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Studies on Groundwater Quality of Kunnamangalam Grama Panchayat Calicut, Kerala (India)

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A study was carried out to assess the groundwater quality of Kunnamangalam Grama Panchayat, Calicut, Kerala. Out of 110 groundwater samples analysed, 93% of samples were acidic in nature and 4% samples had iron content beyond the desirable limit as per BIS in all seasons. Majority of the samples (91%) were bacteriologically contaminated in all the seasons. Studies on groundwater chemistry using Piper diagram revealed that calcium and bicarbonates are the major dominating cation and anion in all the water type. Two major hydrochemical water types Ca-Na-Mg-Cl-HCO_3 and Ca-Na-Cl- HCO_3 constituting 90% of groundwater sources in the study area have been identified. A systematic calculation was made to determine the correlation coefficient 'r' amongst the various water quality parameters and the significant values of the observed correlation coefficient between the parameters was worked out. Total hardness, chloride, calcium and magnesium exhibited a positive correlation with total dissolved solids. Similarly total hardness showed a significant correlation with calcium, magnesium and potassium. A negative correlation was found between pH and chloride. The present study revealed that groundwater sources were not polluted with respect to physico-chemical assessment. All the values were within permissible limit when compared with Bureau of Indian Standards except pH. But bacteriological studies revealed that groundwater was not fit for drinking purposes due to the presence of coliform bacteria.

Key word : *Physico-chemical parameters, water quality*

Introduction

Water is the most abundant liquid and is essential component of our life supporting system. All of us use water in sufficient quantities for leisure, domestic, agricultural and industrial purposes. Thus water is related to the economic, mental and physical health of the people. Availability of freshwater is a major problem faced by many countries. Groundwater has been regarded as the pure form of water compared to surface water; because of purification of the former in the soil column through anaerobic decomposition filtration. This is one of the reasons for excessive consumption of groundwater in rural and semi-urban areas all over the world[1].

Gradual depletion of groundwater in terms of quantity and quality is a major problem faced by us. This can be either due to environmental factor or anthropogenic activities. Water resource of Kerala is having both abundance and scarcity. Kerala is rain blessed. It is true that with its enchanting greenery and network of backwaters and rivers, Kerala is still thought to be water plenty state. The spatial and temporal distribution pattern is mainly responsible for the frequent flood and drought in Kerala.Filling up of wells and ponds, concreting of compound yards etc prevent rainwater from reaching the bowls of earth. Climate changes and unplanned withdrawal of groundwater also deteriorate the quantity of water.

Another important issue is related to groundwater quality. Groundwater contamination due to chemicals is generally irreversible, that is once contaminated its original quality cannot be restored back. The excessive mineralization of groundwater degrades quality by providing objectionable taste, odour and hardness. Dumping grounds for garbage, synthetic fertilizers and pesticides, seepage from septic tank, seepage of sewage etc have adversely affected the groundwater quality in several parts. The incident of groundwater pollution is high in urban area where large volumes of domestic and industrial wastewater are discharged into relatively small areas as point sources. The depletion and degradation of groundwater are a major cause of increasing the rural poverty in India[2].

Groundwater contamination is a socio-economic problem that receives considerable attention in modern society. According to World Health Organization about 80% of epidemic and chronic diseases are caused by water[3]. Therefore water that is supplied for drinking must be of good quality. It is generally considered that groundwater is least polluted compared to other inland water resources, but studies indicate that groundwater is not absolutely free from pollution though

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it is likely to be free from suspended solids. The major problem with groundwater is that once contaminated, it is difficult to restore its quality. Hence there is need and concern for the protection and management of groundwater quality[4]. A continuous periodical monitoring of water quality is necessary so that appropriate steps may be taken for water resources management practices. At regular intervals, if the source of water is subjected to integrated analysis to monitor its physical, chemical and biological properties, we can take appropriate action to make the water potable. In this study an attempt is made to carry out a systematic investigation of physico-chemical and bacteriological parameters of samples collected from Kunnamangalam Panchayat in order to assess its suitability for drinking purpose.

Materials and methods

Kunnamangalam panchayat is located in the north western side of Kerala state with geographical coordinates 11° 19' 0"N and 75° 53'0" E. In order to assess the quality of groundwater sources, a total of 110 samples were collected from 22 wards of Kunnamangalam Panchayat during April 2009 to May 2010. The map showing sampling stations are given in **Fig.1**. General procedures for groundwater sampling, preservation and chemical analysis were carried out according to standard procedures. pH, electrical conductivity and total dissolved solids of groundwater samples were determined in the field. Other chemical constituents and bacteriological analysis were done in the laboratory as per the Standard Methods for the Examination of Water and Wastewater[5]. Alkalinity, chloride, and total hardness were analyzed titrimetrically. Sodium and potassium were analyzed by using flame photometer. Colorimetric method was used for the analysis of nitrate. Water type classification was obtained by putting the analytical data in AQUACHEM software. Statistical analyses were performed using SYSTAT software.

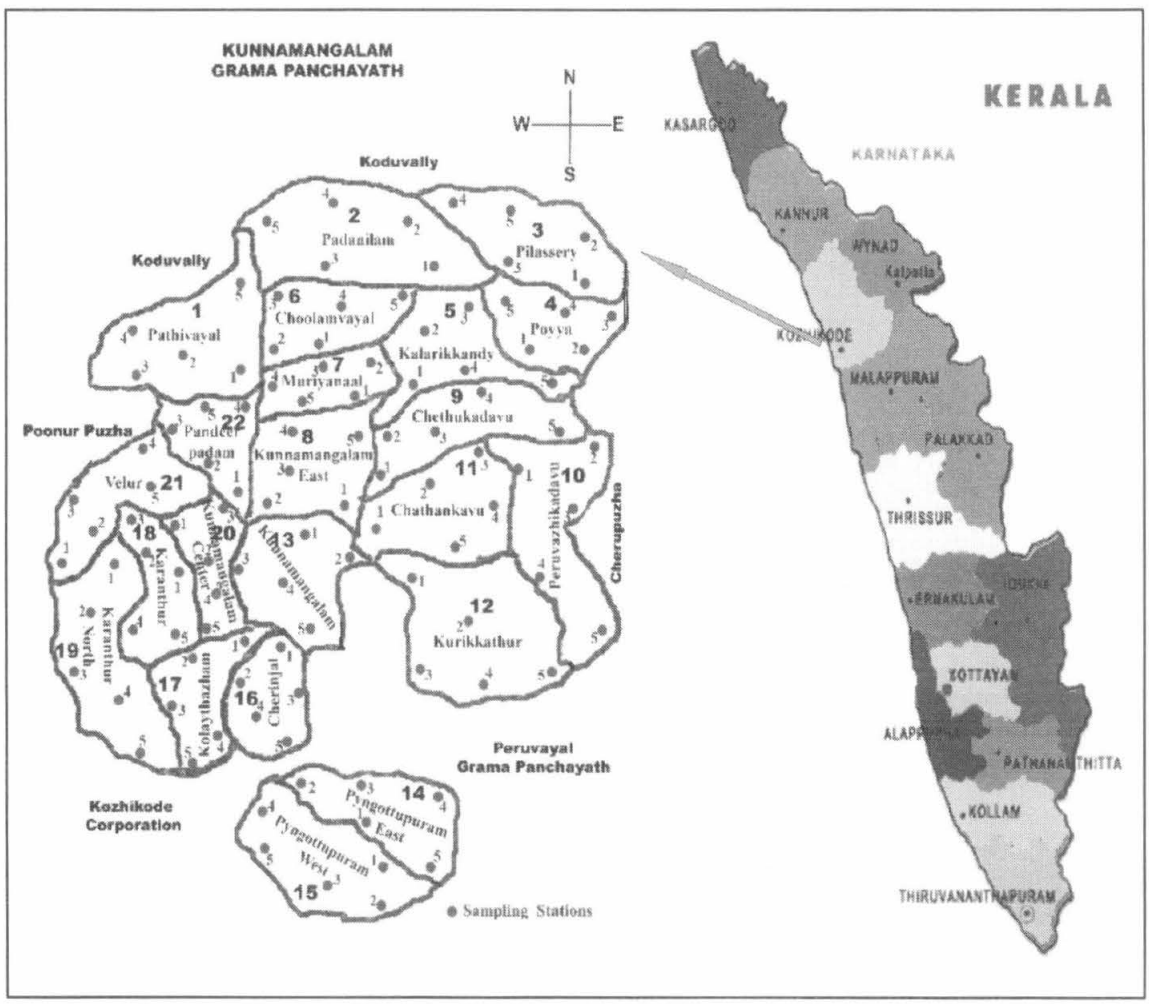

Fig.1 : Map of Kunnamangalam grama panchayat showing the water sampling locations

Results and discussion

Groundwater samples were collected from Kunnamangalam grama panchayat during pre-monsoon, monsoon and post-monsoon during the year 2009-2010. The latitude and longitude are between 11° 20' 035"N and 75° 53'519" E. The minimum and maximum concentrations of various water quality parameters are given in **Table 1**.The salient findings of the report are summarized in the following section.

Water quality status

All the water quality characteristics were within the desirable limit when compared with Bureau of Indian Standards except pH. During the pre-monsoon period, the pH ranged from 4.90 to 8.61. Of the total samples analysed, 92 % of samples were acidic in nature during pre-monsoon. During monsoon, the pH value ranged from 4.70 to 8.62. It was found that 93% and 94% of the samples were acidic in monsoon and post-monsoon respectively. The acidic nature of samples could be attributed to the increase in concentration of carbon dioxide in the infiltrating water. The seasonal variation of pH is shown in **Fig .2.** Bacteriological analyses revealed that majority of the groundwater sources were contaminated. 48% wells were contaminated by *E. coli* during pre-monsoon .During monsoon 65% of samples were contaminated by *E.coli*. The samples were found to be contaminated in the order of 93% and 17% with respect to total coliforn and *E. coli* during post-monsoon. The reason behind the microbial contamination is due to poor

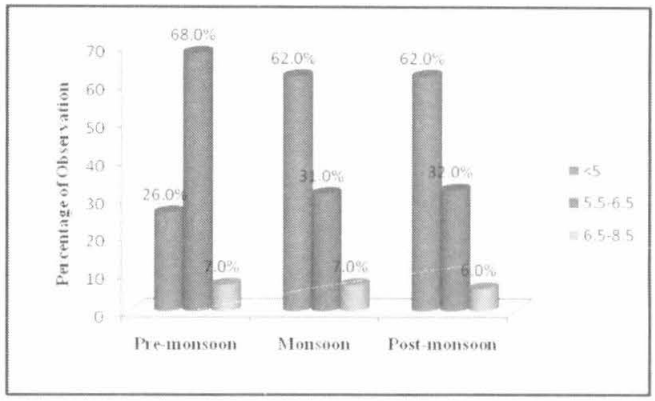

Fig. 2: Seasonal variation of pH

Table1 : The minimum and maximum concentrations of various water quality parameters

Parameters	Pre -monsoon		Monsoon		Post - Monsoon	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
pH	4.90 (±0.15)	8.61 (±0.65)	4.70 (±0.10)	8.62(±0.60)	4.75(±0.20)	8.53 (±0.69)
Colour, Hazen	ND	21.0 (±2.48)	ND	3.70 (±2.68)	ND	44.20 (±3.98)
Turbidity, NTU	ND	85.0 (±1.18)	ND	2.20 (±1.20)	ND	9.30 (±1.38)
Electrical Conductivity, µS/cm	30.0 (±1.23)	346.0 (±5.83)	29.0 (±1.30)	331.0 (±4.33)	29.0 (±1.30)	395.0 (±6.19)
Total Dissolved Solids, mg/L	20 (±1.33)	204.0 (±4.73)	14.0 (±1.15)	213.0 (±3.65)	17.0 (±1.10)	252.0 (±4.18)
Total Hardness ,mg/L	8.0 (±0.61)	176.0 (±8.61)	4.0 (±0.10)	160.0 (±5.13)	4.0 (±0.90)	128.0 (±2.96)
Sulphate, mg/L	ND	52.0 (±3.63)	0.04 (±0.01)	18.92 (±3.46)	0.32 (±0.05)	23.44 (±3.45)
Chloride, mg/L	7.98 (±0.62)	64.0 (±2.62)	0.96 (±0.10)	38.45 (±1.15)	7. 66 (±1.22)	39.28 (±2.92)
Nitrate-N, mg/L	ND	5.13 (±1.20)	0.08 (±0.01)	7.45 (±1.10)	0.25 (±0.02)	5.75 (±1.26)
Calcium, mg/L	1.60 (±0.07)	36.80(±20.7)	1.6 (±0.15)	40.0 (±1.15)	1.20 (±0.20)	25.60 (±2.37)
Magnesium, mg/L	ND	20.41 (±2.46)	0.97 (±0.10)	7.78 (±2.11)	0.97 (±0.10)	15.55 (±2.25)
Iron, mg/L	ND	0.98 (±0.16)	ND	0.72 (±0.15)	ND	3.75 (±1.46)
Manganese, mg/L	ND	0.17 (±0.05)	ND	0.28 (±0.06)	ND	0.07 (±0.05)
Sodium, mg/L	2.80 (±0.20)	28.40 (±1.60)	1.20 (±0.08)	25.60 (±1.18)	2.80 (±0 .40)	26.40 (±1 .90)
Potassium, mg/L	0.10 (±0.33)	3.70 (±1.73)	0.10 (±1.31)	8.90 (±1.31)	ND	7.50 (±0.93)
Total Coliform, MPN /100mL	< 2	≥ 2400	< 2	≥ 2400	< 2	≥ 2400
Faecal Coliform, MPN/100mL	< 2	≥ 2400	< 2	≥ 2400	< 2	≥ 2400
E. coli	Absent	Present	Absent	Present	Absent	Present

ND- Not Detected

sanitation, dumping of wastes nearby wells and unhygienic condition of surrounding area. The variation of different types of bacteria is represented in **Fig.3.**

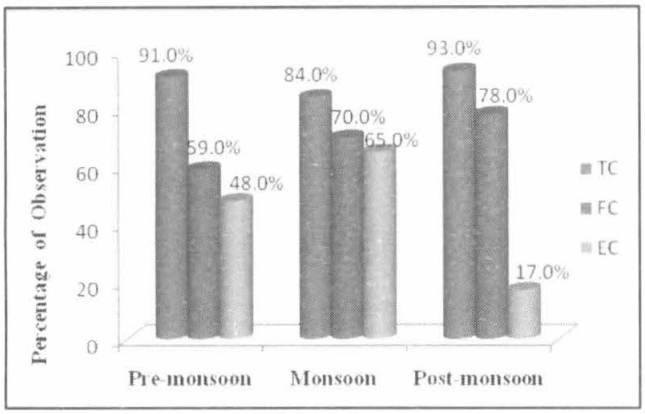

Fig. 3 : Seasonal variation of total coliforms & *E.coli*

Classification of water type

Groundwaters of the study area were classified based on the hydrogeochemical characteristics. Four types of groundwater were recognized in the study area **(Fig. 4)**. Study of groundwater chemistry revealed that calcium and bicarbonates were the major dominating cation and anion in all the water type. The hydrogeochemical composition of fresh groundwater unaffected by seawater intrusion was dominated by calcium and bicarbonate ions[7]. Two major hydrochemical water types observed in the study area are Ca-Na-Mg-Cl-HCO_3 and Ca-Na-Cl- HCO_3. The chemical properties of the water are dominated by alkaline earths and weak acids[7]. These water types represented 50% and 40% of groundwater samples respectively in the study area. Piper diagram of major ion concentrations of water samples in the Kunnamangalam Panchayat is represented by **Fig.5**.

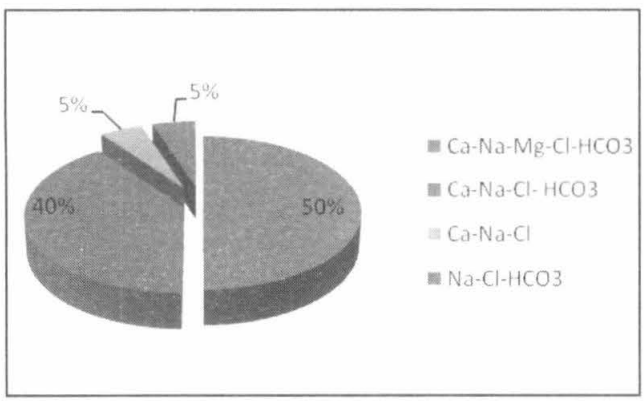

Fig. 4 : Classification of groundwater types during post-monsoon

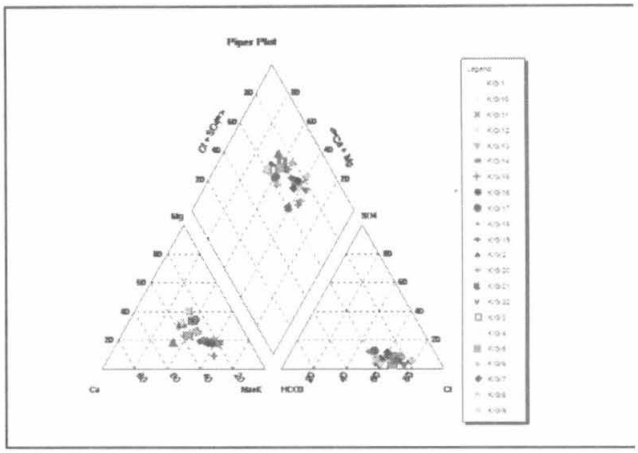

Fig. 5 : Piper diagram of groundwater during post-monsoo

Statistical analysis

The data were statistically analysed using SYSTA software in order to indicate the sufficiency of one variable t predict other. The correlation matrix for different groundwate quality variables for pre-monsoon, monsoon and post monsoon in Kunnamangalan Panchayath is shown in **Table** to **Table 4**. Examination of correlation among various wate quality parameters makes it possible to monitor the status o drinking water quality in an area. Correlation analysis measure the closeness of the relationship between chosen independen and dependent variables. Hence, correlation between differen parameters in specific environmental conditions is useful an when such correlation exists, determination of few parameter would suffice to give some idea about the quality of water i the area. If the correlation coefficient is nearer to +1 or -1 i shows the probability of excellent correlation between th variables. The systematic calculation of correlation coefficient between water qualities variables provides an indirect mean for rapid monitoring of water quality.

During pre-monsoon, total hardness, chloride calcium and magnesium exhibited a positive correlation witl TDS. Similarly total hardness showed significant correlatio with calcium, magnesium and potassium. A negativ correlation was found between pH and chloride. Durin monsoon all parameters were negatively correlated to pH.TD showed a positive correlation between total hardness an calcium. Chloride and sulphate showed a low positiv correlation with all other parameters. During post-monsoon i was observed that pH exhibited a negative correlation witl chloride and potassium. Calcium, magnesium and sodium ion were found to be negatively correlated to potassium. Tota hardness, calcium, magnesium, sodium and potassiun exhibited positive correlations with TDS.

Table 2 : Correlation coefficients between different physico-chemical parameters during pre-monsoon

Parameters	pH	TDS	TH	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
pH	1	0.447	0.728	0.337	-0.155	0.629	0.650	0.186	0.638
TDS		1	0.805	0.252	0.618	0.765	0.686	0.833	0.658
TH			1	0.270	0.192	0.876	0.844	0.501	0.848
$SO4^{2-}$				1	0.065	0.220	0.369	0.247	0.295
Cl^-					1	0.226	0.189	0.748	0.096
Ca^{2+}						1	0.775	0.462	0.788
Mg^{2+}							1	0.486	0.695
Na^+								1	0.381
K^+									1

Table 3 : Correlation coefficients between different physico-chemical parameters during monsoon

Parameters	pH	TDS	TH	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
pH	1	-0.068	-0.039	-0.038	-0.006	-0.002	-0.109	-0.033	-0.030
TDS		1	0.767	0.569	0.435	0.825	0.505	0.274	0.450
TH			1	0.314	0.187	0.851	0.477	0.190	0.344
$SO4^{2-}$				1	0.253	0.423	0.486	0.194	0.205
Cl^-					1	0.320	0.340	0.210	0.270
Ca^{2+}						1	0.503	0.150	0.391
Mg^{2+}							1	0.095	0.330
Na^+								1	-0.058
K^+									1

Table 4 : Correlation coefficients between different physico-chemical parameters during post-monsoon

Parameters	pH	TDS	TH	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
pH	1	0.913	0.651	0.394	-0.082	0.544	0.642	0.048	-0.0009
TDS		1	0.916	0.576	0.456	0.842	0.896	0.840	0.855
TH			1	0.550	0.291	0.931	0.928	0.391	0.840
$SO4^{2-}$				1	0.181	0.567	0.415	0.097	0.054
Cl^-					1	0.258	0.289	0.627	-0.015
Ca^{2+}						1	0.819	0.428	-0.021
Mg^{2+}							1	0.334	-0.013
Na^+								1	-0.186
K^+									1

Conclusions

The groundwater quality status of Kunnamangalam Grama Panchayat based on seasonal monitoring can be summarized as : All the eighteen water quality parameters selected for the study were found to be within the desirable limit when compared with Bureau of Indian Standards except pH. The analysis revealed that 93% of samples were acidic in nature in all the seasons. Bacteriological studies revealed that groundwater was not fit for drinking purposes due to high coliform bacteria, which require treatment before using for drinking purposes. An average of 90% of the samples was bacteriologically contaminated in all the seasons. Studies on groundwater chemistry using Piper diagram showed that calcium and bicarbonates were the major dominant cation and anion in all the water type.

The groundwater of Kunnamangalam can be mainly classified into Ca-Na-Mg-Cl-HCO_3, Ca-Na-Cl- HCO_3, Ca-Na-Cl and Na-Cl-HCO_3 types based on its hydrochemical characteristics. The groundwater samples exhibited a strong positive correlation of total dissolved solids with total hardness, chloride, calcium and magnesium. Similarly total hardness showed significant correlation with calcium, magnesium and potassium. A negative correlation was found between pH and chloride. The study indicated that pH and bacteriological contamination are the major threats to groundwater quality in Kunnamangalam Grama Panchayat .The improper sanitation and hygiene conditions existing in the area coupled with lack of protection of the drinking water sources lead to well contamination. Proper water safety measures shall be adopted to protect the drinking water sources.

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