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RESEARCH ARTICLE

Water Quality Index and Correlation Study for the Assessment of Water Quality and its Parameters of Yercaud Taluk, Salem District, Tamil Nadu, India

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Abstract: Groundwater samples of bore wells (BW), open wells (OW), Hand Pumps (HP), lakes, falls and streams collected from different locations in Yercaud Taluk in Salem District, Tamil Nadu were analyzed for their physicochemical characteristics. The ground water samples were studied during pre-monsoon (June-July 2010) and post-monsoon (December 2010-January 2011) seasons from 25 different villages. The present study was undertaken to characterize the physicochemical parameters such as temperature, pH, Total Alkalinity (TA), Electrical Conductivity (EC), salinity, Calcium Hardness (CH), Magnesium Hardness (MH), Total Hardness (TH), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Solids (TS) and fluoride. Each parameter was compared with its standard permissible limit as prescribed by World Health Organization (WHO). The Water Quality Index (WQI) reflected that most of the samples are of good and excellent quality. The Karl Pearson Correlation matrix has approved the influence of CH on EC, Salinity and TDS with significantly positive correlation. The study reveals that all the villages have hardness within the desirable limit prescribed by WHO.

Keywords: Dental fluorosis, Physicochemical parameters, Water Quality Index, Karl-Pearson Correlation, Salem, Yercaud

Introduction

Groundwater is generally recognized to be good for human consumption and is used as a potential source of drinking water. Agricultural development, urbanization and industrialization are the major causes for all changes in the quality of water[1]. In order to meet the rising water needs, evaluation of water quality is important for allocation to various uses. Only during the last three decades of the twentieth century, the concern for water quality has been exceedingly felt so that, water quality has now acquired as much importance as water quantity[2]. According to WHO[3], about 80% of all the diseases in human beings are caused by contaminated water. Once the groundwater is polluted, its quality cannot be renovated by stopping the pollutants from the source. It is therefore vital to regularly monitor the quality of groundwater. Groundwater pollution by heavy metals has

been given much attention due to their low biodegradability and toxic effects[4,5]. The water from the sources *viz.*, streams, falls, lake, hand pump, open well and bore well are contaminated with domestic, agricultural and industrial wastes and likely to cause water related diseases[6]. Similarly, Bullard[7] inferred that polluted surface water always results in an unhealthy socio-economic environment. In this study, physicochemical parameters are determined to draw a conclusion on the quality of water whether it is good or unfit for drinking purpose.

Statistical analysis of physicochemical parameters of water has been reported from the different parts of World and India[8-12]. C. R. Ramakrishnaiah *et al*.[13], have assessed the Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India. Linear correlation analysis study of drinking water quality data for Al-Mukalla city, Hadhramout, Yemen was carried out by Sami G. Daraigan *et al*.,[14] and from this study they showed that all the physicochemical parameters of drinking water in Mukalla city are more or less correlated with each other. Papita Das Saha *et al*.,[15] have assessed the water quality characteristics of River Ganga at Kolkata Region, India using water quality index and ANN simulation method[15]. Dadolahi - Sohrab *et al.*[16]. have studied the Water quality index as a simple indicator of watersheds pollution in southwestern part of Iran and from this study it is revealed that quality declined significantly during the dry season. So, an attempt is made to study the physicochemical parameters of water samples taken from Yercaud Taluk in Salem, Tamil Nadu, India.

The main objectives of the study are

- Collection of ground water samples from open wells, bore wells, hand pumps, streams, falls and lakes -Yercaud Taluk, Salem District, Tamil Nadu.
- Analysis of a few quality parameters *viz*., pH, Total alkalinity, Electrical conductivity, Total solids, Hardness, Fluoride *etc*., as recommended by World Health Organization.
- To establish the nature of the relationship between the water quality parameters using correlation analysis.
- Assessment of the water quality using water quality index (WQI).

Salient features of the study area

Salem District in Tamil Nadu, India is geographically situated between the North latitudes 11°14´ to 12°53´ and East longitudes 77 °44´ to 78° 50´ covering an area about 7905.38 square kilometers. On the Northern side, it is bounded by Dharmapuri District; on the Western side, it is bounded by Erode District; on the Eastern side, it is bounded by Viluppuram District and on the Southern side, it is bounded by Namakkal and Tiruchirappalli Districts. Salem District consists of nine Taluks *viz*., Attur, Edappadi, Gengavalli, Mettur, Omalur, Salem, Sangagiri and Yercaud. The present study area (Yercaud Taluk) is one of the nine taluks in Salem District.

Yercaud is a hill station situated in Salem District, Tamil Nadu. It is located in the Shervaroys range of hills in Eastern Ghats. The total extent of Yercaud Taluk is 382.67 km^2, including reserve forest. It is situated at an altitude of 1515 meters (4970 ft) above the sea level. The yercaud range consists of achaean plutonic rocks of charnockite series and these have weathered into the rugged masses of hills. It is so named owing to the large quantity of trees categorized as a forest near the lake, the name signifying lake forest. A popular tourist destination, Yercaud is also called Jewel of the South. The climate of Yercaud is moderate and pleasant. There is neither a sharp winter nor a roasting summer. Winters are fairly mild, starting in September and ending in December. During winter, the hills are covered in mist. Winters range from 12 °C to 25 °C and summers from 16 °C to 30 °C. Rainfall is 1500–2000 nm.

The coffee bushes blossom in April and offer a spectacular view. Coffee and citrus fruits, most notably oranges, are grown in abundance, as well as bananas, pears and jackfruit. Spices such as black pepper and cardamom are other crops raised on the coffee estate. Sandal wood, teak and silver oak are rich in this area. It also has an orchidarium run by the Botanical Survey of India. Wild life includes bison, deer, rabbits, hares, foxes, mongoose, squirrels, partridges, snakes, bulbuls, kites, sparrows, swallows and the bird of paradise. The nearest city is Salem, 36 km away from Yercaud. It is 355 km from Chennai and 195 km from Coimbatore. The nearest airports are Salem Airport at 38 km, Tiruchirappalli at 165 km and Coimbatore at 195 km. The entire Taluk is a Township. Yercaud has population approximately 40,000 people during the 2001 census period[17].

Experimental

The water samples were collected from bore wells (BW), open wells (OW), Hand Pumps (HP), lakes, falls and streams of Yercaud Taluk in Salem District, Tamil Nadu during pre-monsoon (June-July 2010) and post-monsoon (December 2010-January 2011) periods. Of the total 25 water samples, 4 were from bore wells, 5 were from hand pumps, 7 were from open wells, 5 were from falls, 2 were from streams and 2 were from lakes. The samples were collected in sterilized bottles and were analyzed just after the sampling. The analysis was carried out[18] for various physicochemical parameters such as temperature, pH, Electrical conductivity (EC), Total alkalinity (TA), Salinity (SAL), Calcium hardness (CH), Magnesium hardness (MH), Total hardness (TH), Total dissolved solids(TDS), Total suspended solids (TSS), Total solids (TS) and Fluoride content.

Methodology

The temperature of water samples was recorded on the spot using thermometer. pH meter (Systronics digital model 335) was used to determine the hydrogen ion concentration. The samples were analyzed for EC using conductivity meter. Total alkalinity (TA) was estimated by neutralizing with standard HCl acid. Salinity and total dissolved solids (TDS) were estimated using systronics water analyzer. Total hardness (TH) and calcium hardness (CH) as $CaCO_3$ were determined titrimetrically, using standard EDTA. The calculation of magnesium hardness (MH) was done by subtracting the CH from TH value. The fluoride was estimated by SPANDS [2-(*p*-sulphophenylazo) 1,8-dihydroxy-naphthalene - 3,6 - disulphonic acid tri sodium salt), $C_{16}H_9N_2O_{11}S_3Na_3$] colorimetric method[18].

Statistical analysis

Statistical analysis was carried out using statistical package for social sciences (SPSS-Version 13). Statistical parameters *viz*., mean, SD, SE and correlation coefficient for physicochemical parameters. The mean and standard deviations are calculated to know the chemical parameters which are deviating from WHO standard. Correlation analysis measures the closeness of the relationship between chosen variables. If the correlation coefficient is nearer to +1 or –1, it shows the perfect linear relationship between the two variables. This way analysis attempts to establish the nature of the relationship between the water quality parameters.

Water quality index (WQI)

Water quality index[19] expresses overall water quality based on several water quality parameters. Water Quality Index is computed by the following formula

WQI = Antilog [$SW^{n}_{n=1}$ log $_{10}q_n$], where, W_n, Weightage = K/S_n and K, constant = $1/ (S^{n}_{n=1} 1 /S_i)$, S_n and S_i correspond to the WHO / ICMR standard value of the parameters. Quality rating (q) is calculated as $Q_{ni}= [(V_{actual} – V_{ideal}) / (V_{standard} - V_{ideal})] \times 100$, where q_{ni} = quality rating of i^{th} parameter for a total of n water samples, V_{actual} = value of the water quality parameter obtained from the laboratory analysis, $V_{standard}$ = value of the water quality parameter obtained from the standard tables. V_{ideal} for pH =7 and for the other parameters it is equivalent to zero.

Results and Discussion

Season-wise chemical compositions of 12 water samples of Yercaud Taluk, Salem District in the pre-monsoon and post-monsoon seasons are presented in Table 1 and Table 2. Statistical summary of water samples in pre-monsoon and post-monsoon of Yercaud Taluk in Salem District, Tamil Nadu is shown in Table 3.

Table 1. Physicochemical parameters of water samples of Yercaud Taluk in the pre – monsoon season

Place	Source	Temp °C	pH	EC mS	TA mg/L	Salinity mg/L	CH mg/L	MH mg/L	TH mg/L	TDS mg/L	TSS mg/L	TS mg/L	F mg/L
Arasamarathur	HP	32	7.34	0.912	222.5	249.9	160.1	48.7	208.8	267.6	40.7	308.3	0.82
ChinnaMathur	BW	36	7.46	1.162	376.4	201.7	141.7	78.6	220.3	265.5	81.2	346.7	1.66
Karadiyur	OW	30	7.46	0.81	227.8	269.9	170	38.6	208.6	288.4	97.3	385.7	0.82
Killiyur1	OW	30	7.3	0.682	150	180.3	112.2	56.7	168.9	202.6	96	298.6	0.76
Killiyur2	Lake	26	7.2	0.676	182.5	198.2	116.4	19.4	135.8	221.3	79.7	301	0.83
Kondayannur	OW	34	7.56	1.261	357.2	296.8	198.8	60.6	259.4	341.6	87.1	428.7	0.72
Mathur1	OW	31	7.32	0.576	178.2	176.5	106	60	166	195	90.7	285.7	0.96
Mattur2	HP	36	7.61	0.717	223.5	290.3	191.3	78.1	269.4	321	60.7	381.7	1.15
Mundagambadi	OW	30	7.09	0.653	271	175.5	106.2	46.7	152.9	210.6	151.8	362.4	0.89
Mundagapadi	Falls	24	7.3	0.41	190.1	179.3	67.9	77.6	145.5	190.7	48.3	239	0.36
Mundagkadu	BW	35	7.27	1.47	380	357.9	207.2	78	285.2	400.3	80.4	480.7	1.68
Nagalur	Stream	29	7.2	0.396	207.5	109.3	55.2	30.7	85.9	160.3	65.3	225.6	0.34
Narthansedu	HP	33	7.16	0.926	270	267.4	168.8	59.7	228.5	304.1	51.8	355.9	1.07
Periyakadu1	Stream	28	7.12	0.631	227.5	161.7	55.8	39.6	95.4	178.6	80.6	259.2	0.76
Periyakadu2	Falls	26	7.16	0.407	172.9	131.6	38.8	42.5	81.3	156.7	47.2	203.9	0.42
Puthur	OW	30	7.24	0.65	185.8	160.7	79.9	60.5	140.4	178.6	80.1	258.7	0.35
Seenapadi	BW	35	6.79	1.01	309	181.4	118.1	49.8	167.9	207.7	60.9	268.6	0.98
Sollampadi	HP	34	7.6	0.857	246.5	289.9	175.6	68.3	243.9	335.5	59.3	394.8	1.12
Suraikaipatti	OW	29	7.35	0.715	217	220.5	119	49.8	168.8	241.6	65.6	307.2	0.25
Yercard1	Falls	26	7.2	0.351	160.3	160.6	96.7	48.8	145.5	175.1	106.3	281.4	0.18
Yercard2	Falls	23	7.3	0.41	143	82.1	67.3	19.7	87	106.1	39.9	146	0.25
Yercard3	Falls	22	7.19	0.452	158	103.4	57.8	37.8	95.6	131.5	42.4	173.9	0.26
Yercard4	Lake	25	7.3	0.723	238	208.4	147.1	57.5	204.6	246.7	81.8	328.5	0.42
Yercarud5	BW	34	7.19	1.416	406.1	368.8	171.6	69.9	241.5	419.7	71.3	491	1.52
Yercarud6	HP	32	7.45	1.302	340	307.2	180	50.8	230.8	366	75	441	0.82

Table 2. Physicochemical parameters of water samples of Yercaud Taluk in the post-monsoon season

Place	Source	Temp˚C	pH	EC mS	TA mg/L	Salinity mg/L	CH mg/L	MH mg/L	TH mg/L	TDS mg/L	TSS mg/L	TS mg/L	F mg/L
Arasamarathur	HP	29	7.07	0.826	215.8	241.8	215.9	42.3	258.2	275.3	32.4	307.7	0.76
ChinnaMathur	BW	32	7.15	1.058	369.5	280.1	135.5	72.9	208.4	340.6	75.8	416.4	1.59
Karadiyur	OW	26	7.22	0.752	220.4	231.6	161.2	35.8	197.0	392.2	95.5	487.7	0.75
Killiyur1	OW	25	7.12	0.589	141.8	172.3	102.2	30.7	132.9	210.1	90.6	300.7	0.69
Killiyur2	Lake	21	6.91	0.502	178.5	190.5	103.8	16.0	119.8	232.2	70.6	302.8	0.76
Kondayannur	OW	30	7.23	1.152	345.2	290.1	196.5	58.7	255.2	345.9	84.6	430.5	0.69
Mathur1	OW	27	7.09	0.515	171.6	171.2	100.4	33.8	134.2	205.2	85.9	291.1	0.91
Mattur2	HP	32	7.38	0.628	215.5	182.9	183.5	71.5	255.0	326.3	55.6	381.9	0.98
Mundagambadi	OW	28	6.97	0.593	265.7	169.6	99.3	41.1	140.4	215.4	148.2	363.6	0.78
Mundagapadi	Falls	22	7.06	0.356	185.8	171.5	60.5	69.3	129.8	198.8	40.2	239.0	0.25
Mundagkadu	BW	31	7.13	1.266	347.5	350.5	200.6	71.8	272.4	410.8	78.5	489.3	1.42
Nagalur	Stream	25	7.02	0.369	200.2	148.4	49.9	22.8	72.7	198.7	62.5	261.2	0.29
Narthansedu	HP	29	6.89	0.852	262.8	261.5	160.3	51.2	211.5	310.6	48.8	359.4	0.99
Periyakadu1	Stream	23	6.89	0.588	219.6	155.3	49.0	33.9	82.9	284.2	72.5	356.7	0.69
Periyakadu2	Falls	21	6.78	0.362	168.5	183.5	33.5	35.6	69.1	262.9	42.3	305.2	0.35
Puthur	OW	26	6.98	0.512	179.5	152.6	71.4	51.6	123.0	185.6	72.4	258.0	0.28
Seenapadi	BW	30	6.58	0.943	298.6	263.3	108.7	40.9	149.6	311.8	55.6	367.4	0.88
Sollampadi	HP	29	7.28	0.721	218.7	211.7	169.6	62.5	232.1	339.9	56.2	396.1	1.07
Suraikaipatti	OW	25	7.13	0.656	205.6	203.7	100.3	42.4	142.7	245.4	63.2	308.6	0.19
Yercard1	Falls	21	7.02	0.222	151.4	153.4	91.8	45.6	137.4	182.9	98.7	281.6	0.15
Yercard2	Falls	19	7.02	0.355	138.8	178.5	62.6	15.5	78.1	215.8	35.4	251.2	0.22
Yercard3	Falls	18	7.01	0.324	145.9	165.8	51.2	33.1	84.3	235.7	40.5	276.2	0.21
Yercard4	Lake	21	7.15	0.628	232.2	200.2	142.5	32.7	175.2	258.5	80.3	338.8	0.39
Yercarud5	BW	30	6.98	1.372	400.3	359.8	165.8	62.5	228.3	422.6	69.7	492.3	1.48
Yercarud6	HP	28	7.12	1.285	332.5	350.9	172.6	43.6	216.2	421.5	73.8	495.3	0.75

The temperature mean values of Yercaud Taluk water samples were 30 °C and 26 °C in the pre-monsoon and post-monsoon seasons respectively. It is obvious that the samples collected from bore wells were found to have higher temperature than hand pumps, open wells, lakes and falls. The increase in temperature decreases the potability of water due to the unpleasant taste produced by CO_2 and other gases. Thus, the taste of sample differs from place to place[20]. The pH mean values of the water samples in the pre-monsoon and post-monsoon seasons were 7.29 and 7.05 respectively. This approves that the nature of ground water samples vary from slightly acidic to slightly alkaline. All the samples were registered with the pH values between 6.5 and 8.5 as per WHO. EC value is an index to represent the total concentration of soluble salts in water. The mean total alkalinity (TA) of the water samples of Yercaud area was 241.6 mg/L in the pre-monsoon season and 232.5 mg/L in the post-monsoon season. The salinity values of water samples ranged from 82.1 mg/L to 368.8 mg/L and 148.4 to 359.8 mg/L in the pre-monsoon and post-monsoon seasons respectively. The samples were registered with higher TA and salinity values than the values recommended by WHO (TA=200 mg/L). The impact of rainfall at the sampling stations has influenced marginal changes with respect to carbonate and bicarbonate ions. The same trend has been reported in Ramanathapuram District also[21].

In the pre-monsoon and post-monsoon seasons, Ca^{2+} was observed with the mean values of 124.4 mg/L and 131.8 mg/L respectively. The Mg^{2+} mean values of the water samples in the pre-monsoon and post-monsoon seasons were 53.1 mg/L and 44.7 mg/L respectively. The Ca^{2+} and Mg^{2+} concentrations slightly decreased during post-monsoon (except Arasamarathur) when compared to the pre-monsoon. The presence of CH and MH in all water samples is more than the recommended limit of WHO (CH= 75 mg/L; MH=30 mg/L). The total hardness of the water samples varied between 81.3 mg/L and 285.2 mg/L in pre-monsoon and between 72.7 mg/L and 272.4 mg/L in post-monsoon.

Most of the ground water samples of Yercaud Taluk were found to be hard (100-300 mg/L) as suggested by Sawyer and Mc Carty(1967)[22]. The ground water samples were observed with the 36% and 44% of moderately hard nature in the pre-monsoon season and 64% and 52% of hard nature in the post-monsoon season. The hard nature was converted to soft nature in the study area Nagalur (85.9 mg/L to 72.7 mg/L) thus revealed the change in the quality of soil when the water table gets raised in the post-monsoon season.

The TDS values of water samples were found within the desirable limit of WHO (*i.e.*) 500 mg/L. The total ground water samples of study area were registered with 100% belonging to fresh type (TDS<1000 mg/L) in both pre-monsoon and post-monsoon seasons as per TDS classification given by Fetter[23].

The fluoride content of the samples varied from 0.2 mg/L to 1.7 mg/L and 0.15 mg/L to 1.6 mg/L in the pre-monsoon and post-monsoon respectively. Three *viz*., Chinna Mathur (BW), Mundagkadu (BW) and Yercaud 5 (BW) out of 25 samples in the pre-monsoon season and one (Chinna Mathur) out of 25 samples in the post-monsoon season have exceeded the permissible limit of 1.5 mg/L (WHO). As reported earlier[24], the dissolution of fluoride bearing minerals may be contributing the high percentage of fluoride in water samples. In this attempt, the suitable conditions for the dissolution of CaF_2 in the potable water are slightly alkaline pH and moderate EC and being approved by the positive correlation value of F-CH (r=0.6663 in pre-monsoon; r = 0.5590 in post-monsoon). 9 samples out of 25, both in pre-monsoon season and post-monsoon season were observed with fluoride lesser than 0.5, the desirable limit of WHO. The comparison of fluoride concentration for Yercaud Taluk in pre-monsoon & post-monsoon seasons reveals that, in general, fluoride ion concentration decreases in post-monsoon as compared to pre-monsoon due to increase in water table. Especially higher concentrations of fluoride were observed in bore well and hand pump water[25]. It was found that the bore well and hand pump water samples (4 bore well water samples and 5 hand pump water samples) contain more fluoride than the open well, lake, falls and stream samples. This is due to the increase in depth, the temperature increases and hence more fluoride gets dissolved from rocks.

The Karl pearson correlation matrix calculated for the water quality parameters is displayed in Table 4 and Table 5. The parameters, highly interrelated with each other, are EC – Salinity: 0.8442; EC-TDS: 0.8799 and Salinity-TDS: 0.9876. The values account for greater percentage of TDS. In pre-monsoon season and post-monsoon season, the influence of CH on EC, Salinity and TDS were also observed with significantly positive correlation. The correlation of fluoride with calcium in pre-monsoon has been found with higher positive r value (0.6663) than in post-monsoon (0.5590). The parameters F-EC; F-Salinity and F-TDS were positively correlated. In both the seasons, pre-monsoon and post-monsoon, the values indicate the association of calcium with bicarbonate, carbonate and fluoride.

Table 3. Statistical summary of physicochemical parameters

Parameters	Pre-monsoon							Post-monsoon						
	Max.	Min.	Mean	Sum	SD	σ^2	CV	Max.	Min.	Mean	Sum	SD	σ^2	CV
pH	7.61	6.79	7.286	182.2	0.1782	0.0317	2.445	7.38	6.58	7.047	176.18	0.1649	0.0272	2.3401
EC	1.47	0.351	0.783	19.6	0.3297	0.1087	42.111	1.372	0.222	0.697	17.426	0.3251	0.1057	46.6350
TA	406.1	143.0	241.6	6040.8	78.0601	6093.38	32.305	400.3	138.8	232.5	5811.9	76.0684	5786.394	32.7210
Salinity	368.8	82.1	213.2	5329.3	76.8163	5900.75	36.035	359.8	148.4	217.6	5440.7	65.5448	4296.122	30.1178
CH	207.2	38.8	124.4	3109.5	50.9724	2598.19	40.981	219.03	49.9	131.8	3293.9	52.9447	2803.137	40.1838
MH	78.6	19.4	53.1	1328.4	17.2796	298.583	32.519	72.9	15.5	44.7	1117.8	16.8832	285.0428	37.7599
TH	285.2	81.3	177.5	4437.9	80.416	6466.733	45.3001	272.4	72.7	176.5	4411.7	61.4043	3770.487	34.7963
TDS	419.7	106.1	244.5	6112.8	84.1937	7088.576	34.433	422.6	182.9	281.2	7028.9	76.9938	5928.049	27.3847
TSS	151.8	39.9	73.7	1841.4	24.7474	612.4342	33.599	148.2	32.4	69.2	1729.8	24.9964	624.8191	36.1261
TS	491.0	146.0	318.2	7954.2	89.7876	8061.817	28.220	495.3	239.0	350.3	8758.7	80.8026	6529.053	23.0635
F	1.7	0.2	0.8	19.4	0.4364	0.19044	56.266	1.6	0.15	0.7	17.5	0.4139	0.1713	59.0673

Max. Maximum, Min. Minimum, SD Standard Deviation, σ^2 Square of standard deviation, CV coefficient of variance

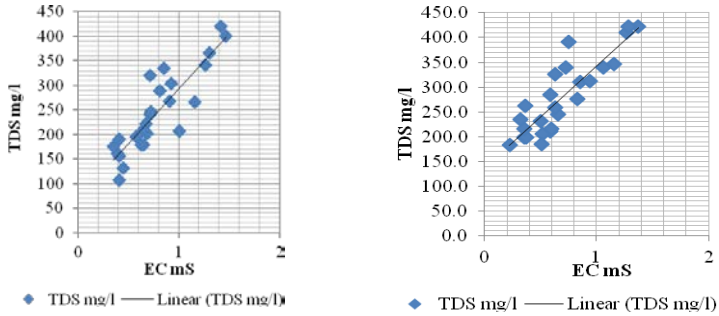
Table 4. Karl pearson correlation matrix for water samples of Yercaud Taluk, Salem District during pre-monsoon season

Parameters	pH	EC	TA	Salinity	CH	MH	TH	TDS	TSS	TS	Fluoride
pH	1										
EC	0.2019	1.0000									
TA	0.0964	0.9209	1.0000								
Salinity	0.4239	0.8442	0.7350	1.0000							
CH	0.5166	0.8102	0.6756	0.9163	1.0000						
MH	0.3627	0.4871	0.5119	0.5844	0.5190	1.0000					
TH	0.5281	0.8059	0.7010	0.9206	0.9720	0.7052	1.0000				
TDS	0.4347	0.8799	0.7991	0.9876	0.9172	0.5849	0.9215	1.0000			
TSS	-0.0504	0.8481	0.1608	0.0846	0.1272	0.0398	0.1164	0.0866	1.0000		
TS	0.3937	0.8481	0.7937	0.9494	0.8951	0.5595	0.8962	0.9616	0.3568	1.0000	
F	0.1572	0.7704	0.7491	0.6958	0.6663	0.5616	0.7069	0.7277	0.1529	0.7245	1.0000

Table 5. Karl pearson correlation matrix for water samples of Yercaud Taluk, Salem District during post-monsoon season

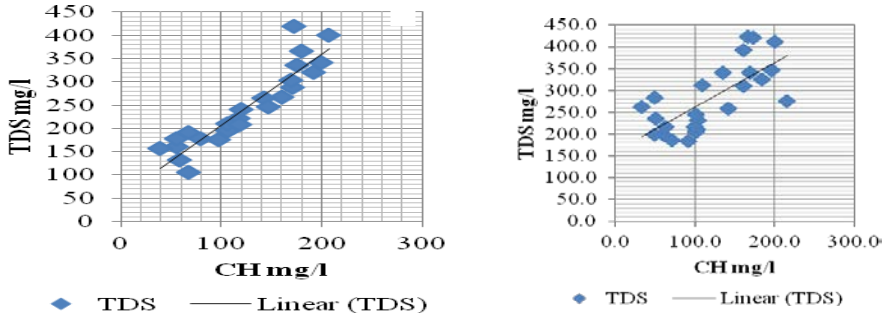
Parameters	pH	EC	TA	Salinity	CH	MH	TH	TDS	TSS	TS	Fluoride
pH	1										
EC	0.2188	1.0000									
TA	0.0987	0.9240	1.0000								
Salinity	0.2036	0.9523	0.8776	1.0000							
CH	0.2611	0.6221	0.5168	0.5518	1.0000						
MH	0.4377	0.5103	0.5787	0.4740	0.3817	1.0000					
TH	0.2994	0.6767	0.6047	0.6061	0.9672	0.6040	1.0000				
TDS	0.1449	0.8722	0.7928	0.8763	0.7187	0.4883	0.7539	1.0000			
TSS	0.0886	0.1158	0.2088	-0.0129	-0.0056	-0.0079	-0.0070	-0.0062	1.0000		
TS	0.2776	0.8669	0.8201	0.8310	0.6831	0.4629	0.7162	0.9509	0.3035	1.0000	
F	0.1788	0.7583	0.7425	0.6842	0.5590	0.5440	0.6315	0.7105	0.1706	0.7298	1.0000

From Figure 1, it is found that WQI for 25 samples ranges from 7.61 to 90.18. WQI has been registered about 32% and 48% under the excellent category (WQI < 25) and 40% and 36% under good category (WQI = 25-50). About 20% and 16% of water samples are poor in quality (WQI=51-75) during pre-monsoon and post-monsoon seasons. 8% of water samples are very poor during pre-monsoon season.



(a) Pre-monsoon period (b) Post-monsoon period

Figure 1(a) & (b). Scatter diagrams sho ing correlation between EC and TDS during pre- and post-monsoon seasons



(a) Pre-monsoon period (b) Post-monsoon period

Figure 2(a) & (b). Scatter diagrams showing correlation for CH and TDS during pre- and post-monsoon seasons

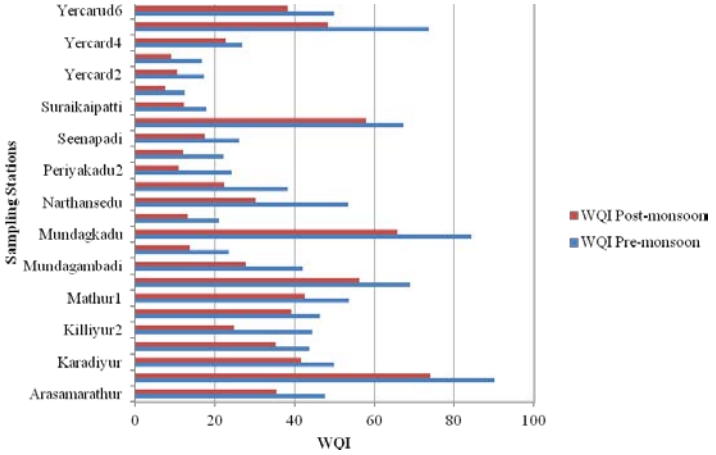


Figure 3. WQI for water samples of Yercaud Taluk in Salem District

Conclusion

The present study was confined to Yercaud Taluk. The pH of water samples vary from slightly acidic to slightly alkaline. The influence of rain fall on the carbonate and bicarbonate ions of water samples was observed. The water samples were found to be moderately hard (36% in pre-monsoon and 44% in post-monsoon) and hard nature (64% in pre-monsoon and 52% in post-monsoon). The study reveals that all the villages have hardness within the desirable limit prescribed by WHO. The TDS values of total water samples of study area have been registered with 100% belonging to fresh type in both pre-monsoon and post-monsoon seasons. In the areas where the fluoride content of water is more than the permissible limit of 1.5 mg/L (WHO) defluoridation has to be done and supplied to the children and public. The rate of accumulation of fluoride in the human body can be reduced by calcium and phosphorous rich food[26]. The children and people those, who were affected by dental fluorosis, are to be recommended to take nutritional diet. As an essential nutrient in drinking water, Fluoride promotes dental health if it is between 0.5 – 1.5 mg/L. But when it exceeds 1.5 mg/L, it causes dental fluorosis. In the areas where the fluoride content of water is lower than the desirable limit of 0.5 mg/L (WHO) fluoridation has to be done and supplied to the children and public. It was found that the bore well and hand pump water samples (4 bore well water samples and 5 hand pump water samples) contain more fluoride than the open well, lake, falls and stream samples. From the Karl-Pearson correlation matrix, good correlation is observed between the parameters EC and Salinity, TDS, TSS, TS and also between CH and TH, TDS. The poor correlation is observed for TSS and other parameters except EC in pre-monsoon season. WQI has been registered about 32% and 48% under the excellent category (WQI < 25) and 40% and 36% under good category (WQI = 25-50). About 20% and 16% of water samples are poor in quality (WQI=51-75) during pre-monsoon and post-monsoon seasons. 8% of water samples are very poor during pre-monsoon season.

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References

1. Papatheodorou G, *et al*., *Ecological Modelling,* 2006, **193,** 759–776.
2. Abbasi S A, Water quality Indices state-of-the art, center for pollution control and energy technology, Pondichery University, 1999.
3. World Health Organization, Guidelines for drinking water quality, 3rd Edn., WHO, Geneva, 2006.
4. Kaplay R D and Patode H S, *India Environ Geol*., 2004, **46**, 871–882.
5. Rima Chatterjee, Gourab Tarafder and Suman Paul, *Bull Eng Geol Environ*., 2010, **69**, 137-141.
6. Ayeni A O, Balogun I I and Soneye A S O, *Res J Environ Sci.*, 2011, **5(1),** 21-33, DOI:10.3923/rjes.2011. 21.23.
7. Bullard W E, Effects of Land use on Water Resources in the Ecology of Man: An Ecosystem Approach, Smith R L, (Ed)., New York, Harper and Row Publisher, 1972.
8. Dewangan S, Vaishnav M M and Chandrakar P L and Korba C G, *Rasayan J Chem.*, 2010, **3(4),** 710-720.

9. Dhirendra Mohan Joshi, Narendra Singh Bhandari, Alok Kumar and Namita Agrawal, *Rasayan J Chem*., 2009, **2(3)**, 579-587.
10. Navneet Kumar and Sinha D K, *Int J Environ Sci.*, 2010, **1(2),** 253-259.
11. Suhaimi – Othaman M, Ahmad A, Mushrifah I and Lim E C, Seasonal influence on water quality and heavy metal concentration in Tasik Chini, Peninsular Malaysia, Proceedings of Taal 2007: The 12th World Lake Conference, 2007, 300-303.
12. Vassilis Z Antonopoulos, Dimitris M Papamichail and Konstantina A Mitsiou, *Hydrology and Earth System Sciences*, 2001, **5(4),** 679-691.
13. Ramakrishnaiah C R, Sadashivaiah C and Ranganna G, *E-J Chem.*, 2009, **6(2)**, 523-530.
14. Sami G Daraigan, Ahmed S Wahdain, Ahmed S Ba-Mosa and Manal H Obid, *Int J Environ Sci.*, 2011, **1(7)**, 1692- 1701.
15. Papita Das Saha, Sengupta R, Jhuma Saha and Banerjee P K, *Arch Environ Sci*., 2012, **6**, 34- 41.
16. Dadolahi-Sohrab A, Arjomand F and Fadaei-Nasab M, 2012, DOI: 10.1111/j. 1747-6593.2011.00303.x
17. www.yercaudindia.com
18. APHA, Standard methods for the examination of water and wastewater, Washington, D C, American Public Health Association, 1998.
19. Tiwari T N and Mishra M, *Indian J Environ Protect.*, 1985, **5(4)**, 276-279.
20. Karunakaran K, Thamilarasu P and Sharmila R, *E-J Chem*., 2009, **6(3)**, 909-914.
21. Sivasankar V and Ramachandramoorthy T, *Environ Monit Assess.*, 2009, **156**, 307-315. DOI:10.1007/s10661-008-0486-0.
22. Sawyer C N and McCarty P I, Chemistry for Sanitary Engineers (2nd Ed.), New York, McGraw Hill, 1967.
23. Fetter C W, Applied hydrology, New Delhi, CBS, 1990.
24. Ramachandramoorthy T, Sivasankar V and Gomathi R, Fluoride and other Parametric Status of Ground water Samples at various locations of the Kolli Hills, Tamil Nadu, *Indian J IPHE*, 2010, **3**.
25. Medikondu Kishore and Hanumantharao Y, *Rasayan J Chem.*, 2010, **3(2),** 341-346.
26. Janardhana Raju N, Sangita Dey and Kaushik Das, *Current Science*, 2009, **96(7)**, 979-985.