



RESEARCH ARTICLE

CORRELATION ANALYSIS OF PHYSICO-CHEMICAL PROPERTIES OF GROUND WATER IN AND AROUND MALAIYEEDU AREA NEAR KUNDARU RIVER PUDUKKOTTAI DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

The present investigation is aimed to water quality for the ground water samples of Malaiyeedu area Pudukkottai district .Seven groundwater samples were collected and analyzed for some important physico- chemical parameter such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Biological Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Dissolved Oxygen (DO), Calcium(Ca), Magnesium(Mg), Total Hardness (TH), Bicarbonate (HCO₃), Carbonate (CO₃) and Chloride (Cl) were determined for water samples and the results were compared with standards prescribed by WHO. The study indicates that the water quality parameter such as EC, TDS, COD, BOD and Cl are exceeded the permissible limits. This result shows that the water quality of the study area is very poor and not suitable for drinking purpose. The correlation analysis provides an excellent tool for the prediction of parameter values within a reasonable degree of accuracy. This result was considered for correlation analysis and it was observed that many of the Physico- Chemical parameters bear a positive correlation and some bear negative correlation.

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INTRODUCTION

Water is an important component of all the living beings. The water which is found available deep in the ground due to percolation of surface water is called underground water. Underground water is the major source of water. It is pure and used for all purposes in the world. Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes. The rapid increase in population and industrial growth have increased the demand for water resources .Due to increase of ground water usage, the annual extraction of ground water is in far excess than the natural recharge .In coastal area, over exploitation of ground water would lead to rapid intrusion of salt water from the sea. The chemical, physical and bacterial characteristics of groundwater determine its usefulness for drinking purposes. Chemical analysis of groundwater includes the determination of the concentrations of inorganic constituent. 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 create health problems (Mariappan *et al.*, 2005). 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. 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 (Patil *et al.*, 2001).

Study area

Pudukkottai is located at 10.38°N 78.82°E in the valley of river south Vellar. It is one of the most important historical cities in Tamil Nadu. The district is bound on the north and northwest by Tiruchirappalli district, West and southwest by Sivaganga district, on the east and northeast by Thanjavur district and on the southeast by Bay of Bengal. The study area Malaiyeedu is located about 3 km away from the Pudukkottai

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Junction. Malaiyeedu area is situated near by Kundaru River at Pudukkottai district. The population of the area is around 25,000. Many small scale industries are located in and around this area. Therefore the groundwater sources at Malaiyeedu area have been drastically polluted with the effluents of industries, domestic sewage and agricultural inputs like fertilizers, manures and pesticides. People of this area have depending only on the ground water as the main source for drinking purpose and other purposes. Hence the present study has been undertaken to analyze the ground water quality in and around Malaiyeedu area Pudukkottai district by using correlation analysis.

pH

The pH indicates the intensity of acidity and alkalinity and measures the hydrogen ion concentration in water. In water, a small number of water (H_2O) molecules dissociate and form hydrogen (H^+) and hydroxyl (OH^-) ions (Arvnabh Mishra. *et.al.* 2010). If the relative proportion of the hydrogen ions is greater than the hydroxyl ions, then the water is defined as being acidic. If the hydroxyl ions dominate, then the water is defined as being alkaline. The pH values are observed within the range of 7.6 - 7.9 for the water samples. The pH values are found to be within the permissible limit of WHO (6.5-8.5)

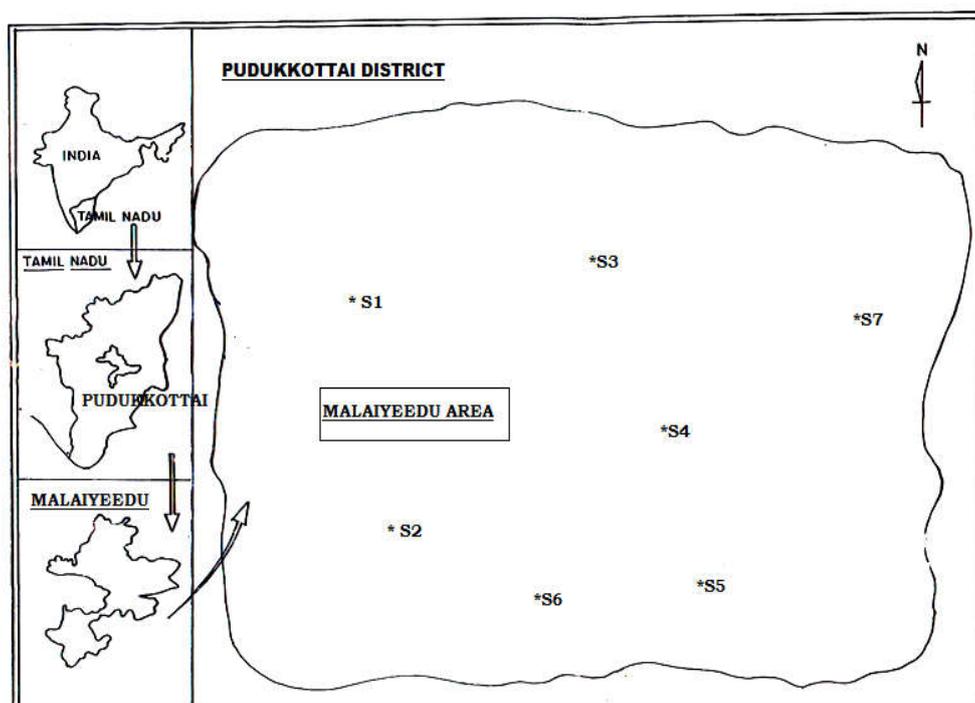


Fig. 1. Location map of the study area

MATERIALS AND METHODS

Sample collections

The water samples were collected from the bore wells in and around Malaiyeedu area. During this collection the distance between one and other location was maintained at a minimum of 2 km. The water samples were collected in polyethylene bottles (2.0 liters capacity) which have been thoroughly washed, filled with distilled water and then taken to the sampling site. The bottles were emptied and rinsed several times with the water to be collected. Also, the sample bottles were partially filled with the collected water and vigorously shaken to note the odour. The sample bottles were tightly covered immediately after collection and the temperature is noted. They were then stored in a refrigerator at 4°C to slow down bacterial and chemical reaction rates. All the collected of samples were labeled and transported to the laboratory for the analysis. The samples were subjected to physico-chemical analysis. All the parameters were analyzed using standard procedure of APHA (1995).

RESULTS AND DISCUSSION

The results of the physico-chemical parameter for water samples collected in and around Malaiyeedu area Pudukkottai District, are presented in table given below

except the stations S5, S6 and S7. The slight alkalinity observed in ground water samples are due to the contribution by the reaction of CO_2 between water and dolomite rock form, gives bicarbonates and it will affect the pH of water (Arul Manikandan *et al.*, 2013). Carbonic acid (H_2CO_3) dissociates partly to produce (H^+) and bicarbonate (HCO_3^-) ions (Sirajudeen *et al.*, 2015).

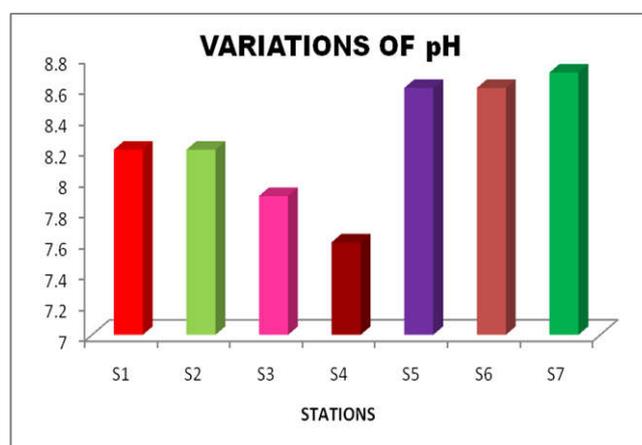


Fig.2. Variation of pH values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Table 1. Physico- Chemical parameters of various water samples collected in and around Malaiyeedu area, Pudukkottai district

Stations	PARAMETERS													
	Tem	Color	pH	EC	TDS	TH	Ca	Mg	Cl	DO	COD	BOD	CO ₃	HCO ₃
S1	22	colourless	8.2	5802	1097	327	87	240	603	1	65	25	ND	700
S2	23	colourless	8.2	4677	864	225	38	187	390	2	71	39	ND	650
S3	25	colourless	7.9	7632	1395	375	56	319	710	1	70	32	ND	630
S4	27	colourless	7.6	5927	1109	447	86	361	702	1	56	28	ND	400
S5	30	colourless	8.6	7760	1440	255	55	200	738	1	48	21	ND	740
S6	28	colourless	8.6	9424	1721	262	32	230	1050	2	54	23	ND	700
S7	28	colourless	8.7	13400	2489	375	68	307	1472	2	40	21	ND	900

All the values are expressed in terms of ppm except pH, Tem^{°C} and EC (micro mho/c)
 ND- Non-Detectable

Electrical conductivity

Electrical conductivity in water is due to ionization of dissolved inorganic solids and becomes a measure of TDS. It is used as a basic index to select the suitability of water for agricultural purposes. It signifies the amount of total dissolved salts. The importance of Electrical Conductivity is its measure of salinity which greatly affects the taste and thus has a significant impact on the user acceptance of the water as potable. The EC values are within the range of 4677 – 13,400 micro mho cm⁻¹ for ground water samples. The EC values are well above the permissible limit of WHO (600µmho cm⁻¹) for all water samples. High EC values may be contributed by the increased percolation rate of domestic sewages, industrial effluents and agricultural wastes containing high dissolved solids and increase evaporation effects leading to increasing ionic content (Syed Abed and Vidya Pradhan, 2011). High EC values usually affect the waters palatability and taste.

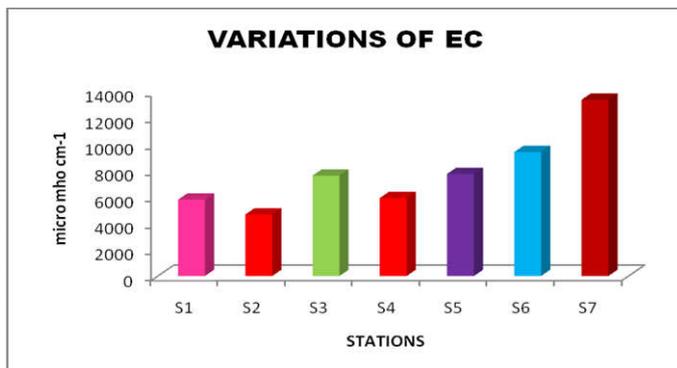


Fig.3. Variation of EC values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Total dissolved solids

The total dissolved solid indicates the salinity behavior of ground water. It indicates the salinity behavior of ground water. In natural water, dissolved solids consist mainly of inorganic salts such as carbonates, bicarbonates, chlorides, phosphates and nitrates small amount of organic matter and dissolved gases (Baruah, Das and Sengutappa, 2003). The quality of water and EC is determined by TDS. The TDS values are found in the range of 864 -2489 ppm. In our study the TDS values are well above the permissible limit of WHO (500 ppm) for ground water samples in all sampling stations. A very high value of TDS is due to the addition of excess of

sewage, agricultural and unprotected drainage wastes percolates in to the ground water to leading to increase in TDS values (Geetha *et al.*, 2008). The high level of TDS is also reported to cause gastro intestinal irritation (Shanthi *et al.*, 2012)

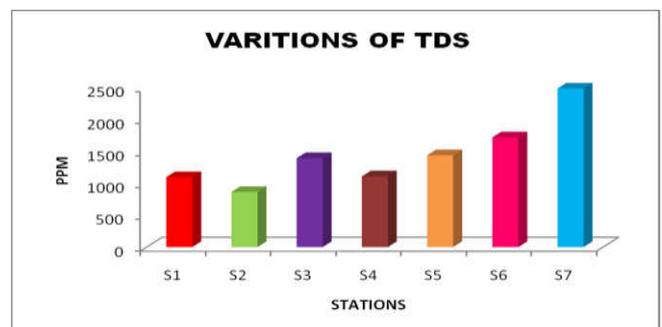


Fig.4. Variation of TDS values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Total hardness

Total Hardness of water plays a vital role. Externally hard water does not form lathers with soap leading to wastage of much quantity of soap and internally, if used for longer times can be one of the causes of stone formation in the human body (Manivaskam, 2005). Mainly the hardness of water is due to carbonates, bicarbonates and chlorides of calcium and magnesium (Mahananda *et al.*, 2010). TH values are found in the range of 225-447 ppm. In the present investigation TH values are within the permissible limit of WHO (500 ppm) for all water samples.

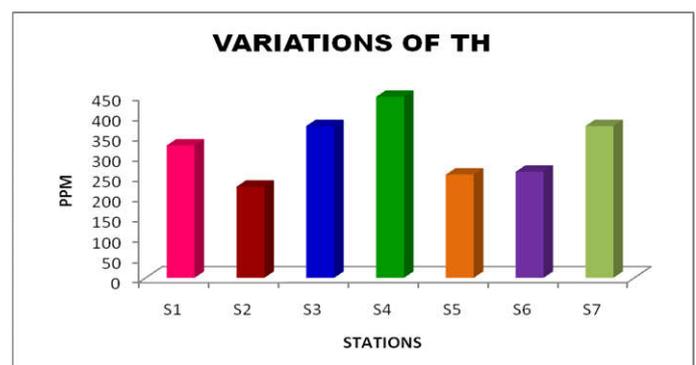


Fig.5. Variation of TH values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Magnesium

Magnesium occurs in all kinds of natural waters along with calcium, but its concentration remains generally lower than the calcium (Lohani, 2005). The principal sources in the natural water are various kinds of rocks. The magnesium values are found in the range of 187 - 361 ppm for ground water samples. In our study the Mg values are found above the permissible limit of WHO (150 ppm) for all ground water samples. High values of Mg may be due to ground water pollution, when sewage, detergents wastes water from residential and industries are discharged into drainage (Abdul Jameel and Sirajudeen, 2006). While minimum magnesium content may be due to dilution of soluble salts or due to more leaching of granitic terrain rock minerals. High concentration of Magnesium may cause gusting in intestinal irritation of human system.

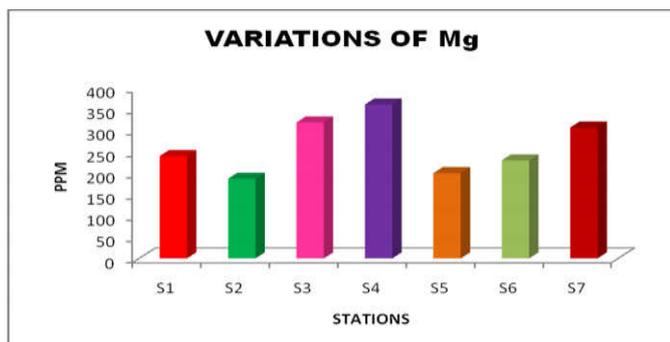


Fig.6. Variation of Mg values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Calcium

Calcium is an important element to develop proper bone growth. It is from natural sources like granitic terrain which contain large concentration of these elements (Verma *et al.*, 2010). The calcium values are recorded in the range of 32 – 87ppm for all ground water samples. In our investigation all the Ca values are found below the permissible limit of WHO (100 ppm).

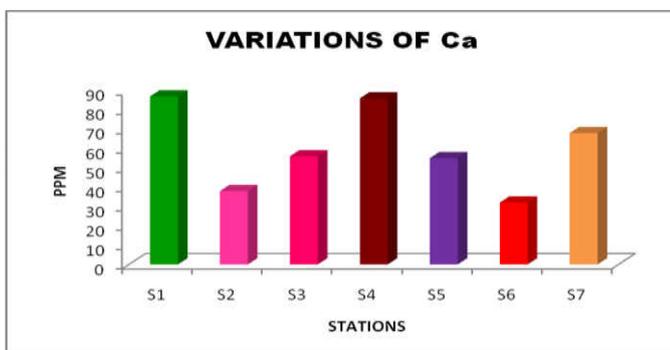


Fig.7. Variation of Ca values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Dissolved Oxygen (DO)

DO refer to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water (Gopalkrushna, 2011). The main source of DO is from dissolution from atmosphere and the photosynthesis of aquatic plants. The DO value indicates

the degree of pollution in water bodies. The DO values are recorded in the range of 1.0 -2.0 ppm for ground water samples. In the present study all the DO values are found below the limit of WHO (5ppm). Low DO values may be due the regular addition of domestic sewage and other solid wastes in to the river that percolate in to ground water (Pavanguru *et al.*, 2003). A very low DO may be due the solubility of dissolved oxygen decrease with increase in temperature. It is unsuitable for fish and fauna.

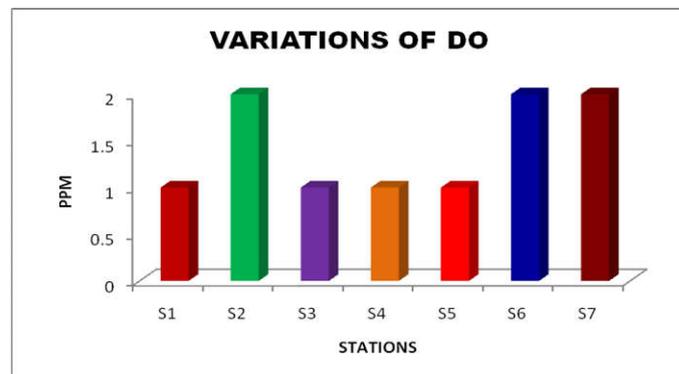


Fig. 8. Variation of DO values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Chemical Oxygen Demand (COD)

COD is a measure of organic matter in the sample including bio and chemically degradable fractions (Mahananda *et al.*, 2010). It is used to measure the pollution of domestic and industrial waste. The waste is measured in terms of quantity of oxygen required for oxidation of organic matter to produce carbon dioxide and water. The mean COD values are within the range of 40-71 ppm for ground water samples. In our study, the values of COD are found to exceed the permissible limit of WHO (10ppm). High COD values indicating pollution by bio and chemically degradable organic wastes from various sources. Industrial wastes often contain inorganic contamination which are chemically oxidizable and therefore lead to high COD values (AchuthanNair, Premkumar, *et al.*, 2005). High COD may affect aquatic life

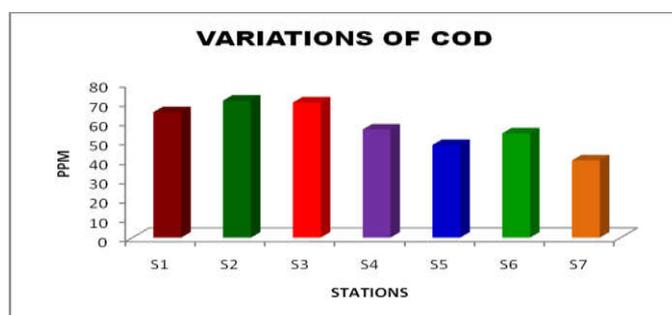


Fig.9. Variation of COD values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Biological Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is defined as the amount of oxygen required by microorganisms while decomposing organic matter in a waste under aerobic conditions (Patil and Gorade, 2013). Biological and Chemical oxygen demands are the good measures of pollution load. They together measure the dangerous affects of O₂ deficiency on the aquatic lives. It is

an important parameter to evaluate the water quality with respect to organic pollutant. The term decomposable may be interpreted as the organic matter which can serve as food for the bacteria and energy is derived from its oxidation. The BOD values are in the range of 21 – 39 ppm for all ground water samples. In our study BOD values are beyond the permissible limit of WHO (10ppm). High BOD may be due to the dumping of sewage, effluents and other wastes are might have offered intense bacterial growth which consequently resulted in increased BOD level and may causes to affect the aquatic life (Nivedita Agrawa *et al.*, 2014)

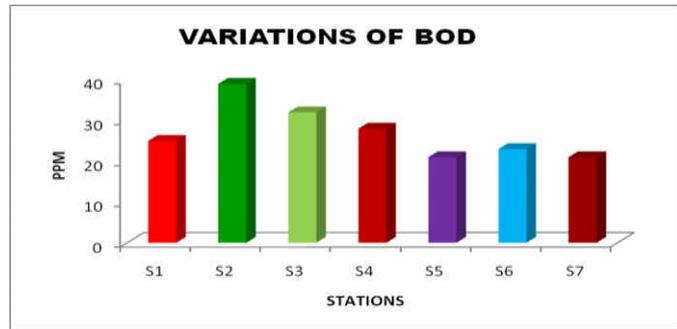


Fig.10. Variation of BOD values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Chloride

Chloride is one of the major anions in water and sewage. It is found in the form of sodium chloride in the water. Soil porosity and permeability also has a key role in building up the chloride concentration (Ombaka *et al.*, 2013). The salty taste produced by chloride concentration is variable and dependent on the chemical composition of the water. Some water containing 250 mg/l chloride may give evidence for a detectable salty taste with sodium ions. The values of chloride are found in the range from 390-1472 ppm. In our study the Chloride values are found above the permissible limit of WHO (250ppm) in all stations. High chloride values, due to the increased rate of percolation of agricultural land water, domestic sewage and weathering of rocks. The high concentration of chloride imparts a salty taste to water and causes accelerate corrosion of metals and kidney stone formation.

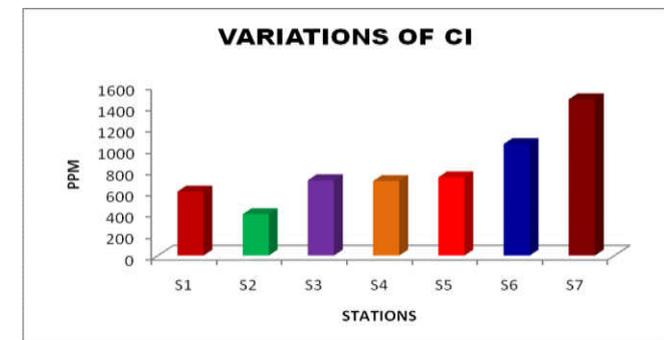


Fig. 11. Variation of Cl values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Alkalinity (Carbonate and Bicarbonate)

Alkalinity of water is a measure of its capability to neutralize acids. It is usually imparted by the bicarbonate, carbonate and hydroxide components of natural or treated water supply

(Edokpayi, 2005). Alkalinity has little known significance with regard to human health however high alkaline waters are unpalatable and also affect the efficiency of coagulation process. The carbonates values are not detectable for ground water samples throughout the study. The bicarbonate values are recorded in the range of 400-900 ppm. In the present study all the bicarbonate values are found above the limit of WHO (500ppm), which may be due to the input of domestic sewage and the regular addition of pollution load (Enango, 2003). High bicarbonate value causes Gastro intestinal irritation

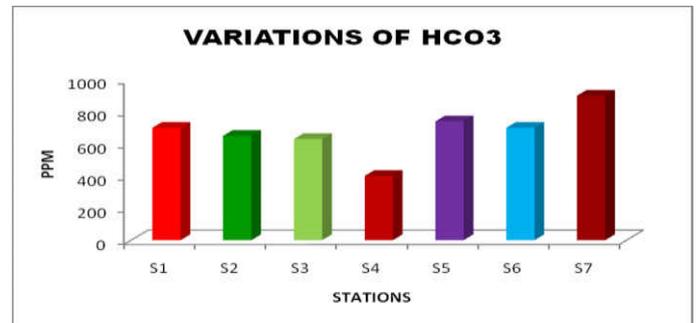


Fig.11. Variation of HCO₃ values collected from different sampling sites of Malaiyeedu area Pudukkottai District

Statistical analysis

Statistical analysis in water quality

Water quality depends on several parameters. A strong correlation exists among different parameters and a combined effect of inter relationship among these parameters reflect on the quality of the water. The task of monitoring the quality of water can be facilitated if the correlations among the water quality parameters are known. If correlation exists among water quality parameters, measuring few parameters and predicting the other parameters using correlation would provide necessary indications about the water quality (Jothivenkatachalam *et al.*, 2010).

Pearson correlation

Pearson correlation coefficient is commonly used to measure and establish the strength of a linear relationship between two variables or two sets of data. It is a simplified statistical tool to show the degree of dependency of one variable to the other (Kumar and Sinha, 2010). The Pearson correlation coefficient (r_{xy}) is computed by using the formula as given below

Formula. $r_{xy} =$

$$\frac{n\sum(x_1 y_1) - (\sum x_1)(\sum y_1)}{\sqrt{[n\sum x_1^2 - (\sum x_1)^2][n\sum y_1^2 - (\sum y_1)^2]}}$$

The variables x and y represents two different water quality parameters; n= number of data points/ number of groundwater samples. The inter dependence of different water quality parameters on each other was evaluated on the basis of rxy from equation (1). The correlation coefficient is always between -1 and +1. A correlation closer to +/- 1 implies that the association is closer to a perfect linear relation. Interpretation of the Pearson correlation coefficients, adopted

Table 2. Correlation co-efficient matrixes of physico-chemical characteristics of groundwater samples collected in and Malaiyeedu area, Pudukkottai district

	pH	EC	TDS	TH	DO	BOD	COD	HCO ₃	Ca	Mg	Cl
pH	1										
EC	0.166	1									
TDS	0.366	.925*	1								
TH	0.076	0.863	0.866	1							
DO	0.535	0.577	0.447	0.164	1						
BOD	-0.441	-0.636	-0.493	-0.198	-0.988**	1					
COD	-0.244	-0.061	-0.241	0.22	-0.196	0.269	1				
HCO ₃	-0.536	0.638	0.561	0.6	-0.057	-0.083	-0.218	1			
Ca	-0.07	.915*	0.776	.926*	0.354	-0.4	0.312	0.637	1		
Mg	-0.318	-0.052	-0.412	-0.257	0.373	-0.354	0.517	-0.175	0.102	1	
Cl	0.559	0.876	.970**	0.825	0.53	-0.54	-0.167	0.345	0.722	-0.382	1

in the present study are: $r = -1$ to -0.7 (strong negative correlation); $r = +0.7$ to $+1.0$ (strong positive correlation); $r = -0.7$ to -0.3 (weak negative correlation); $r = +0.3$ to $+0.7$ (weak positive correlation); $r = -0.3$ to $+0.3$ (negligible or no correlation).

Strong Positive Correlation and Strong Negative Correlation for ground waters

The correlation matrixes for ground water samples are showed in table: 2). EC has positive correlation with TDS, TH, HCO₃, Ca and Cl ($r = 0.92, 0.863, 0.638, 0.915, 0.876$) as well as TDS with TH, Ca and Cl ($r = 0.86, 0.77, 0.97$). Since the TH with positive correlation with HCO₃, Ca and Cl ($r = 0.66, 0.926, 0.825$). Ca showed Positive correlation with Cl ($r = 0.722$). DO showed strong negative correlation with BOD ($r = -0.98$.) Ca shows negative correlation with Mg ($r = -0.73$) and Mg has Strong negative Correlation With Cl (-0.619).

Conclusion

The ground water samples were collected from different localities in and around Malaiyeedu area, Pudukkottai District and analyzed for some important physico-chemical parameters. The present study was undertaken to meet the objectives that the analysis of ground water samples in Malaiyeedu area. The objectives were achieved by the determination physico-chemical parameters of the chosen sample. The following conclusions are arrived from the study.

- The ground water sample is neutral and slightly alkaline in nature.
- From the data it is observed that the ground water samples have permanent hardness. Magnesium content in the water is more which may leads to kidney stone problems to humans. The hardness also can bring hindrance to the utilisation of water in day to day domestic activities.
- The high electrical conductivity of the water sample is a sign of the presence of inorganic salts.
- The high value of total dissolved solids implies that the presence of silicates and carbon contents which may harm the digestive system of the person who consumes the water.
- The lower values of dissolved oxygen content shows that the water is a poor oxygen carrier.
- The higher values of chemical oxygen demand shows that the possibility of the presence of heavy metals in the ground water.
- The higher values of Bio-chemical oxygen demand shows that the possibility of the presence of micro-organisms in the ground water.

In this study the application of Statistical technique has been proven to be a very useful tool for monitoring drinking water and has a good accuracy. A systematic correlation and regression in this study show that there is a significant linear relationship among different pairs of water quality parameters. It can be concluded that the total dissolved solids and electrical conductivity are important physicochemical of drinking water quality parameters, because they are correlated with most of the water parameters. The analysis reveals that the ground water of this area is unfit for drinking purposes. So the ground water of this area needs some degree of treatment before drinking and it needs to be protected from contamination so as to prevent adverse health effects on human beings

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