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Hydro Geochemical Study of Kinathukkadavu Taluk, Coimbatore Integrated with Geographical Information System

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ABSTRACT

Groundwater quality of south India is depending on climate condition and bedrock geology but may also be impacted by pollution, particularly from industrial sources and agricultural activity. In the current study, 15 groundwater samples were collected from different locations in the Kinathukkadavu Taluk, Coimbatore to assess water quality for drinking as well as for irrigation purpose by analyzing the major cations (Ca2+, Mg2+, Na+ and K+) and anions (Cl-, NO3-, SO42- and F-) besides some physical and chemical parameters (pH, total hardness, electrical conductivity and total alkalinity). Statistical analysis like correlation, R- mode factor and cluster analysis were performed for demarcate the association of hydro geochemical parameters. Also groundwater quality mapping was developed using geographic information system.

1. INTRODUCTION

In India, groundwater as the only drinking water source for most of the population (NIUA, 2005 Mahmood and Kundu, 2005 Phansalkar et al., 2005). Since, believed groundwater is to be much clean and pollution free than surface water. But groundwater can also contaminated naturally or numerous types of human activities like industrial, commercial, municipal and agricultural activities (Rivers et al., 1996; Kim et al., 2004; Jalali, 2005; Srinivasamoorthy et al., 2009). However, contamination of groundwater can result in poor drinking water quality, high cleanup costs, loss of water supply, force for alternative water source, and potential health problem.

In addition, found that a wide variety of materials like synthetic organic chemicals, hydrocarbons, inorganic cations and anions, pathogens, and radionuclide in groundwater (Fetter, 1999). In India around 80% of all diseases are directly linked with poor water quality (Prasad, 1984; Olajire and Imeokparia, 2001). On the other hand water scarcity is becoming common in several part of the country, particularly in arid and semiarid area. Also, in several states like Rajasthan, Punjab, Gujarat, Uttar Pradesh, Haryana and Tamil Nadu were overdependence of groundwater resources for domestic, irrigation and industry segments has resulted in overexploitation of groundwater (Rodell et al., 2009 Garg and Hassan, 2007).

2. STUDY AREA

Kinathukadavu Taluk is located in Coimbatore district and lies between 10°43' and 10°53'N latitude and 76° 50' and 77° 10' E longitude. It has salubrious climate because it is bounded with Western Ghats and maximum and minimum temperature various between 35°C and 18°C respectively. The major activity is agricultural especially, this soil well suitable for coconut plantation, which engage 60% of the workforce of the study area. Rests of them are working in Automobile industry, Textile industry and small scale industry development corporation (SIDCO).

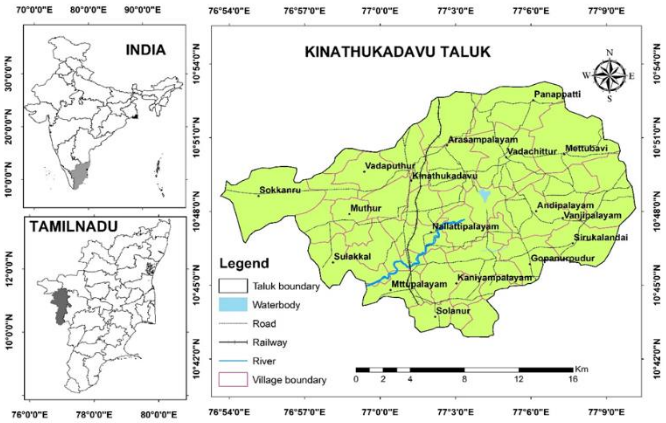

Fig.1. Study Area

3. METHODOLOGY

Ground water samples were collected from 15 locations in the Kinathukkadavu Taluk during the month of February 2015 shown in figure.1. From each station 2 liters of water sample was collected in pre cleaned polyethylene bottles for physical and chemical analysis and the samples were kept in ice box and transported to laboratory, where they stored at 4ºC until further analysis. The pH, EC, salinity and TDS were measured in the field using digital water analysis kit. Chloride concentration was analyzed using MOHR's titration method. Concentration of sodium and potassium were determined by the flame photometric method. The turbidity analyzed by using neophelometric method and total hardness determined by the EDTA (APHA, 1998). Total alkalinity was also determined by the general method (APHA, 1998) and Phosphate was determined by the ammonium molybdate method (APHA, 1998). The nitrate was estimated by the brusine sulphate colorimetric method (APHA, 1998). Descriptive statistics were carried out using the SPSS package (Khan 2011). Spatial distributions of various geochemical parameters were prepared by inverse distanced weighted (IDW) method using Arc-GIS software (Lee et al. 2006).

Table 1. Minimum, maximum, mean and standard deviation of physicochemical parameters groundwater quality, Kinathukadavu Taluk such as pH, EC, TH, TA, TDS and major cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and anions (Cl^-, NO_3^-, SO_4^{2-} and F^-)

Sample No	Location	Turbidity NTU	TDS	EC	pH	TA	TH	Ca	Mg	Na	NO3	Cl	F	So4	K
1	Arasampalayam	2	1335	1907	7.38	290	480	128	38	178	33	370	0.8	99	17
2	Kuthiraialampalayam	1	157	224	7.27	45	58	16	5	21	4	36	0.2	8	2
3	Mettupalayam	1	1181	1687	7.62	328	448	120	36	152	17	236	0.6	99	15
4	Sulakkal	2	1153	1647	7.55	320	440	117	36	150	26	232	0.6	97	15
5	Govindapuram	2	205	293	7.48	58	74	20	6	28	4	47	0.2	8	2
6	Sokkanur	1	1400	2000	7.33	310	500	132	41	184	34	380	0.8	104	18
7	Vadasithur	2	998	1426	7.19	276	396	106	32	122	24	218	0.6	93	12
8	Andipalayam	2	455	650	7.45	124	178	48	14	56	13	82	0.4	52	5
9	Sirukkalandai	1	968	1383	7.36	264	380	102	30	116	22	208	0.6	87	11
10	Periakalandai	2	2919	4170	7.18	400	1110	296	89	368	100	850	1	337	36
11	Kappalangarai	1	1736	2480	7.24	340	580	156	46	248	40	450	0.8	147	24
12	Chettiaakkapalayam	1	863	1233	7.39	236	352	94	28	102	22	184	0.6	78	10
13	M. Kovilpalayam	2	1862	2660	7.46	360	590	156	48	292	41	470	1	60	29
14	Kinathukadavu	1	1168	1669	7.35	324	444	118	46	152	26	236	0.6	98	15
15	Panappatti	2	662	945	7.19	192	272	72	22	78	20	124	0.6	52	7
	Min	1	157	224	7.18	45	58	16	5	21	4	36	0.2	8	2
	Max	2	2919	4170	7.62	400	1110	296	89	368	100	850	1	337	36
	Mean	1.5	1137.5	1624.9	7.4	257.8	420.1	112.1	34.5	149.8	28.4	274.9	0.6	94.6	14.5
	Std. div	0.5	697.7	996.7	0.1	107.8	250.8	66.7	20.4	96.0	22.7	208.6	0.2	76.4	9.6

4. RESULT AND DISCUSSION

Table 1 represents the minimum, maximum, mean and standard deviation of physicochemical parameters groundwater quality, Kinathukadavu Taluk such as pH, EC, TH, TA, TDS and major cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and anions (Cl^-, NO_3^-, SO_4^{2-} and F^-).

Hydrogen ion concentration is a very important indicator of ground water quality and controlled by the amount of dissolved CO_2, carbonate and bicarbonate in groundwater (Ghandour et al., 1985).

The range of permissible limits as per BIS for portable water is 6.5 to 8.5. In the studied samples, the pH value ranged from 7.18 to 7.62 indicating that the groundwater was of alkaline nature due to HCO_3^- form of dissolved carbonate (Nagarajan et al. 2010).

The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water is determined by means of portable organic water tests and the permissible limit of electrical conductivity (EC) is between 750-2250 mhos/ cm (IS: 10500, 1992).

The analyzed result shows that 80% of the samples have EC within permissible limit and rest of the samples exceeds the permissible limit. The excess amount of EC indicates excess amount of TDS present in them.

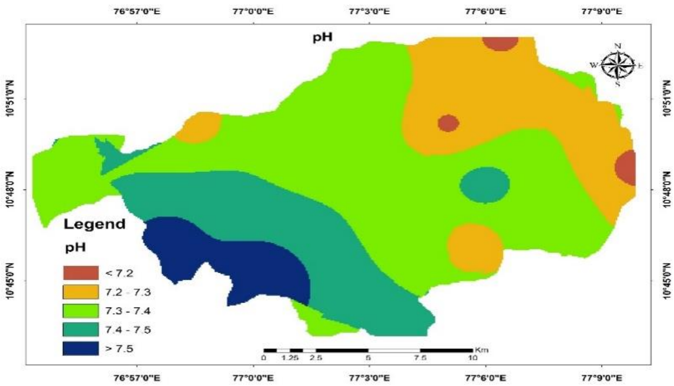

Fig.2. pH Values of Ground water samples

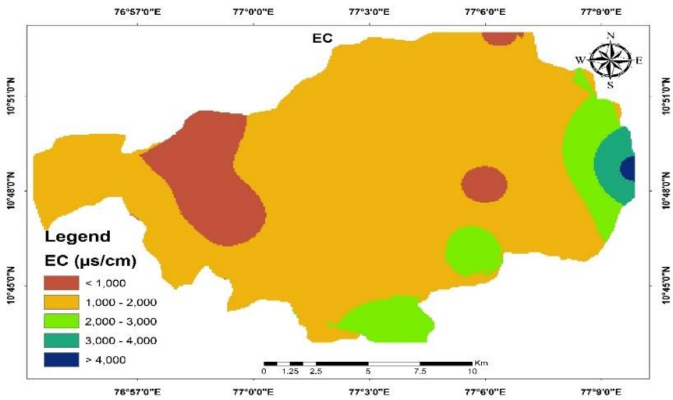

Fig.3. Electrical Conductivity of Ground water samples

TDS contains inorganic salts (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-} and SO_4^{2-}) and organic matter present in the water and also TDS originate from natural as well as anthropogenic activities like industrial discharge and urban runoff. Figure 4. Has shown that TDS value ranged from 157 to 2919 mg/L and the highest TDS was found in Periyakalanthai Village. According to Davis and DeWiest (1966), TDS is classified into four different categories based on drinking suitability.

Table.1 shows that 20% of samples are desirable for drinking water and 26.67% of the samples are within the permissible limit for drinking and 53.33% of samples were useful for irrigation purpose. Freeze and Cherry (1979) also classified the TDS, based on brine, saline, brackish and fresh water type. This classification shows about 46.67% of the groundwater to be under freshwater condition and the remaining samples as brackish water type. Water containing high solids may cause laxative or constipation effects (Kumaraswamy, 1999).

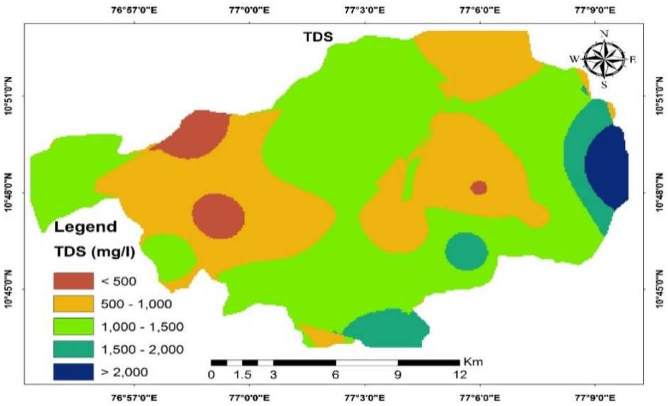

Fig.4. Total Solids of Ground water samples

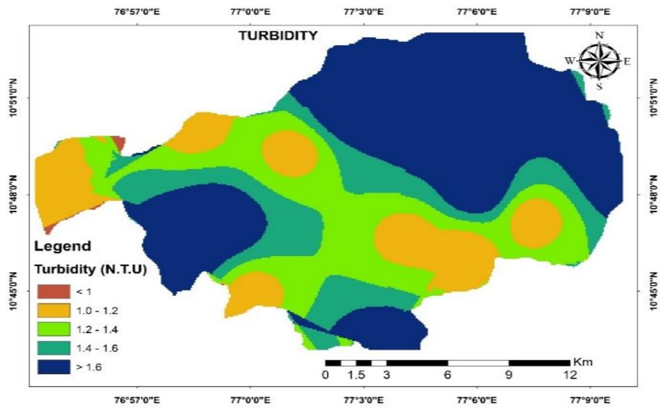

Fig.5. Turbidity of Ground water samples

Turbidity is an expression of optical property of water and the concentration depends on the presence of insoluble substances like colloidal and fine particles (Manivaskam, 1986). The variations of turbidity with standard deviation of fifteen sampling stations are given in table 1. It is observed that, the sampling points 1 to 15 met the BIS (10 N.T.U.). Alkalinity of water may be the presence CO_3^{2-}, HCO_3^{-} and hydroxides compound of Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}, especially CO_3^{2-} and HCO_3^{-} may originate from microbial decomposition of organic matter. The acceptable limit of TA is upto 200 mg/L for drinking water purpose (IS 10500, 1991). The TA for tested sample varies from 45-400 mg/L (table 1). Nearly 73% of the samples are exceeded permissible limit. Strong alkaline water has an objectionable soda taste and cause excessive drying of skin. Hardness in water is due to the presence of Ca^{2+}, Mg^{2+} and also cation likes Fe^{2+}, Sr^{2+} and Mn^{3+} and anions like HCO_3^{-}, CO_3^{2-}, SO_4^{2-}, Cl^{-} and NO_3^{-} etc., (Taylor 1949).

The prescribed limit for hardness in drinking water ranges from 75 to 115 mg/L and nearly 86% of analyzed samples are exceeded the acceptable limit. Table1 shows the TH is in range of 58 to 1110 mg/L. Excess hardness offer a scale formation in kettles, water heaters and clog plumbing, are composed mainly of $CaCO_3$, $Mg(OH)_2$, and $CaSO_4$ (Hermann Weingartner, 2006). Chloride content in studied sample has found to be exceeds the permissible levels and indicates 33.33% of the samples above the acceptable limit. Concentration above 250mg/L may have a detectable salty taste if the Cl^{-} can from sodium chloride (Johnson et al., 1999). Also high concentration of Cl^{-} is due to rock structures because it's widely distributed in all types of rocks. Soil permeability and porosity has also key role in the increase of Cl^{-} concentrations.

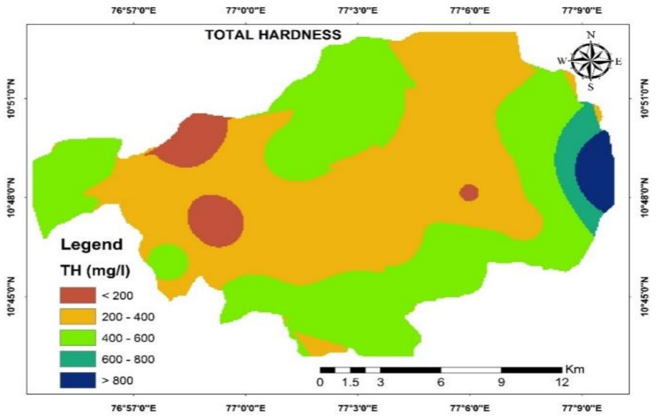

Fig.6. Total Hardness of ground water samples

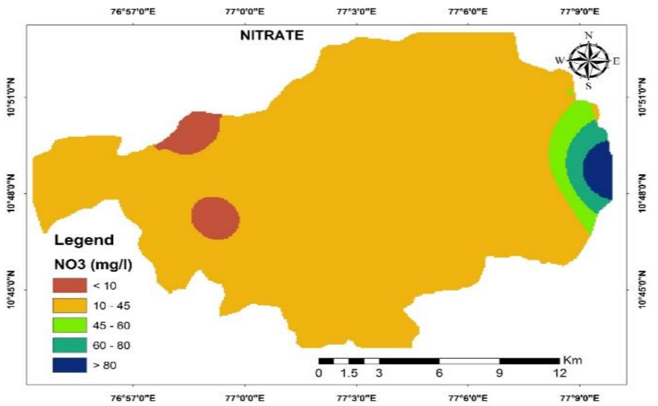

Fig.7. Nitrate levels of ground water samples

Nitrate is a good indicator for contamination by sewage disposal, leaching of fertilizer and animal manure. The NO_3^{-} varied from maximum 100 mg/l at sampling station 10 to minimum 4.0 mg/l at Kuthiraialampalayam sampling station

2. Though NO_3^- is considered comparatively non-toxic, a high NO_3^- concentration in drinking water is an environmental concern because it can harm infants by reducing the transport oxygen in the blood. Sulphate occurs naturally in numerous minerals and the acceptable limit of SO_4^{2-} in drinking water is up to 200mg/L but only the sample number 10 has above the acceptable limit.

Calcium contributes to the TH of water and the value of groundwater samples ranged from 16 to 296 mg/l except station 10, all other samples were within the permissible limits (75-200 mg/L) for drinking purpose (BIS, 1988). The important sources of Ca^{2+} in groundwater are rain water, weathering of calcium silicate, minerals, irrigation, etc., and also Ca^{2+} is essential for nervous system, cardiac function and coagulation of blood (Khurshidet al. 1997). Magnesium occurs commonly in the minerals of magnetite and dolomite and the result has shown that Mg^{2+} varied from 89.0 mg/l to 5.0 mg/l. As per the standards up to 100mg/L is allowable limit for Mg^{2+} for drinking purpose, in studied samples are within the allowable limit. The fluoride content of water samples ranged from 0.2 to 1.0 mg/L, showed within the permissible limit. The acceptable limit of K^+ in drinking water is 250mg/L but nearly 73% of analyzed samples are exceeding acceptable limit (IS 10500, 1992). Increasing K^+ in groundwater is due to agricultural activities and it cause vomiting, diarrhoea, hyperkalaemia, shortness of breath and heart failure.

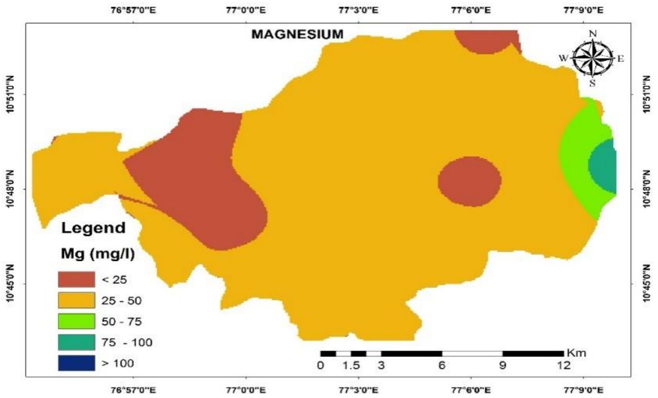

Fig.8. Magnesium level of ground water samples

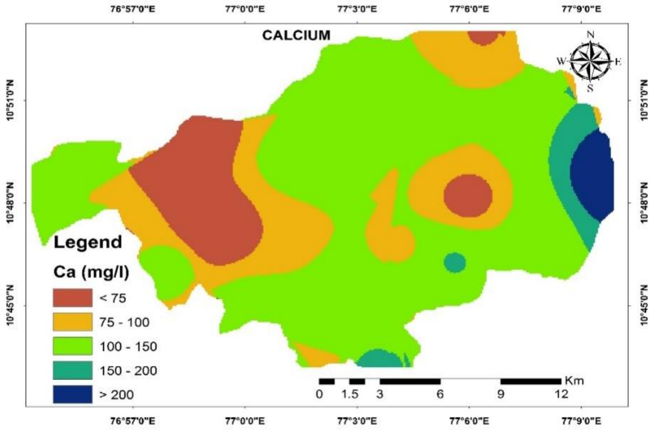

Fig.9. Calcium level of ground water sample

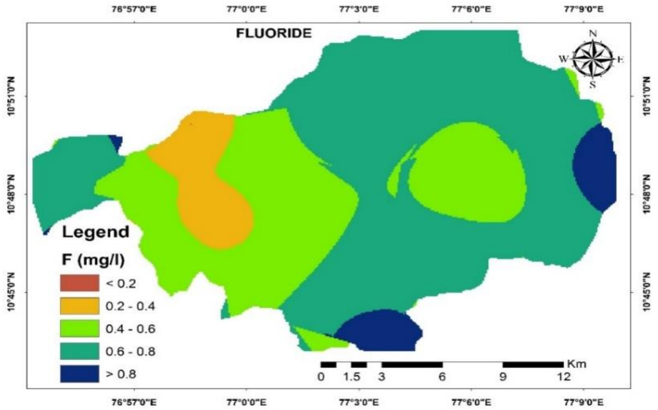

Fig.10. Fluoride level of ground water samples

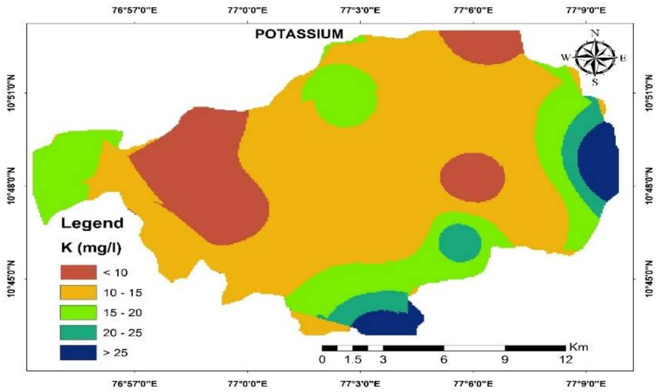

Fig.11. Potassium level of ground water samples

Correlation studies promoting research and reduce the range of uncertainty associated with decision making of among the parameters (Joshi et al., 2009). Hence the attempt is made and table 2 represents correlation among various physicochemical parameters of groundwater. pH shows negative correlation with all the analyzed parameters due to occurrence of rock dissolution (Asif Mahmood et al., 2011). EC and TDS are showing strong positive correlation (r>0.9) with TH, Ca, Mg, Na, K, NO3 and F indicate that similar hydro-chemical characteristics.

Factor analysis is very useful to interpret the groundwater quality data and to understand specific hydro-geochemical processes. Hence, varimax with Kaiser Normalization rotated factor loading matrix was performed. In the current analysis only two factors were found to be exceeding the value one, they are only considered for analysis. In analysis table3, it is inferred that the first two components together account for 88.2% of the total variance in which the first component accounts for more than 78% of the variance was explained.

EC,TDS,Turbidity,TA,TH,Cl-,Mg2+,Na+,Ca2+,K+,NO3-,SO42-and F-were the variables grouped under this factor. The highest factor loading of EC and TDS is 0.991 indicating the strong relationship between these two variables.

The enrichment of Na+ and Cl- ions in groundwater is due to the interaction of water with rocks and secondly the

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association of TDS with higher concentrations of Na+ and Cl- ions (Pathak et al., 2008). Hence, the first component was characterized by their natural geo chemical associations and similar mobility in the groundwater environment (Rao et al.2006 and Hem 1991). Infactor2, around 9.8% of the variance explained by this factor under which pH grouped alone.

Cluster analysis is also another data reduction method that is used to classify entities with similar properties (Pathak et al. 2008). Through hierarchical cluster analysis (HCA), the associations among the stations were obtained using Ward's method with Euclidian distance as a similarity measure with dendrogram plots.

The physicochemical parameter concentrations were used as variables to show the spatial heterogeneity among the stations as a result of sequence and their relationship in the level of contamination.

	pH	EC	TDS	Turbidity	TA	TH	Ca^{2+}	Mg^{2+}	Na^{+}	No_3^-	Cl^-	F^-	So_4^{2-}	K^+
pH	1													
EC	-0.228	1												
TDS	-0.228	1	1											
Turbidity	-0.022	0.097	0.097	1										
TA	-0.031	0.876	0.876	-0.054	1									
TH	-0.256	0.99	0.99	0.099	0.868	1								
Ca^{2+}	-0.257	0.99	0.99	0.096	0.867	1	1							
Mg^{2+}	-0.253	0.98	0.98	0.063	0.882	0.991	0.991	1						
Na^{+}	-0.182	0.988	0.988	0.106	0.87	0.956	0.956	0.947	1					
No_3^-	-0.391	0.947	0.947	0.206	0.714	0.963	0.963	0.947	0.906	1				
Cl^-	-0.293	0.985	0.985	0.129	0.792	0.975	0.974	0.956	0.971	0.969	1			
F^-	-0.2	0.912	0.912	0.109	0.901	0.882	0.88	0.869	0.925	0.804	0.877	1		
So_4^{2-}	-0.359	0.888	0.888	0.075	0.703	0.933	0.935	0.92	0.812	0.944	0.896	0.685	1	
K^+	-0.171	0.986	0.986	0.097	0.876	0.955	0.954	0.947	1.000	0.901	0.966	0.925	0.806	1

Component	1	2	Comm
pH	-0.142	-0.801	0.661
EC	0.991	0.123	0.997
TDS	0.991	0.123	0.997
Turbidity	0.019	0.55	0.303
TA	0.92	-0.195	0.885
TH	0.982	0.162	0.99
Ca^{2+}	0.981	0.163	0.989
Mg^{2+}	0.977	0.135	0.973
Na^+	0.979	0.072	0.963
NO_3^-	0.909	0.375	0.966
Cl^-	0.96	0.22	0.971
F^-	0.92	0.033	0.847

Table 2. (a) Correlation values for ground water samples in the study area (b) Factor analysis of ground water samples

There were three major groups of cluster obtained from the sampling. Group I, which is further subdivided into two subgroups, Ia and Ib, interprets in the physicochemical composition and all the parameter lies within limit. Group II is typically represented by the Ca2+, Mg2+, Cl-, PO43- and NO3 ions and they are influenced by human interference and extent of pollutants and agricultural activity. Sample number 10 comes under group III which shows tremendous changes in the analyzed parameter of groundwater. The change in the parameter is possibly due to the rock composition. Except the Group III, other group are not polluted and fit for drinking purpose.

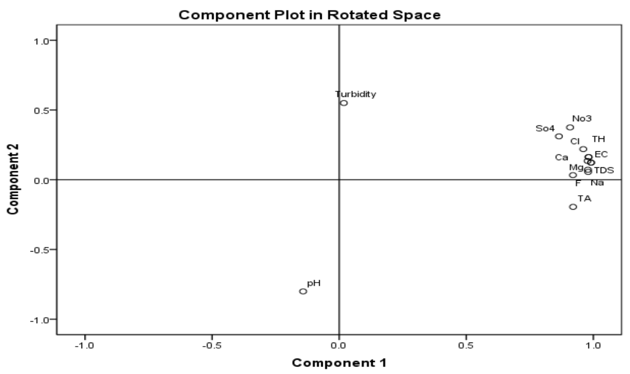

Fig.12. Cluster Analysis of ground water samples

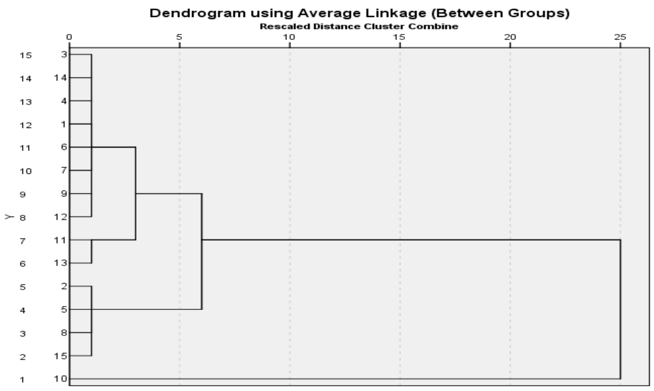

Fig 13. Dendogram plot of ground water samples

5. CONCLUSIONS

The present study of ground water samples in Kinathukadavu Taluk shows that the water quality of the studied samples were within the BIS limits except some samples. The chemical composition of groundwater shows that pH and fluoride for all the samples were within limit. Statistical analysis the R-mode factor analysis has been done and analyzed result shows that first two components together account for 88.2% of the total variance and accounts for more than 78% of the variance. EC, TDS, Turbidity, TA, TH, Cl-, Mg2+, Na+, Ca2+, K+, NO3-, SO42-and F- variables were grouped under this factor. The highest factor loading of EC and TDS is 0.991 indicating the strong relationship between these two variables. HCA shows three major groups of cluster. Group I clustered interprets in the physicochemical composition, and all the parameter lies within limit and Group II is typically represented by the human interference and extent of pollutant. GIS based spatial variation indicates that northern east part of the study area have more ionic concentration, which was found to be mainly due to industrial establishment and over-exploitation of ground water.

6. ACKNOWLEDGEMENT

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