), EC – Ca^{2+} (0.804), TDS – Na^+ (0.889) and TDS – Ca^{2+} (0.804) from Table 3. Highly negative correlation coefficient is seen among Turbidity - TA (-0.085), TA - Ca^{2+} (-0.036), TA - K^+ (-0.072), Ca^{2+}- Mg^{2+} (-0.028), Mg^{2+} - Na^+ (-0.026), $Mg2^+$ - Cl^- (-0.064) and SO_4^{2-}- NO_3^- (-0.083).

TDS had a strong correlation with the parameters like Ca^{2+}, Cl^- and Na^+ indicates the high mobility of these ions. Thus the single parameter of TDS can give a reasonable good indication of a number of parameters [14].

Kalyanaraman et al [15] identified that the water quality of ground water can be predicted with sufficient accuracy just by the measurement of EC alone.There exist very strong correlations between ECand the parameters TDS, Na^+, Ca^{2+}.

Conclusion

In general ground water quality of cuddalore region is not harmful to human beings. The significance of the analysis is that in addition to finding correlation among the parameters, it provides a fairly accurate idea about the quality of the groundwater. Pairs of physico-chemical parameters with high positive correlation show dependency with each other.

The statistical data obtained in the present study indicate that the groundwater quality in the study area (poovanikuppam and thiyagavalli village) is poor as it is polluted with high amount of TDS, chloride and alkalinity. Some of the parameters (TDS, TA and TH) were more than permissible limit. Therefore, the groundwater in the study area is not potable. To maintain quality of groundwater, the continuous monitoring of physicochemical parameters should be done. On the basis of the present study, it is recommended that the groundwater in the above mentioned villages should be suitably treated before it is used for drinking and other domestic purposes.

Abbreviations:

ISI -Indian Standard Institute
NTU - Nephelometric Turbidity Unit

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