RESEARCH ARTICLE OPEN ACCESS

A Study of Groundwater Quality of Cheranallur Panchayath of Kochi, South India

Nify Benny[1],Salas PM,[2]Mary Margret T R[1], Nisha Lilys K J[1]
1 Department of Chemistry,St. Albert's College (Autonomous), Ernakulam, Pin-682018
2 Department of Chemical Oceanography, School of Marine Sciences, Cochin University of Science and Technology,Kochi- 682016.
Corresponding Author: Nify Benny

ABSTRACT
Ground water from fifteen stations of three zones (Chittoor, Edayakunnam and Cheranellur zones) in Cheranellur Panchayath of Kochi, South India was collected during the premonsoon and post monsoon 2016 to understand the quality of water for drinking purposes. It was found that the chloride content varied from 6.6 to 46.2 mg/l and electrical conductivity ranged between 0.04 and 1 microS/Co. Total hardness showes its maximum abundance as 238 mg/L, meanwhile Calcium and Magnesium exhibited their higher abundance as 81.6 mg/L and 11.7 mg/L respectively. The total dissolved solids in study area showed its maximum concentration at Chittoor zone (519 mg/L). The iron content maximum obtained recorded as 1.8 mg/L (Edayakunnam zone). While comparing the three zones, Cheranellur zone showes all the parameters in very low concentration. The study revealed that all the analytical parameters in the water samples does not overcome the permissible limit prescribed for drinking purposes [1]. Besides this, analysis of Coliform bacteria of all water samples except two samples from Edayakunnam zone provided negative results. While comparing the three zones, Chittoor and Cheranellur zone is more pure than Edayakunnam zone. Hence the overall assessment pointed out that ground water in the Cheranellur Panchayath is good for drinking and domestic purposes.
Key words:chlorides, coliformbacteria, iron,total dissolved solids, total hardness.

Date of Submission: 30-03-2019 Date of acceptance: 13-04-2019

I. INTRODUCTION

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. Ground water is generally considered as a safe source of fresh drinking water. Quality of ground water is influenced by the anthropogenic activities. For example, overexploitation of ground water in coastal regions may result in sea water ingress and consequent increase in salinity of ground water. Furthermore, excessive use of fertilizers and pesticides in agriculture and improper disposal of urban/industrial waste can cause contamination of ground water resources. Generally, the physico-chemical and biological characteristics of groundwater in a particular area is determined by the natural - geologicalformations, weathering, dissolution, precipitation, ion exchange and biological processes as well as anthropogenic activities. Often groundwater is being contaminated by non-point (agricultural, urban runoff) and point sources (sewage, industrial effluents disposal) in many developing countries including India. The ground water quality in Ernakulam district (Kerala, India) is getting deteriorated due to the fast growth of urbanization and industrialisation. The closure of several water bodies due to land development and construction prevents infiltration of rainwater into the ground and hence recharge the aquifers. Most of the aquifers are getting polluted from the industrial effluents and chemicals and fertilizers used in agriculture. Such serious issues require proper monitoring of groundwater and steps are to be taken for remedial measures. Hence the present investigation for quality assessment of the ground water isessential for maintaining the purity of drinking water of the study area. In this study, an attempt has been made i) to evaluate the ground water quality of Cheranellur panchayath (Ernakulum, Kerala, India) with respect to the seasonal changes, ii) to investigate the presence of iron and total Coliforms bacteria in the study area, and iii) to find out interrelationship between the ground water parameters.

1.1 Study area

The study area "Fig. 1"Cheranellur Grama panchayath belongs to the Kanayannur Taluk of Ernakulam district in Kerala state of India in

between East 76°16' 31.89" E -76° 17 ' 3.63" E longitudes and North 10° 1' 49.38" N -10° 4' 7.986" N latitudes. It extending from Vaduthala to Cheranallur occupying an area of 10.59 sq. km. The study area is surrounded by Kochi corporation and Kalamassery municipality in the south, Eloor municipality and Varapuzha grama panchayath in the north, Kalamassery municipality and Eloor municipality in the east and Kadamakkudy, Varapuzha and Kochi Corporation in the west. Its population exceeds 30595 which includes 15157 men and 15437 women. It consists of 17 wards and falls in Edapally block, Kanayannur Taluk. A knowledge of ground water quality is required for a village like Cheranallur because recently, news has shown that during summ the locality is devoid of drinking water and water supply is rare in the season.

Cheranallur panchayat has been found to be the worst affected area since it is the dead end of the distribution system and so the residents are hit badly by water shortage. Due to the acute water scarcity during summer, people are forced to fetch water from distant places, in some cases they have to use boats for this purpose. The water authority is trying to supply water in tanker Lorries, but unavailability of potable water is a big problem. Also, people are not too confident about the quality of water supplied to them in tankers. So people have to depend on the ground water sources for their daily requirements. Studies have shown that the ground water in this area is polluted microbially and with metals especially iron. Hence a detailed analysis of water quality and remedial measures is required in this area, so that people can confidently use their own water resources.

To provide a generalized outline of ground water quality, the entire study area has been categorized into three zones on the basis of their topography and source of drinking water - Chittoor, Edayakkunnam and Cheranallur zones. The sampling stations in each zones are presented in "Table 1".

1.1.1 Chittoor zone:

Chittoor region of Cheranallur panchayath extends from the Vaduthala bridge to the Chittoor ferry consisting of two Grama Panchayath wards numbering 8 and 10. In this region existing five sampling points such as Thaipparambu (CT1), Chittoor village office (CT2), Chittoor temple (CT3), Chittoor retreat centre (CT4) and Chittoor ferry (CT5). Study shows that Chittoor region is having good quality ground water and is still using it for household as well as drinking purpose. They have been using water from dug well and tube wells for years. People of ward 8 and 10 are confident about the ground water they are depending on. So they don't have to depend on water supply systems. But most of them have not conducted any quality tests for water.

1.1.2 Edayakkunnam Zone:

Edayakunnam region consists of six Grama panchayath wards (No. 7, 9, 11,12,13 and 14), in which containing five sampling stations namely Edayakunnam Church (E1), Cheranellur Panchayath office (E2), Edayakunnam Bridge (E3), Jayakerala (E4) and Edayakkunnam Kappela (E5). Most of the stations in this area weredeteriorated due to the influence of nearby paddy fields. These fields were became polluted by terrestrial activities. The leaching of this polluted water has given a foul smell to the ground water sources. Staining of clothes and forming of deposits on storing water has been reported by women in this area. Therefore the peoples in this area mainly depends on water supply due to their doubt in the quality of their water resources like wells and bore wells.

1.1.3 Cheranallur zone

This zone included five sampling points namely as Pallikkavala CH1), Vishnupuram (CH2), Kacheripadi CH3), Marapparambu (CH4) and Kottaparambu (CH5) which is spread in the three Grama panchayath ward No. 1, 2 and 17 in Cheranellur Panchayath. The most of the people in this areadepends on open wells for their cooking and drinking purposes.

II. MATERIALS AND METHODS

Water samples from fifteen stations located in the three zones (Chittoor, Edayakkunnam and Cheranallur zones) of the Cheranellur panchayath, Ernakulam, India "Fig. 1"were collected in two sampling campaigns: April 2016 (pre monsoon 2016: PRM16) and November 2016 (post monsoon 2016: POM16). After the collection of water samples, that was immediately transported to the laboratory for chemical analysis, using the regular water quality measures [2]. The pH and electrical conductivity (EC) were determined in situ using a portable pH meter (Eutech, pH Tester 10). The total dissolved solids (TDS) were calculated from EC [3]. The concentration of total hardness (TH) and calcium (Ca^{2+}) weremeasured by using standard EDTA titration. Meanwhile, Magnesium (Mg^{2+}) wascalculated, using the concentration difference between TH and Ca^{2+}. Chloride andtotal alkalinity was estimated by Argentometric and acidimetric titration methodrespectively. Concentration of iron content was estimated using 1, 10 Phenanthroline method. Total coliforms were analysed by Most Probable

Number (MPN)techniques.

III. RESULTS AND DISCUSSION

All the water quality parameters of the study area are comparable with the standard guide line values as prescribed by the International Organization for Standardization 2003-09 [1] for drinking and public health purposes "Table 2". In the present study, pH showed a fluctuating trend, ranging from 5.7 to 8.24 and 5.96 to 8.02 in respective period of PRM16 and POM16. It was within thepermissible range of ISO 2003-09 prescribed for drinking water purpose. Meanwhile, at E3 (Edayakunnam zone) on both seasons acidic character was observed (< 7 pH), but at Edayakunnam zone -E5 and Cheranellur zone-CH3 exhibited an alkaline character. . Figure 2shows that most of the stations in study area come under the permissible limit Table 3, shows that pH makes significant negative correlation (r = -0.36) with Mg^{2+} and positive correlation with alkalinity (r = 0.54).

Electrical conductivity (EC) is a quantity of salt in water in the form of ions. In this study, maximum EC was recorded at CT5 and lower at CH3 of both seasons. Table 3 denoted that EC is highly significantly positively correlated with TDS (r=0.94), Cl^- (r=0.71), TH (r=0.50), Ca^{2+} (r=0.57) and Mg^{2+} (r=0.82). The study revealed that Chittoor zone (CT2, CT5) and Edayakunnam zone (E1, E2, E3) showed elevated level of EC values, which indicate the presence of some pollutant from paddy field and terrestrial activities at these areas [4].

The presence of soluble salt has severely affected the quality of drinking water. The higher TDS grade in drinking water causes harmful effects like constipation in human body [5]and also affect the strength of concrete and taste of food. During the study period TDS ranged from 24 mg/L to 519 mg/L in PRM16, but in POM16, it varied as 30 mg/L to 515 mg/L. TDS is significantly positively correlated with EC (r=0.94), Cl^- (r=0.72), TH (r=0.39), Ca^{2+} (r=0.47) and Mg^{2+} (r=0.79) in study area (Table 3). From the Figure 2, it is clear that Cheranellur zone containing CH2, CH3, CH4 and CH5 recorded a very low TDS concentration on both seasons. According to Fetter [6], ground water is categorised as freshwater (TDS<1000 mg/L) and brackish water (1000-10,000 mg/L) based on their TDS range. In this study, based on above scenario all zones in both seasons come under the fresh water category with lower TDS range (TDS<1000 mg/L) "Table 2".

Naturally chloride occurs in all type of water [7]. According to Sharma and Pande [8] a human being releases approximately 6 grams of chloride per day. In the present study chloride (Cl^-) content recorded, its higher and lower concentration at Edayakkunnam Zone (E3, 46.20 mg/L) and Cheranellur zone (CH2, 45.00 mg/L) respectively on both seasons. Meanwhile Cl^- shows significantly positive correlation with EC (r=0.71), TDS (r=0.72) and Mg^{2+} (r=0.57) at study area "Table 3". While comparing the three zones on both seasons lowest chloride content is observed at Cheranellur zone "Figure 2". Domestic wastes, paddy field and aqua-cultural activities and leaching from territories causes to an abundance of Cl^- in the study area [9,10]. The study revealed that Cl^- content at all the stations of three zones does not violate the limit of ISO 2003-09 instructed for water quality for drinking purposes.

Chemical property, hardness in water is mainly formed by the action of cations like calcium, magnesium, iron and strontium. Higher level of hardness in water (>300 mg/L) may lead to damage of inner organs like heart and kidney in human body. The study showed higher total hardness as 238 mg/L (POM16) and 220 mg/L (PRM16) at same station (CH1) on both seasons. It may be due to the presence of domestic sewage and subsurface clayey soils accompanying with the calcium, magnesium and chlorides [11]. During the study period TH is found to be significantly positively correlated with Ca^{2+} (r=0.98) and Mg^{2+} (r=0.60) in study area "Table 3". The zone level comparison of study area revealed that at E1 to E6 and CH1 stations belonging to Edayakunnam and Cheranellur zone respectively exhibit surplus levels of TH"Figure 2". Meanwhile, total hardness water observed in all stations is within the desirable limits of ISO 2003-09 prescribed for drinking purpose "Table 2".

Weathering of Plagioclase feldspar, pyroxenes, limestone and gypsum worked as major sources of calcium in groundwater [10]. In this study calcium (Ca^{2+}) shows maximum concentration at E1 and minimum at CH3 on both seasons. Further assessment revealed that at Edayakunnam (E1, E2) and Cheranellur zone (CH1)observed higher concentration of Ca^{2+}"Figure 2". The correlation study revealed that Ca^{2+} has high significant positive correlation with EC (r=0.57), TDS (r=0.47) and Mg^{2+} (r=0.65) "Table 3".

During the study period maximum values of magnesium was observed at CT1 (11.6 mg/L) and CT5 (11.7 mg/L). Higher abundance of Mg^{2+} has exhibit at Chittoor (CT5) and Edayakunnam zone (E1,E2,E3). Meanwhile, lower content of Mg^{2+} is observed at Cheranellur zone (CH2, CH3, CH4, CH5) "Figure 2". The ion exchange of rocks minerals and soils by water act as source of Mg^{2+} in

the ground water [7]. And also minerals of ferromagnesian and human activities are responsible for higher Mg^{2+} in the study area [10, 12, 13].

Surplus level of alkalinity in water gives precipitate with cation and develops unpleasant taste, which can destruct the strength of pipes, valves, etc. Even though some alkaline salt is required for drinking water to neutralize the acids like citric acids and lactic acid created by human body [10]. Maximum alkalinity was found at CT2 (365, mg/L, PRM16) during the study period. However, higher alkalinity was recorded at Chittoor (CT2), Edayakkunnam (E5) and Cheranellur zones (CH3) "Figure 2". While comparing to ISO 2003-09 limiting values for drinking purpose of water, it recorded very low concentration "Table 2". And also, it is highly significantly positively correlated with pH (r=0.54) "Table 3".

Iron is naturally occurring metallic element in groundwater. Iron is slowly released from soil and rocks to ground water[11]. In this study, iron was ranged between 0.002 to 1.8 in PRM16 and 0.001 and 1.5 in POM16 period. Meanwhile, at Edayakunnam zone (S8, S9, S10) exhibited higher levels (>1) of iron concentration (Figure 2). It is above the limit of standard guideline values as prescribed by ISO 2003-09 for drinking purpose (Table 2). Naturally minerals like iron sulphide and iron rich clay worked as source in ground water. And also allochthones sources such as industrial effluents, landfill leakages and acid mine drainage act as sources of iron in ground water [14,15]. Pearson correlation study revealed that iron shows significantly positive correlation with Cl- (r=0.37) (Table 3). According to the World Health Organisation1996 [16], the higher doses of iron in human body causes to diseases like epression, rapid and shallow respiration, coma, convulsions, respiratory failure, and cardiac arrest.

The existence of total coliform bacteria (Fecal Coliform bacteria or E. coli) in ground water causes to contamination of water. The presence of these organisms in drinking water can cause various diseases like stomach and intestinal illness with nausea and diarrhea and may lead to death. And also lead to immune deficiencies and other illness in human beings. In this study, majority of the stations does not containing Coliforms "Table 2". Meanwhile, at S6 (POM16) and S7 (PRM16, POM16) Coliforms were reported during the study period. This may be due to the effect of agricultural runoff, effluents from septic tank and sewage liberations, intrusion of domestic or wild animal fecal material associated with these stations (The British Columbia Ground water association 2007).

IV. CONCLUSION

In the present study area (Cheranellur panchayath), three zones of (Chittoor zone, Edayakunnam zone and Cheranellur zones) fifteen stations containing five bore wells and ten open wells. During the study period on both seasons (PRM16 and POM16) an abrupt change in concentration of each component is not obtained. The study revealed that, all the samples from each zones does not violate the ISO 2003-09 standard guideline values for drinking and public health purposes, except from S6 and S7 at Edayakunnam zone, in this stations presence of Coliforms are recorded. This is because these zone/stations affected by pollutant nearby from paddy field and terrestrial activities. While comparing the three zones, Chittoor and Cheranellur zone is more pure than Edayakunnam zone. Hence ground water from those zones (Chittoor and Cheranellur zone) does not need any sterilisation treatment for drinking and other public heath activities. Meanwhile, Edayakunnam zone groundwater especially from S6 and S7 is essential for proper treatment, before the drinking and domestic purposes. Hence, the overall study pointed that; ground water from Cheranellur panchayath is more preferable for drinking and other domestic purposes and also it is not harmful to human beings.

REFERENCES

[1]. InternationalOrganizationforStandardization2003-09fordrinkingandpublichealthpurposes
[2]. APHA (1999) Standard methods for the examination of water and wastewater. American Public Health Association, Washington, DC
[3]. Handa BK (1975) Geochemistry and genesis of fluoride-containing groundwater in India. Ground Water 13:275–281
[4]. Hem JD (1991) Study and interpretation of the chemical characteristics of natural water. In: United States Geological Survey professional paper 2254, Scientific Publisher, Jodhpur.
[5]. FetterCW(1990)Appliedhydrogeology.CBSPublishers&Distributors,NewDelhi592p
[6]. Kumarswami, N. 1991. An approach towards assessmentof dug well water quality by physico-chemicalcharacteristics-a case study. Poll. Res. 10 (1) : 13-20.
[7]. SujathaD.,RajeswaraReddyB.,(2003),"Qualitycharacterizationofgroundwaterinthesouth-easternpartoftheRangaReddydistrict,AndhraPradesh",IndianJournalofEnvironmentalGeology,44,579-586.
[8]. Sharma,S.D.andK.S.Pande,1988.PollutionstudiesonRamagangaRiver,PollutionResearch.17(2):201-209.

[9]. Todd,D.K1980.Groundwaterhydrology.Wiley,NewYork
[10]. SubbaRaoN(2014)Developmentandmanagementofgroundwaterresourcesinacoastalregion:astudyfromPrakasamDistrict,AndhraPradesh.In:Presentedat7thDSTPAC-WTIon10thJanuary2014.IIT,Bhubaneswar.
[11]. SujathaM.,GopalakrishnayyaA.,SatyanarayanaT(2012)AssessmentOfGroundwaterQualityInRural AreasOfVijayawada,A.P.InternationalJournalofEngineeringResearchandApplications(IJERA),2:645-648
[12]. SubbaRaoN,VidyasagarG,SuryaRaoP,BhanumurthyP(2014a)Chemistryandqualityofgroundwaterinacoastalregionof AndhraPradesh.AppliedWaterScience,India.
[13]. SubbaRaoN,VidyasagarG,SuryaRaoP,BhanumurthyP(2014b)Assessmentofhydrogeochemicalprocessesinacoastalregion:applicationofmultivariatestatisticalmodel.JournaloftheGeologicalSocietyofIndia84:494– 500.
[14]. NovaScotiaEnvironment.,2008.Ironandmanganese.Availableat:http://www.gov.ns.ca/nse/water/docs/droponwaterFAQ_IronManganese.pdfAcccessedon:Sep252011
[15]. Mansoor Ahmad 2012, Iron and Manganese removal from groundwater , Master Thesis, Department of Geosciences, University of Oslo, Norway.
[16]. WHO(1996)Guidelinesfordrinkingwaterquality. WorldHealthOrganization,Geneva.
[17]. The British Columbia Ground water association 2007 Total, Fecal & E. coli Bacteria in Groundwater. Water stewardship information series. Available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water wells/coliform020715_fin2.pdf

Table 1: Description of sampling point

SL.No	Zone	Location	Latitude	Longitude	Sample	Sample type
1	Chittoor	Thaipparambu	10°1'49.38"N	76°16'31.89"E	CT1	Open well
2	Chittoor	village office	10°1'53.2"N	76°16'29.9"E	CT2	Borewell
3	Chittoor	Chittoor temple	10°1'58.77"N	76°16'27.15"E	CT3	Open well
4	Chittoor	Chittoor retreat	10°2'9.396"N	76°16'32.07"E	CT4	Borewell
5	Chittoor	Chittoor ferry	10°2'16.12"N	76°16'23.92E	CT5	Borewell
6	Edayakkunnam	Church	10°2'21.09"N	76°16'46.02"E	E1	Open well
7	Edayakkunnam	Panchayath office	10°2'23.81"N	76°16'48.75"E	E2	Open well
8	Edayakkunnam	Bridge	10°2'31.72"N	76°17'7.34"E	E3	Bore well
9	Edayakkunnam	Jayakerala	10°2'31.76"N	76°17'15"E	E4	Open well
10	Edayakkunnam	Kappela	10°2'46.65"N	76°17'12.66"E	E5	Borewell
11	Cheranallur	Pallikkavala	10°2'54.9"N	76°17'27.7"E	CH1	Openwell
12	Cheranallur	Vishnupuram	10°3'4.518"N	76°17'23.11"E	CH2	Openwell
13	Cheranallur	Kacheripadi	10°3'22.302"N	76°17'16.57"E	CH3	Openwell
14	Cheranallur	Marapparambu	10°3'29.99"N	76°17'2.815"E	CH4	Openwell
15	Cheranallur	Kottaparambu	10°4'7.986"N	76°17'3.63"E	CH5	Openwell

Table 2: Comparison table of water quality parameters at study area with values of International Organization for Standardization 2003-09 (ISO 2003-09).

		pH	EC, microS/cm	TDS, mg/L	Cl^-, mg/L	TH, mg/L	Ca^{2+}, mg/L	Mg^{2+}, mg/L	Alkalinity, mg/L	Iron, mg/L	Total Coliforms
Permissible Limit (ISO2003-09		*6.5 - 8.5*	*---*	*2000*	*1000*	*600*	*200*	*100*	*600*	*1*	*Absent*
Stations											
PRM16	S1	7.28	0.4	193	28.9	30	11.3	5.7	208	0.05	Absent
	S2	7.7	0.7	362	35	43	15.9	7.9	365	0.05	Absent
	S3	6.89	0.2	109	19.8	22	10.7	8.9	96	0.09	Absent
	S4	6.53	0.5	258	28.2	35	13.6	6.2	58	0.07	Absent
	S5	6.54	1	519	39	52	22.8	8.7	96	0.12	Absent
	S6	7.04	0.7	365	36.7	220	81.6	10	125	0.7	Absent
	S7	6.85	0.8	334	23	216	80.1	9.9	70	0.82	Present
	S8	5.7	0.6	310	46.2	48	18.9	11	290	1.8	Absent
	S9	7.56	0.3	305	19.6	20.3	9.23	6.3	130	1.6	Absent
	S10	8.24	0.5	190	19.8	27.6	11.3	5	346	1.3	Absent
	S11	6.86	0.6	240	6.8	238	76	12	190	ND	Absent
	S12	7.5	0.1	48	6.6	34	5.6	4.9	216	0.007	Absent
	S13	7.98	0	24	9.8	20	4.8	1.9	290	0.005	Absent
	S14	6.85	0.2	90	13	26	6.4	2.4	70	ND	Absent
	S15	6.55	0.2	113	19.7	40	10	3.8	84	0.002	Absent
POM16	S1	7.23	0.4	172	26.3	25	10	5.1	223	0.04	Absent
	S2	7.55	0.6	360	34	40	15	7.7	306	0.05	Absent
	S3	6.76	0.3	110	20	20	10	5	105	0.1	Absent
	S4	7.23	0.4	250	27	32	12	6.1	62	0.05	Absent
	S5	7.45	0.9	515	36	50	23	12	125	0.1	Absent
	S6	7.19	0.7	340	37	186	80	9.1	146	0.55	Present
	S7	6.93	0.8	320	25	206	80	8.2	90	0.72	Present
	S8	5.96	0.6	278	45	43	19	9.7	190	1.4	Absent
	S9	7.6	0.3	176	20.5	20	10	5.1	165	1.5	Absent
	S10	8.02	0.4	228	18.9	26	10	4.8	340	1.2	Absent
	S11	6.59	0.5	280	6.6	220	74	9.2	106	ND	Absent
	S12	7.62	0.1	50	6.5	42	5	2.6	198	0.005	Absent
	S13	7.8	0.1	30	9.5	20	5	2	314	0.005	Absent
	S14	6.5	0.2	80	12	22	6	3.1	80	ND	Absent
	S15	6.58	0.2	100	20.1	35	12	3.1	82	0.001	Absent

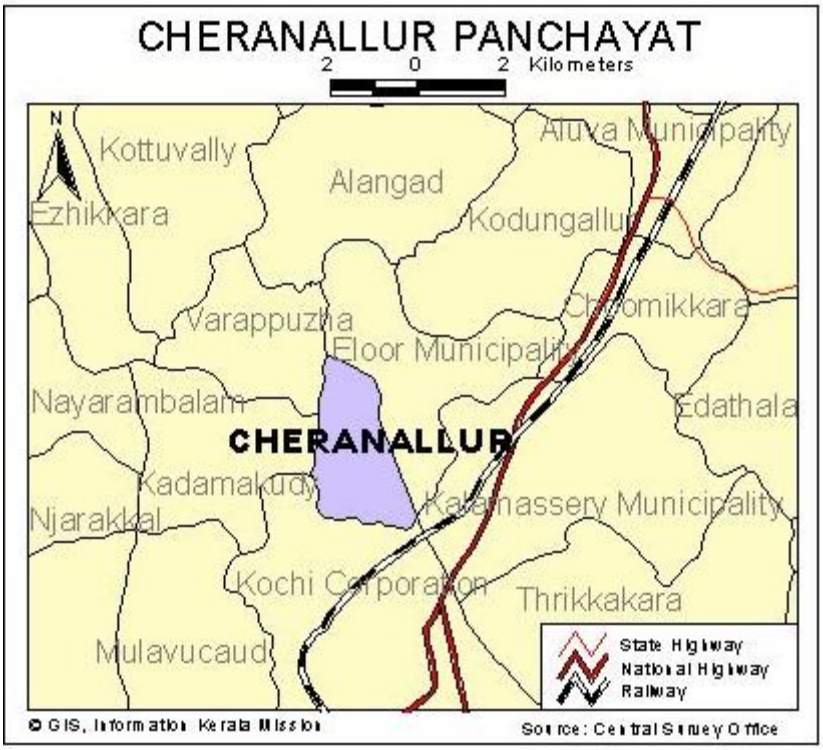
Note : ND- below detectable level

Table 3: Pearson correlation matrix for the analyses variables in water samples

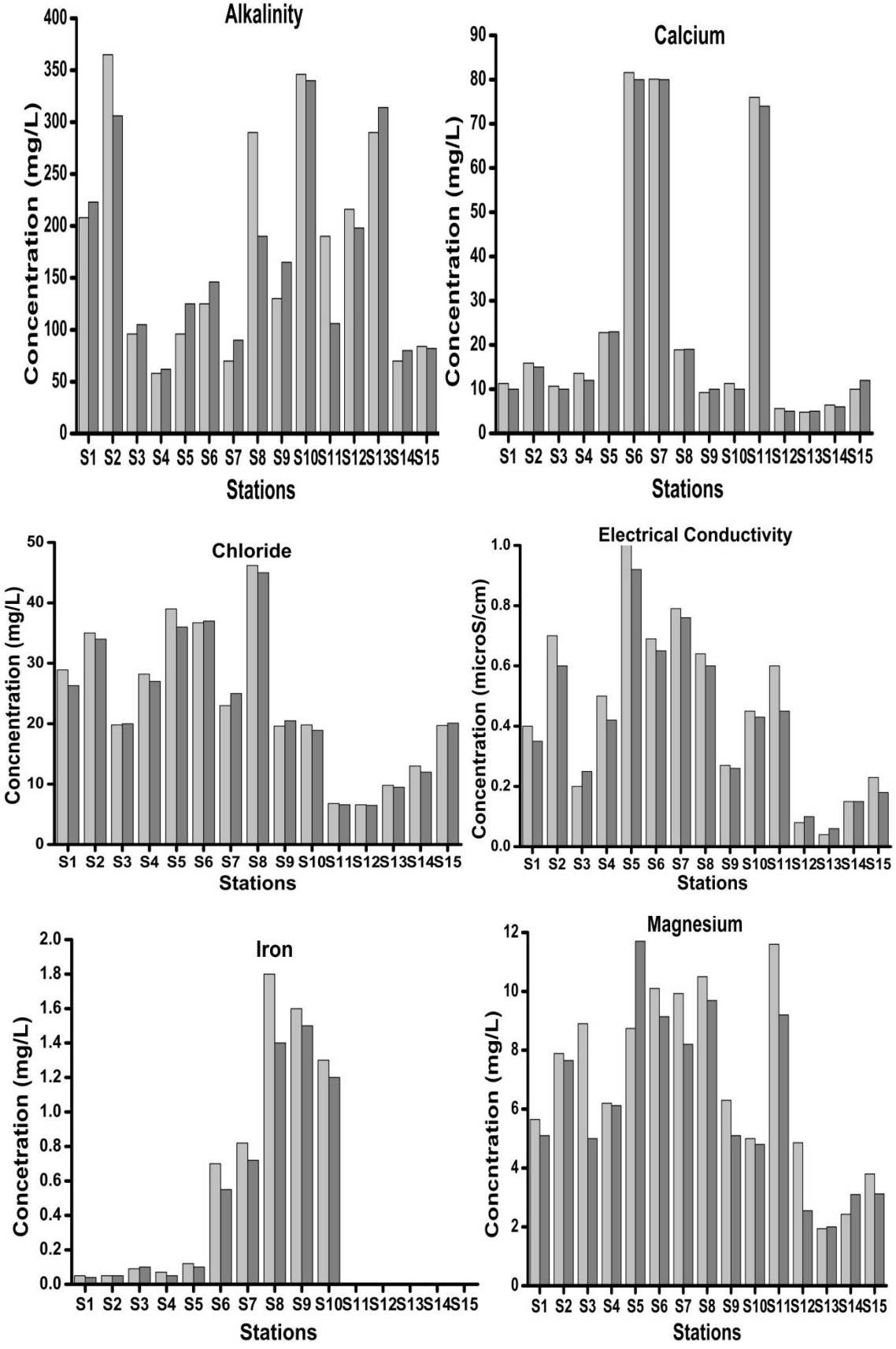
	pH	**EC**	**TDS**	**Cl^-**	**TH**	**Ca^{2+}**	**Mg^{2+}**	**Alkalinity**	**Iron**
pH	1								
EC	-0.23	1							
TDS	-0.16	0.94 (**)	1						
Cl^-	-0.34	0.71 (**)	0.72 (**)	1					
TH	-0.21	0.50 (**)	.039 (*)	0.01	1				
Ca^{2+}	-0.22	0.57 (**)	0.47 (**)	0.12	0.98 (**)				
Mg^{2+}	-0.36 (*)	0.82 (**)	0.79 (**)	0.57 (**)	0.60 (**)	0.65 (**)	1		
Alkalinity	0.54 (**)	-0.05	-0.08	0.04	-0.25	-0.27	-0.12	1	
Iron	-0.04	0.23	0.26	0.37 (*)	0.03	0.09	0.26	0.22	1

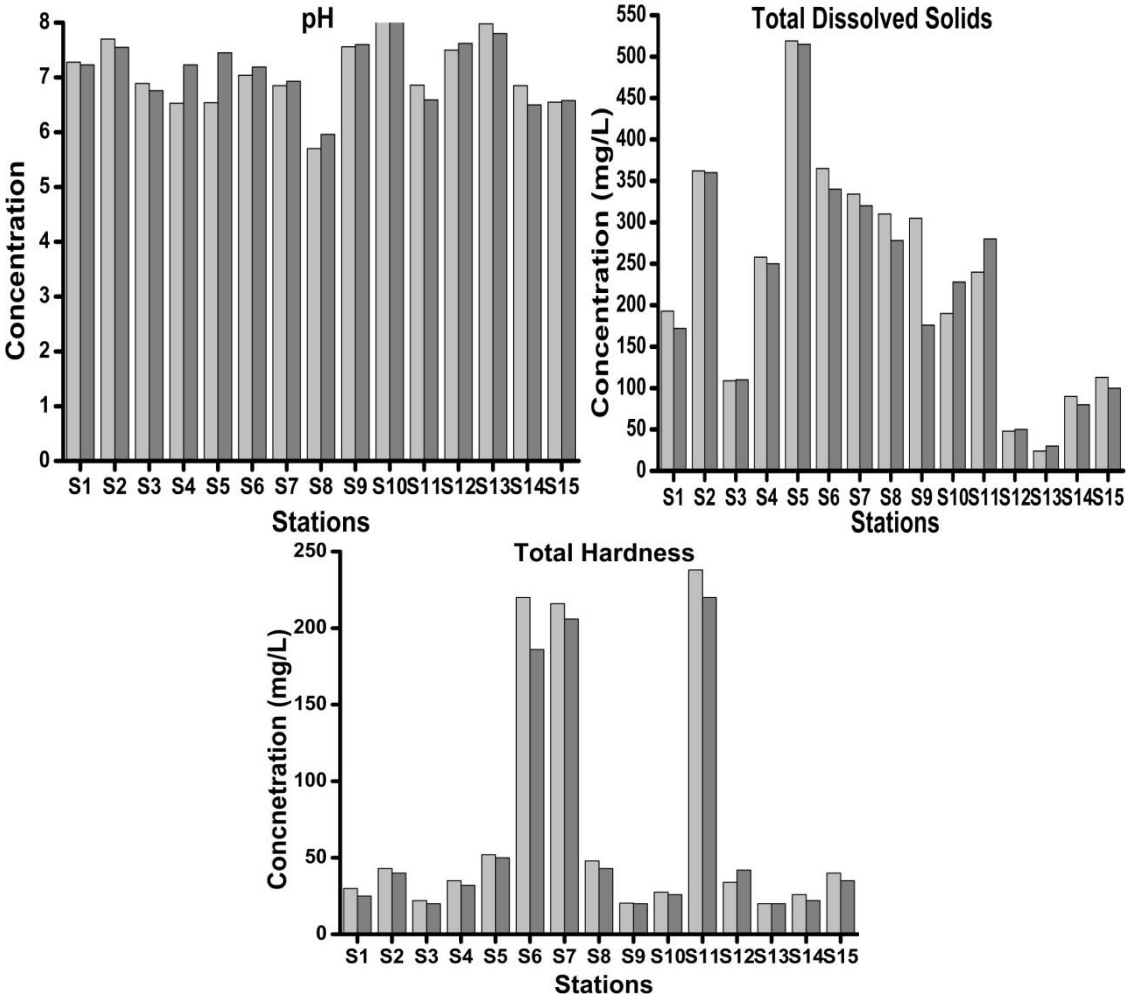
Note: **Correlation is significant at the 0.01 level,*correlation is significant at the 0.05 level

Figure 1: The study area – Cheranallur Panchayath



Figures 2-10: Variation of water quality parameters during premonsoon and postmonsoon




pH
Concentration
Stations
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15
Total Dissolved Solids
Concentration (mg/L)
Stations
Total Hardness
Concnetration (mg/L)
Stations