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Physicochemical Analysis of Groundwater samples near Industrial Area, Cuddalore District, Tamilnadu, India

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Abstract: The study was carried out to assess the impacts of industrial activities on the ground water quality in and around SIPCOT Industrial complex in Cuddalore District. The quality was assessed in terms of physico-chemical parameters. Ground water and municipal water samples were collected from seven (7) villages in cuddalore Taluk 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: Groundwater, Physicochemical characteristics, municipal water, water quality, SIPCOT.

INTRODUCTION

Groundwater is used for agricultural, industrial, household, recreational and environmental activities all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization[1].The quality of water is vital concern for mankind since it is directly linked with human welfare. In India, most of the population is dependent on groundwater as the only source of drinking water supply.

Potable water is the water that is free from disease producing microorganisms and chemical substances that are dangerous to health[2,3], majority of the rural common people do not have access to potable water and therefore, depend on well, stream and river water for domestic use. In India, there are over 20 million private wells in addition to the government tube wells. The story of each city may be different, but the main reasons for the water crisis are common, such as, increasing demand, zonal disparity in distribution of water supply, lack of ethical framework, inadequate knowledge and resources, major land-use changes, long term water level declines, increase in salinity and pollution[4].

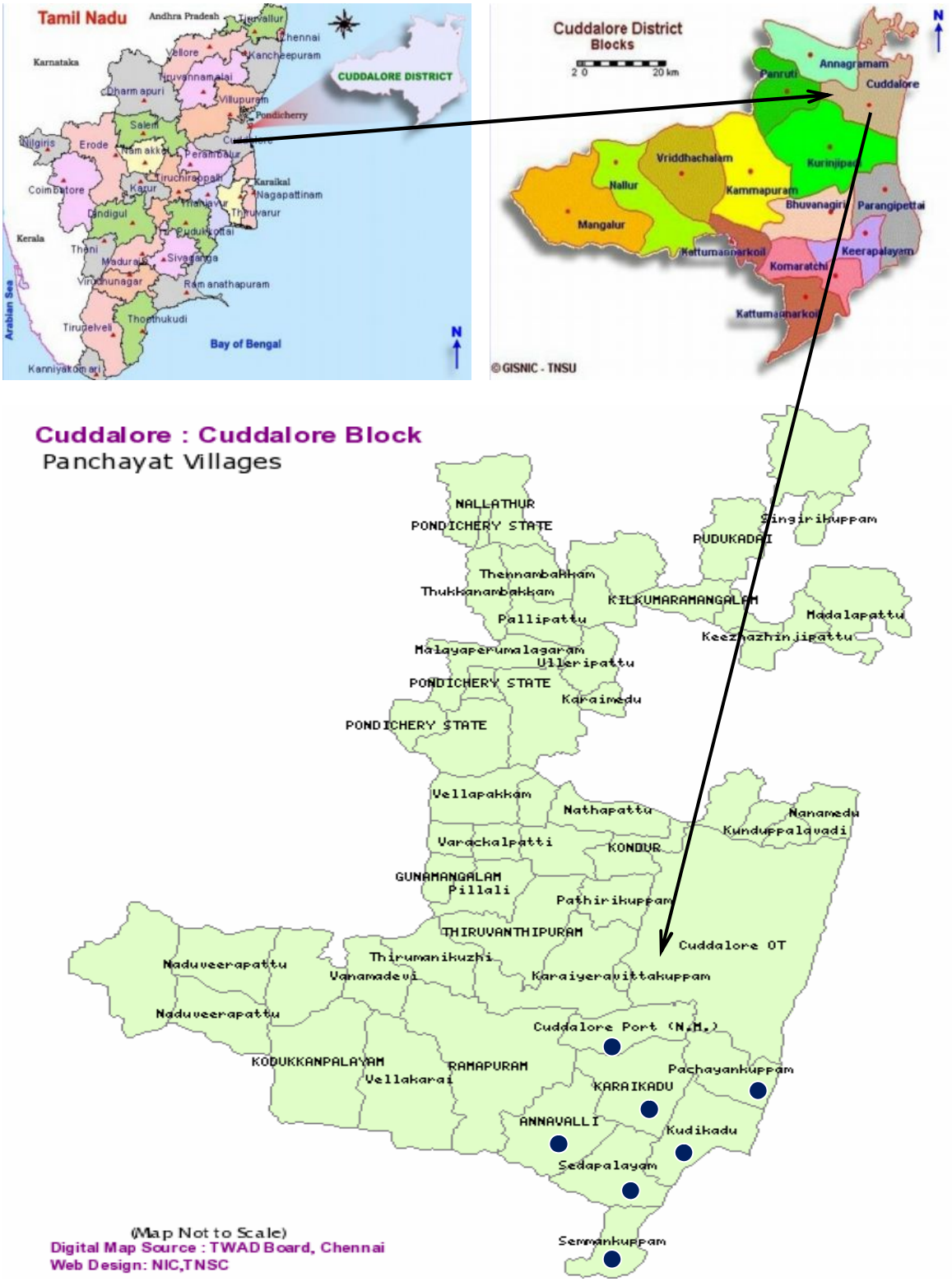

Fig. 1: Sampling locations and map of study area

Ground water is generally considered as a safe source of fresh drinking water[5]. But the wells are generally considered as the worst type of ground water sources in the term of physio-chemical contamination due to the lack of concrete plinth and surrounding drainage system W.H.O, 1998[6]. The reason for elucidation of important parameters in water quality assessment may be attributed to the fact that in the overall potability of water, such parameters should not be ignored[7,3].

There are various ways as ground water is contaminated such as use of fertilizer in farming[8], seepage from effluent bearing water body[9]. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. It therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it[1]. The objective of this study is to investigate qualitative analysis of some physico-chemical parameters of ground water and municipal water in study area.

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 the two key reasons for deterioration of water quality. The ground water samples were collected in polythene bottles from bore wells and Municipal supply water of seven panchayat villages of Cuddalore district during December 2010 - February 2011. The sampling locations are given in Table 1.

MATERIALS AND METHODS

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)[10]. 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.

The simple linear correlation analysis has been carried out to find out correlation between two tested parameters.

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[11]. 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[12]. TDS values varied from 0.887 mg/L to 1066 mg/L. The samples BW1, MW1, BW2, BW3, BW5, MW5, BW7 and MW7 showed higher TDS values than the prescribed limit given by ISI 10500-91.

Table 1: Name of villages of Cuddalore district used for water sampling

Villages of various region of Cuddalore district		
	Source	
Sampling locations	Bore well	Municipal supply water
Cuddalore port	BW 1	MW 1
Karaikadu village	BW 2	MW 2
Pachaiyankuppam village	BW 3	MW 3
Annavalli village	BW 4	MW 4
Kudikadu village	BW 5	MW 5
Sedapalayam village	BW 6	MW 6
semmankuppam village	BW 7	MW 7

Turbidity

In most waters, turbidity is due to colloidal and extremely fine dispersions. The turbidity values varied between 0.3 to 1.4 NTU and found within the limits prescribed by ISI 10500-91.

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 5.7 mg/L. The samples BW1, MW2, BW4, MW4 and BW6 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 BW1, MW1 and BW3. The values varied from 146 to 544 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[13]. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The hardness values shown range from 158 mg/L to 536 mg/L. The values for bore well sample BW2, BW3, BW7 and municipal water supply sample MW7 were higher than the prescribed limit.

Calcium and magnesium ($Ca^{2+,}$ Mg^{2+})
Calcium and Magnesium are directly related to hardness. Calcium concentration ranged between 0.9 mg/L to 77.5 mg/L and found below permissible limit, except bore well sample BW3. Magnesium content in the investigated water samples was ranging from 0.4 mg/L to 22.0 mg/L which were found within the prescribed limit.

Sodium (Na^{+})
Sodium concentrations were found in between 22.4 mg/L to 179.0 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[13]. Potassium content in the water samples varied from 1.5 mg/L to 26.4 mg/L.

Chloride (Cl^{-})
The chloride concentration serves as an indicator of pollution by sewage. People accustomed to higher chloride in water are subjected to laxative effects[11]. In the present analysis, chloride concentration was found in the range of 56 mg/L to 250 mg/L. All the values are within the limit.

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 7.0 mg/L to 53.0 mg/L and found within the prescribed limit except the bore water sample BW2.

Sulphate (SO_4^{2-})
Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals[14]. Discharge of industrial wastes and domestic sewage tends to increase its concentration. The sulphate concentration varied between 18.0 mg/L and 119 mg/L and found within the prescribed limit.

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. The correlation co-efficient 'r' was calculated using the equation[15].

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

Where, X_i and Y_i represents two different parameters. N = Number of total observations. The numerical values of correlation coefficient (r) for 14 parameters are tabulated in Table 3. Correlation studies have also indicated the contribution of changes in land use and industrial discharge.

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	6.8	7.3	6.7	6.7	6.6	6.8	6.9	6.8	6.6	6.5	6.6	6.7	6.9	6.9	6.5-8.5
EC	1510	875	1640	437	1000	887	476	547	1000	831	334	342	1176	1276	-
TDS	981	568	1066	284	650	0.887	309	355	650	540	217	311	764	829	500
Turbidity	1.4	0.3	0.7	0.8	1.0	1.2	1.2	0.3	0.9	0.9	0.6	0.5	0.7	0.8	10
DO	4.2	5.4	5.6	4.0	5.0	5.0	3.9	4.0	5.6	5.7	4.3	5.0	5.2	5.2	5.0
TA	146	148	214	318	148	232	544	436	231	266	432	404	286	522	200
TH	210	244	358	212	304	220	158	188	186	224	210	204	536	488	300
Ca^{2+}	58.3	48.1	69	2.8	77.5	41.5	3.7	5.2	50.1	41.5	0.9	0.9	51.8	40.2	75
Mg^{2+}	2.8	4.0	7.2	7.8	20.6	22.0	0.4	5.0	1.8	9.8	14.2	9.8	3.7	4.2	30
Na^{+}	98.7	32.5	115	28	173	33.9	28.1	26.5	179	66.9	109	22.4	107	69.7	200
K^{+}	26.4	2.9	2.0	3.0	10.2	3.2	1.7	3.6	18.1	6.3	1.5	1.6	8.1	7.9	-
Cl^{-}	188	160	154	56	228	150	110	84	250	90	62	64	122	74	250
NO_3^{-}	14	36	53	42	19	12	15	26	7	13	30	22	17	19	45
SO_4^{2-}	107	40	52	94	119	52	38	76	46	116	27	18	19	42	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	0.115	1												
TDS	0.072	0.859	1											
Turbidity	-0.270	0.326	0.096	1										
DO	-0.044	0.484	0.405	-0.150	1									
TA	-0.007	-0.511	-0.359	-0.177	-0.440	1								
TH	0.210	0.5635	0.548	-0.114	0.412	0.009	1							
Ca^{2+}	0.032	0.862	0.705	0.304	0.633	-0.750	0.455	1						
Mg^{2+}	-0.388	-0.165	-0.440	0.131	0.095	-0.259	-0.083	0.132	1					
Na^{+}	-0.439	0.483	0.525	0.241	0.391	-0.433	0.260	0.650	0.111	1				
K^{+}	-0.135	0.548	0.545	0.537	0.053	-0.451	0.016	0.506	-0.260	0.550	1			
Cl^{-}	-0.003	0.545	0.412	0.384	0.371	-0.711	-0.039	0.768	0.050	0.696	0.628	1		
NO_3^{-}	0.167	0.031	0.150	-0.507	-0.053	-0.068	0.092	-0.075	-0.019	-0.180	-0.496	-0.290	1	
SO_4^{2-}	-0.390	0.185	0.173	0.387	-0.110	-0.439	-0.242	0.325	0.239	0.175	0.399	0.249	-0.068	1

CONCLUSION

Deviations were observed by groundwater samples from municipal water and water quality standards indicating groundwater pollution. In general ground water quality of cuddalore region is not harmful to human beings. Except few instances where some parameters such as TDS at karaikadu Village, Pachaiyankuppam village, Kudikadu village, semmankuppam village bore well water and total hardness at semmankuppam village were crossed prescribed limits of drinking water (ISI: 10500-91). The reason behind this may be due to industrial activities, industrial discharge, urbanization, other anthropogenic activities and increased human interventions in the ground water quality.

Municipal water was found to be fit for drinking purpose than groundwater. The bore water samples from Pachaiyankuppam village, Annavalli village, semmankuppam village showed poor water quality as compared to other water samples. The bore water samples from site Cuddalore port is highly polluted and unfit for drinking purpose. The samples from Sedapalayam village showed physicochemical parameters within the water quality standards and the quality of water is good and it is fit for drinking purpose. Correlation studies have also indicated the contribution of changes in land use and industrial discharge. The values of correlation coefficients will help in selecting proper treatment to minimize groundwater pollution.

Abbreviations:

ISI - Indian Standard Institute
NTU - Nephelometric Turbidity Unit

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