DENDROGRAM STUDIES OF WATER QUALITY PARAMETERS OF WATER SAMPLES FROM POZHIKKARAI TO MANAVALAKKURICHI IN KANYAKUMARI DISTRICT

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ABSTRACT

A methodical study has been carried out to explore physico-chemical parameters of drinking water from well and bore hole in and around the villages from Pozhikkarai to Manavalakurichi of Kanyakumari District. Water samples from well and bore hole in four sites namely Pozhikkarai, Periyakadu, Muttom, Manavalakurichi were collected in pre monsoon and post monsoon seasons during 2019 ad 2020 and analyzed for temperature, pH, turbidity, alkalinity, hardness, salinity, fluoride, chloride, total dissolved solids, dissolved oxygen, BOD, electrical conductivity, total nitrogen, nitrate, sulphate, ammonia, phosphate, total phosphorus, sodium, potassium and oxidation & reduction potential. The physico-chemical parameters were analyzed and the results were compared with water quality standards described by WHO. Statistical techniques, calculation of basic statistics, Correlation matrix, Hierarchical Cluster analysis were simultaneously applied to the physico-chemical parameters of water samples taken from in different sites. The above study will be useful

to know the water quality and their fitness for drinking purposes at various stations undertaken. Overall water quality was found satisfactory for drinking purpose without prior treatment.

Key Words:

Bore hole, Shallow well, Pozhikarai, Periyakadu, Muttom, Manavalakurichi, physic-chemical parameters, basic statistics, Correlation matrix, Dendrogram .

INTRODUCTION

Surface waters are primary and limited water resources to meet agricultural industrial and domestic water needs of human and living beings. Drinking water or potable water is defined as that having acceptable quality in terms of its physical, chemical, bacteriological and acceptability parameters so that it can be safely used for drinking and cooking[1]. Polluted waters contain significant levels of pollutants, usually at levels above WHO certified drinking water quality standards and these are able to cause significant problems when ingested by humans[2]. The natural cleansing ability of oxygen contained in the water is compromised and the water can no longer breakdown organic pollutants[3]. According to Buchholz[3], point sources are those that come from industrial facilities and municipal sewage systems. Thus, they can be said to be pollution that can be traced to a particular source. Cairncross and Cliff[4] have shown that soakage pits and pit latrines can extend their influence on ground-water quality up to 10m or more as groundwater flow is either lateral or vertical. Additionally, filtration does not occur during lateral flow and could carry feacal pollution for much longer distances possibly resulting in contamination of well water with pathogens[5,6]. Pye and Patric[7] have shown that land disposal of sewage sludge, illegal dumping of septic tank pumpage, improper toxic waste disposal and run off from agricultural operations all contributed to surface and ground water contamination with chemicals and microorganisms.

MATERIAL AND METHODS
Physico-Chemical Analysis

Samples collected from all the stations were analyzed for physico-chemical analysis using standard methods[8]. The following physico-chemical parameters such as temperature, pH, turbidity, alkalinity, hardness, salinity, fluoride, chloride, total dissolved solids, dissolved oxygen, BOD, electrical conductivity, total nitrogen, nitrate, sulphate, ammonia, phosphate, total phosphorus, sodium, potassium and oxidation & reduction potential have been analyzed. The temperature of the water samples was measured by mercury thermometer. The pH measurement of the water samples was carried out using digital pH meter (Elico pH-13 model). A conductivity meter was used to measure EC. Volumetric method using sulfuric acid as titrant and phenolphthalein and methyl orange as indicators was used to determine alkalinity. EDTA (complexometric)

method was used to determine calcium, magnesium and total hardness titrenetrically. Flame photometer was used to identify sodium and potassium. Mohr's method was used to measure chloride by titration with silver nitrate. UV-Vis Spectrophotometer was used to analyze nitrate. Salinity was estimated by Argentometric titration method. The dissolved oxygen was estimated by Winkers method. The findings of the present investigation were summarized and compared with standards [9,10].

Statistical Analysis

The correlation between various physic-chemical parameters of water samples analyzed statistically conducting basic statistics (mean, standard deviation (SD), median, minimum, maximum, variance (V), Kurtosis (K), Skewness (S), Hierarchical cluster analysis, Pearson correlation analysis with the help of SPSS (Statistics Package for the Social Sciences) software (Windows version 19).

Descriptive statistics in the forms of mean, SD, median, minimum, maximum, variance (V), Kurtosis (K), Skewness(S), standard error of kurtosis (SEK), standard error of skewness (SES) were calculated and summarized in Tabular forms in Tables 2, 5, for well water and Table 8, 11 for bore hole water samples respectively.

Dendrogram studies

Cluster analysis (CA) [11,12] was used for multivariate modeling of the input data. The main goal of the Hierarchical Agglomerative cluster analysis to spontaneously classify data into groups of similarity (cluster) searching objects in the n-dimensional space located in closest neighbourhood and to separate a stable cluster from other clusters. In figure 1 to 8, the hierarchical dendrogram for the clustering of determined physical and chemical parameters for all the studied stations is plotted (Ward's method of linkage, squared Euclidean distance as similarity measure, standardization of the input data). For clustering altogether 22 physical and chemical parameters were chosen. It could be concluded that the one big cluster and three small clusters are formed additionally sub clusters are also formed. Statistical Analysis of Ground water quality parameters in Erode District, Tamilnadu was studied by M.Jamuna et al[13]. Spatial and Temporal changes in water quality at AsiRiver using Multivariate Statistical Techniques was studied by Ece et al[14]. Statistical assessment of water quality parameters for pollution source identification in Bektas Pond was extended by Aydin et al[15].

The **Pearson correlation analysis** was performed for measured parameters to determine the relation between these variables and given in Tables 3, 6, 9, 12. A correlation analysis is a bivariate method applied to describe the degree of relation between two hydro chemical parameters. A high correlation coefficient (near 1 or -1) means a good relationship between two variables and its value around zero means no relationship between them at a significant level of <0.05. More precisely it can be said that parameters showing coefficient >0.7 are considered to be strongly correlated where as coefficient between 0.5 and 0.7 shows moderate correlation.

RESULT AND DISCUSSION

For our research studies, the name of the villages are abbreviated, Pozhikari as PO, Periyakadu as PE, Muttom as MU, Manavalakurichi as MA. The water samples drawn during the period 2019 in pre monsoon season are abbreviated as PRA19PO, PRA19PE, PRA19MU and PRA19MA. The water samples drawn from well are abbreviated as WPRA19PO, WPRA19PE, WPRA19MU and WPRA19MA. The water samples drawn during the period 2020 in pre monsoon season are abbreviated as PRA20PO, PRA20PE, PRA20MU and PRA20MA. The water samples drawn from well are abbreviated as WPRA20PO, WPRA20PE, WPRA20MU and WPRA20MA.

The water samples drawn during the period 2019 in post monsoon season are abbreviated as PON19PO, PON19PE, PON19MU and PON19MA. The water samples drawn from well are abbreviated as WPON19PO, WPON19PE, WPON19MU and WPON19MA. The water samples drawn during the period 2020 in pre monsoon season are abbreviated as PON20PO, PON20PE, PON20MU and PON20MA. The water samples drawn from well are abbreviated as WPON20PO, WPON20PE, WPON20MU and WPON20MA.

The water samples drawn from bore hole are abbreviated as BPRA19PO, BPRA19PE, BPRA19MU and BPRA19MA. The water samples drawn during the period 2020 in pre monsoon season are abbreviated as PRA20PO, PRA20PE, PRA20MU and PRA20MA. The water samples drawn from bore hole are abbreviated as BPRA20PO, BPRA20PE, BPRA20MU and BPRA20MA.

The water samples drawn during the period 2019 in post monsoon season are abbreviated as PON19PO, PON19PE, PON19MU and PON19MA. The water samples drawn from bore hole are abbreviated as BPON19PO, BPON19PE, BPON19MU and BPON19MA. The water samples drawn during the period 2020 in pre monsoon season are abbreviated as PON20PO, PON20PE, PON20MU and PON20MA. The water samples drawn from bore hole are abbreviated as BPON20PO, BPON20PE, BPON20MU and BPON20MA.

Table 1: Comparison of water quality parameters of well water in Pre monsoon and Post monsoon season during 2019

S.No	Parameters	Sample code							
		WPRA19PO	WPRA19PE	WPRA19MU	WPRA19MA	WPON19PO	WPON19PE	WPON19MU	WPON19MA
1	pH	7.4	7.4	7.9	7.9	7.4	7.4	7.3	7.9
2	Turbidity (NTU)	8	8	8.0	8	7	8	7	8.1
3	Dissolved oxygen (DO) (ppm)	7	7	8	8	7	8	7	7
4	Biological Oxygen Demand (BOD) (ppm)	8	9	6	8	8	9	8	8
5	Hardness Mg (mg/L)	4.9	4.9	4.9	4.9	4.8	4.9	4.8	4.8
6	Sulphate (mg/L)	7	0.8	6	0.8	6	0.9	6	7.4
7	Total Nitrogen (mg/L)	4.9	4.9	4.9	4.9	4.8	4.9	4.8	4.8
8	Nitrate (mg/L)	0.2	0.3	0.2	0.2	0.2	0.9	0.2	0.4
9	Ammonia (mg/L)	0.9	0.9	0.9	6	0.8	0.2	0.8	0.3
10	Phosphate (mg/L)	0.3	0.4	0.8	0.8	0.2	0.3	0.2	0.2
11	Total Phosphorous (mg/L)	0.4	0.5	0.3	0.2	0.3	25.6	0.3	0.3
12	Fluoride (ppm)	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7
13	Chloride (ppm)	241	250	290	290	240	214	240	180
14	Total dissolved solids (TDS)(ppm)	540	590	590	570	581	580	580	620
15	Electrical conductivity (Mics/cm)	621	620	620	630	620	670	620	620
16	Oxidation-Reduction Potential (mV)	711	711	710	719	711	710	710	562
17	Temperature (°C)	28	29	29	28	30	28	27	28
18	Sodium (mg/L)	25.1	24.6	26.6	25.3	25.6	25.1	25.6	25.6
19	Potassium (mg/L)	16.1	17.3	16.3	16.1	16.4	16.3	16.3	12.2
20	Alkalinity (mg/L)	164	175	164	166	165	169	165	190
21	Hardness Ca (mg/L)	50	60	60	51	50	50	50	60
22	Salinity (ppm)	96	96	96	96	95	96	95	110

Table 2: Descriptive Statistics of water quality parameters of well water in Pre monsoon and Post monsoon season during 2019

Descriptive Statistics

|	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Temp	8	3	27	30	28.38	.916	.839	.421	1.481
pH	8	.6	7.3	7.9	7.575	.2712	.074	-2.180	1.481
Turbidity	8	1.1	7.0	8.1	7.763	.4719	.223	-.026	1.481
Alkalinity	8	26	164	190	169.75	8.972	80.500	4.217	1.481
HardnessCa	8	10	50	60	53.88	5.083	25.839	-2.234	1.481
HardnessMg	8	.1	4.8	4.9	4.863	.0518	.003	-2.240	1.481
Salinity	8	15	95	110	97.50	5.071	25.714	7.813	1.481
Fluoride	8	.1	.7	.8	.775	.0463	.002	.000	1.481
Chloride	8	110	180	290	243.13	36.447	1328.411	.201	1.481
TDS	8	80	540	620	581.38	22.316	497.982	2.267	1.481
DO	8	1	7	8	7.25	.463	.214	.000	1.481
BOD	8	3.0	6.0	9.0	8.000	.9258	.857	3.500	1.481
EC	8	50	620	670	627.63	17.468	305.125	7.043	1.481
TotNitrogen	8	.1	4.8	4.9	4.863	.0518	.003	-2.240	1.481
Nitrate	8	.7	.2	.9	.325	.2435	.059	5.885	1.481
Sulphate	8	6.6	.8	7.4	4.363	2.9664	8.800	-2.151	1.481
Ammonia	8	5.8	.2	6.0	1.350	1.8996	3.609	7.496	1.481
Phosphate	8	.6	.2	.8	.400	.2563	.066	-.438	1.481
Totphosphorus	8	25.4	.2	25.6	3.488	8.9352	79.838	7.998	1.481
Sodium	8	2.0	24.6	26.6	25.438	.5829	.340	2.067	1.481
Potassium	8	5.1	12.2	17.3	15.875	1.5332	2.351	6.684	1.481
ORP	8	157	562	719	693.00	53.018	2810.857	7.924	1.481
Valid N (listwise)	8								

Figure 1: Cluster Diagram of water quality parameters of well water in Pre monsoon and Post monsoon season during 2019
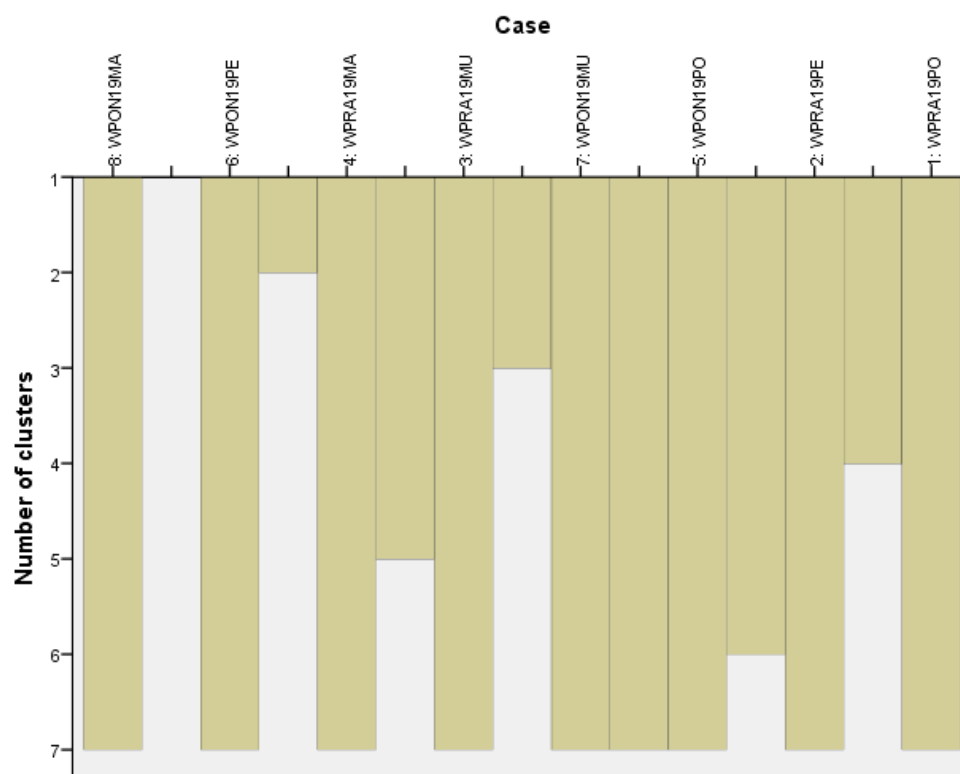
Figure 2: Dendrogram of water quality parameters of well water in Pre monsoon and Post monsoon season during 2019

Dendrogram using Ward Linkage
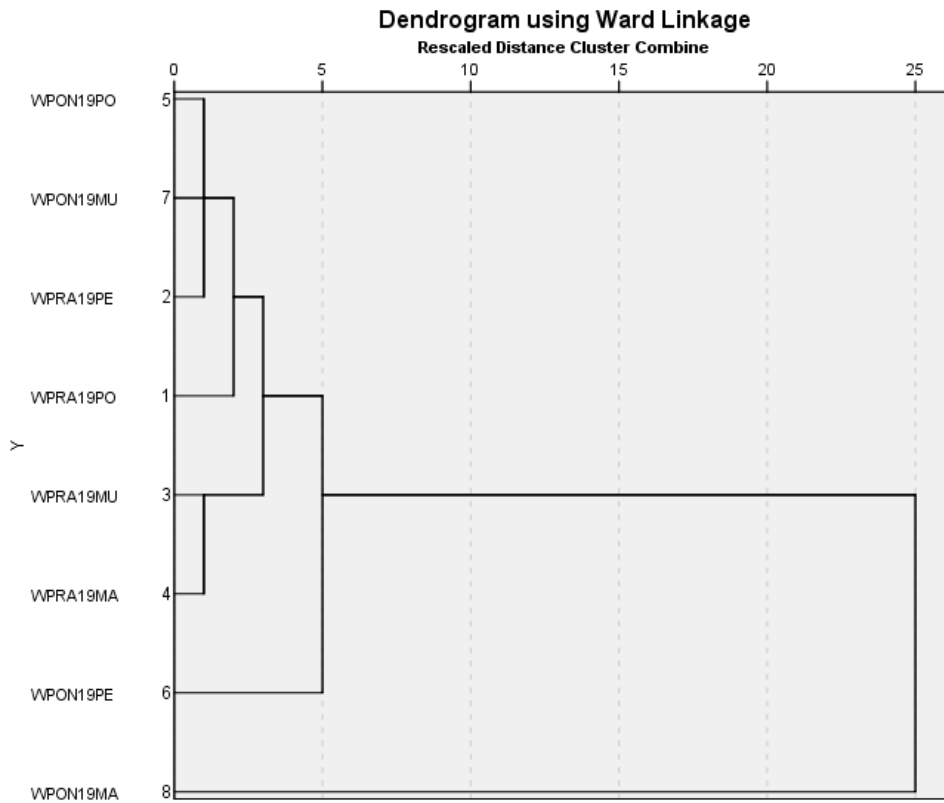Rescaled Distance Cluster Combine

Table 3: Pearson Correlation Coefficient (r) of water quality parameters of well water in Pre monsoon and Post monsoon season during 2019

Correlations[a]

		Temp	pH	Turbidity	Alkalinity	HardnessCa	HardnessMg	Salinity	Fluoride	Chloride	TDS	DO	BOD	EC	TotNitrogen	Nitrate	Sulphate	Ammonia	Phosphate	Totphosphorus	Sodium	Potassium	ORP
Temp	Pearson Correlation	1	.043	-.095	-.091	.257	.038	-.169	.590	.217	.125	.758	-.168	-.204	.038	-.176	-.015	-.119	.122	-.163	.130	.252	.159
	Sig. (1-tailed)		.460	.411	.415	.270	.465	.344	.062	.303	.384	.015	.345	.314	.465	.338	.486	.389	.387	.350	.379	.274	.354
pH	Pearson Correlation	.043	1	.539	.343	.526	.127	.519	-.057	.226	.427	.171	-.569	-.171	.127	-.162	.070	.452	.657	-.266	.522	-.534	-.454
	Sig. (1-tailed)	.460		.084	.202	.090	.382	.094	.447	.295	.146	.343	.071	.343	.382	.351	.435	.130	.038	.262	.092	.086	.129
Turbidity	Pearson Correlation	-.095	.539	1	.389	.498	.695	.373	.278	-.001	.076	-.343	.000	.251	.695	.320	-.303	.159	.449	.205	-.160	-.260	-.275
	Sig. (1-tailed)	.411	.084		.171	.105	.028	.181	.253	.500	.429	.203	.500	.274	.028	.220	.233	.354	.132	.313	.352	.267	.255
Alkalinity	Pearson Correlation	-.091	.343	.389	1	.607	-.331	.920	-.533	-.709	.762	-.361	.275	-.074	-.331	.265	.100	-.250	-.329	-.032	-.181	-.793	-.912
	Sig. (1-tailed)	.415	.202	.171		.055	.212	.001	.087	.024	.014	.190	.255	.431	.212	.263	.407	.275	.213	.470	.334	.009	.001
HardnessCa	Pearson Correlation	.257	.526	.498	.607	1	.088	.518	-.137	-.036	.689	.137	-.304	-.364	.088	-.101	.072	-.220	.263	-.305	.228	-.330	-.495
	Sig. (1-tailed)	.270	.090	.105	.055		.418	.091	.374	.466	.029	.374	.232	.188	.418	.406	.433	.301	.264	.231	.293	.212	.106
HardnessMg	Pearson Correlation	.038	.127	.695	-.331	.088	1	-.408	.745	.525	-.456	-.149	.000	.361	1.000	.198	-.587	.312	.646	.295	-.231	.491	.500
	Sig. (1-tailed)	.465	.382	.028	.212	.418		.158	.017	.091	.128	.362	.500	.189	.000	.319	.063	.226	.042	.239	.291	.109	.104
Salinity	Pearson Correlation	-.169	.519	.373	.920	.518	-.408	1	-.609	-.678	.685	-.243	.000	-.148	-.408	.150	.373	-.202	-.264	-.121	.094	-.963	-.993
	Sig. (1-tailed)	.344	.094	.181	.001	.094	.158		.055	.032	.030	.281	.500	.364	.158	.182	.316	.388	.412	.388	.412	.000	.000
Fluoride	Pearson Correlation	.590	-.057	.278	-.533	-.137	.745	-.609	1	.561	-.515	.333	.000	.269	.745	.063	-.486	.260	.482	.220	-.172	.654	.664
	Sig. (1-tailed)	.062	.447	.253	.087	.374	.017	.055		.074	.096	.210	.500	.259	.017	.441	.111	.267	.113	.300	.342	.039	.036
Chloride	Pearson Correlation	.217	.226	-.001	-.709	-.036	.525	-.678	.561	1	-.417	.370	-.491	-.222	.525	-.520	-.293	.615	.833	-.325	.279	.656	.722
	Sig. (1-tailed)	.303	.295	.500	.024	.466	.091	.032	.074		.152	.108	.299	.091	.091	.052	.005	.216	.251	.039	.022		
TDS	Pearson Correlation	.125	.427	.076	.762	.689	-.456	.685	-.515	-.417	1	.114	-.069	-.082	-.456	.200	.073	-.270	-.105	-.026	.272	-.581	-.707
	Sig. (1-tailed)	.384	.146	.429	.014	.029	.128	.030	.096	.152		.394	.435	.423	.128	.317	.431	.259	.402	.476	.257	.065	.025
DO	Pearson Correlation	.758	.171	-.343	-.361	.137	-.149	-.243	.333	.370	.114	1	-.667	-.269	-.149	-.317	.341	-.162	.241	-.220	.701	.191	.204
	Sig. (1-tailed)	.015	.343	.203	.190	.374	.362	.281	.210	.183	.394		.035	.259	.362	.222	.204	.350	.283	.300	.026	.325	.314
BOD	Pearson Correlation	-.168	-.569	.000	.275	-.304	.000	.000	.000	-.491	-.069	-.667	1	.442	.000	.507	-.536	-.057	-.542	.440	-.926	.101	.003
	Sig. (1-tailed)	.345	.071	.500	.255	.232	.500	.500	.500	.108	.435	.035		.137	.500	.100	.086	.447	.083	.137	.000	.406	.497
EC	Pearson Correlation	-.204	-.171	.251	-.074	-.364	.361	-.148	.269	-.222	-.082	-.269	.442	1	.361	.919	-.568	-.049	-.035	.979	-.261	.127	.174
	Sig. (1-tailed)	.314	.343	.274	.431	.188	.189	.364	.259	.299	.423	.259	.137		.189	.001	.071	.454	.467	.000	.266	.383	.340
TotNitrogen	Pearson Correlation	.038	.127	.695	-.331	.088	1.000	-.408	.745	.525	-.456	-.149	.000	.361	1	.198	-.587	.312	.646	.295	-.231	.491	.500
	Sig. (1-tailed)	.465	.382	.028	.212	.418	.000	.158	.017	.091	.128	.362	.500	.189		.319	.063	.226	.042	.239	.291	.109	.104
Nitrate	Pearson Correlation	-.176	-.162	.320	.265	-.101	.198	.150	.063	-.520	.200	-.317	.507	.919	.198	1	-.430	-.327	-.252	.955	-.289	-.113	-.138
	Sig. (1-tailed)	.338	.351	.220	.263	.406	.319	.361	.441	.093	.317	.222	.100	.001	.319		.144	.214	.274	.000	.243	.395	.372
Sulphate	Pearson Correlation	-.015	.070	-.303	.100	.072	-.587	.373	-.486	-.293	.073	.341	-.536	-.568	-.587	-.430	1	-.454	-.366	-.473	.552	-.492	-.437
	Sig. (1-tailed)	.486	.435	.233	.407	.433	.063	.182	.111	.241	.431	.204	.086	.071	.063	.144		.129	.118	.078	.140		
Ammonia	Pearson Correlation	-.119	.452	.159	-.250	-.220	.312	-.202	.260	.615	-.270	-.162	-.057	-.049	.312	-.327	-.454	1	.666	-.250	-.077	.145	.278
	Sig. (1-tailed)	.389	.130	.354	.275	.301	.226	.316	.267	.052	.259	.447	.454	.129	.226	.214	.129		.036	.275	.428	.366	.253
Phosphate	Pearson Correlation	.122	.657	.449	-.329	.263	.646	-.264	.482	.833	-.105	.241	-.542	-.035	.646	-.252	-.366	.666	1	-.161	.363	.269	.346
	Sig. (1-tailed)	.387	.038	.132	.213	.264	.042	.264	.113	.005	.402	.283	.083	.467	.042	.274	.186	.036		.352	.188	.260	.201
Totphosphorus	Pearson Correlation	-.163	-.266	.205	-.032	-.305	.295	-.121	.220	-.325	-.026	-.220	.440	.979	.295	.955	-.473	-.250	-.161	1	-.239	.115	.131
	Sig. (1-tailed)	.350	.262	.313	.470	.231	.239	.388	.300	.216	.476	.300	.137	.000	.239	.000	.118	.275	.352		.284	.393	.379
Sodium	Pearson Correlation	.130	.522	-.160	-.181	.228	-.231	.094	-.172	.279	.272	.701	-.926	-.261	-.231	-.289	.552	-.077	.363	-.239	1	-.223	-.122
	Sig. (1-tailed)	.379	.092	.267	.334	.293	.291	.412	.342	.251	.257	.026	.000	.266	.291	.243	.078	.428	.188	.284		.298	.387
Potassium	Pearson Correlation	.252	-.534	-.260	-.793	-.330	.491	-.963	.654	.656	-.581	.191	.101	.127	.491	-.113	-.492	.145	.269	.115	-.223	1	.963
	Sig. (1-tailed)	.274	.086	.267	.009	.212	.109	.000	.039	.039	.065	.325	.406	.383	.109	.395	.108	.366	.260	.393	.298		.000
ORP	Pearson Correlation	.159	-.454	-.275	-.912	-.495	.500	-.993	.664	.722	-.707	.204	.003	.174	.500	-.138	-.437	.278	.346	.131	-.122	.963	1
	Sig. (1-tailed)	.354	.129	.255	.001	.106	.104	.000	.036	.022	.025	.314	.497	.340	.104	.372	.140	.253	.201	.379	.387	.000	

a. Listwise N=8

Table 4: Comparison of water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2019

S.No	Parameters	Sample code							
		Pre moon Season				Post moon Season			
		BPRA19PO	BPRA19PE	BPRA19MU	BPRA19MA	BPON19PO	BPON19PE	BPON19MU	BPON19MA
1	pH	7.8	7.8	7.8	7.9	7.8	7.3	7.9	7.3
2	Turbidity (NTU)	8.1	8.1	8.2	8.9	8.9	8.2	8.1	7
3	Dissolved oxygen (DO) (ppm)	6	6	9	6	6	7	6	6
4	Biological Oxygen Demand (BOD) (ppm)	6.4	6.4	6.3	6.4	6.3	6.4	6.3	8.3
5	Hardness Mg (mg/L)	8	8	8	8	7	8	7	7
6	Sulphate (mg/L)	7.1	0.3	7.5	0.4	7.4	4.4	7.4	6
7	Total Nitrogen (mg/L)	5	5	5	5	5	6	5	5
8	Nitrate (mg/L)	0.9	0.9	0.5	0.4	0.4	0.4	0.4	0.2
9	Ammonia (mg/L)	0.9	0.3	0.9	7.4	0.3	0.1	0.3	0.8
10	Phosphate (mg/L)	0.2	0.3	0.1	0.3	0.1	0.4	0.1	0.1
11	Total Phosphorous (mg/L)	0.1	0.6	0.4	0.1	0.4	11.4	0.4	0.4
12	Fluoride (ppm)	0.8	0.9	0.9	0.9	0.9	0.8	0.9	0.9
13	Chloride (ppm)	182	181	190	181	181	190	180	240
14	Total dissolved solids (TDS)(ppm)	630	631	620	630	621	621	620	630
15	Electrical conductivity (Mics/cm)	531	531	531	540	531	540	530	530
16	Oxidation-Reduction Potential (mV)	739	741	741	742	742	742	740	672
17	Temperature (°C)	29	30	27	31	31	29	28	27
18	Sodium (mg/L)	11.6	11.4	12.1	11.4	11.6	21	11.4	11.4
19	Potassium (mg/L)	19	19	19	18	18	19	19	11.4
20	Alkalinity (mg/L)	191	195	192	192	190	199	190	165
21	Hardness Ca (mg/L)	61	50	61	61	90	70	60	50
22	Salinity (ppm)	111	117	111	110	116	112	110	95

Table 5: Descriptive Statistics of water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2019

Descriptive Statistics

|	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Temp	8	4	27	31	29.00	1.604	2.571	-1.478	1.481
pH	8	.6	7.3	7.9	7.700	.2507	.063	-.145	1.481
Turbidity	8	1.9	7.0	8.9	8.188	.5915	.350	2.116	1.481
Alkalinity	8	34	165	199	189.25	10.250	105.071	6.158	1.481
HardnessCa	8	40	50	90	62.88	12.744	162.411	2.886	1.481
HardnessMg	8	1	7	8	7.63	.518	.268	-2.240	1.481
Salinity	8	22	95	117	110.25	6.714	45.071	4.765	1.481
Fluoride	8	.1	.8	.9	.875	.0463	.002	.000	1.481
Chloride	8	60	180	240	190.63	20.368	414.839	7.029	1.481
TDS	8	11	620	631	625.38	5.236	27.411	-2.721	1.481
DO	8	3	6	9	6.50	1.069	1.143	5.469	1.481
BOD	8	2.0	6.3	8.3	6.600	.6887	.474	7.877	1.481
EC	8	10	530	540	533.00	4.342	18.857	-.052	1.481
TotNitrogen	8	1.0	5.0	6.0	5.125	.3536	.125	8.000	1.481
Nitrate	8	.7	.2	.9	.513	.2532	.064	-.289	1.481
Sulphate	8	7.2	.3	7.5	5.063	3.0882	9.537	-.753	1.481
Ammonia	8	7.3	.1	7.4	1.375	2.4546	6.025	7.611	1.481
Phosphate	8	.3	.1	.4	.200	.1195	.014	-1.204	1.481
Totphosphorus	8	11.3	.1	11.4	1.725	3.9129	15.311	7.956	1.481
Sodium	8	9.6	11.4	21.0	12.738	3.3470	11.203	7.877	1.481
Potassium	8	7.6	11.4	19.0	17.800	2.6252	6.891	7.287	1.481
ORP	8	70	672	742	732.38	24.419	596.268	7.954	1.481
Valid N (listwise)	8								

Figure 3: Cluster Diagram of water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2019
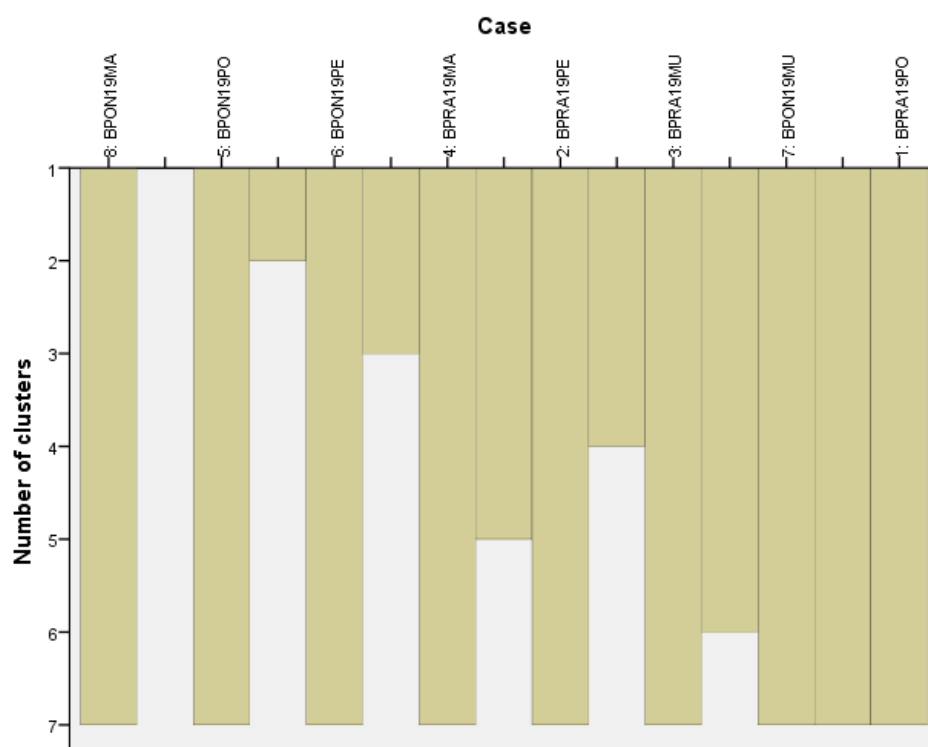
Figure 4: Dendrogram of water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2019
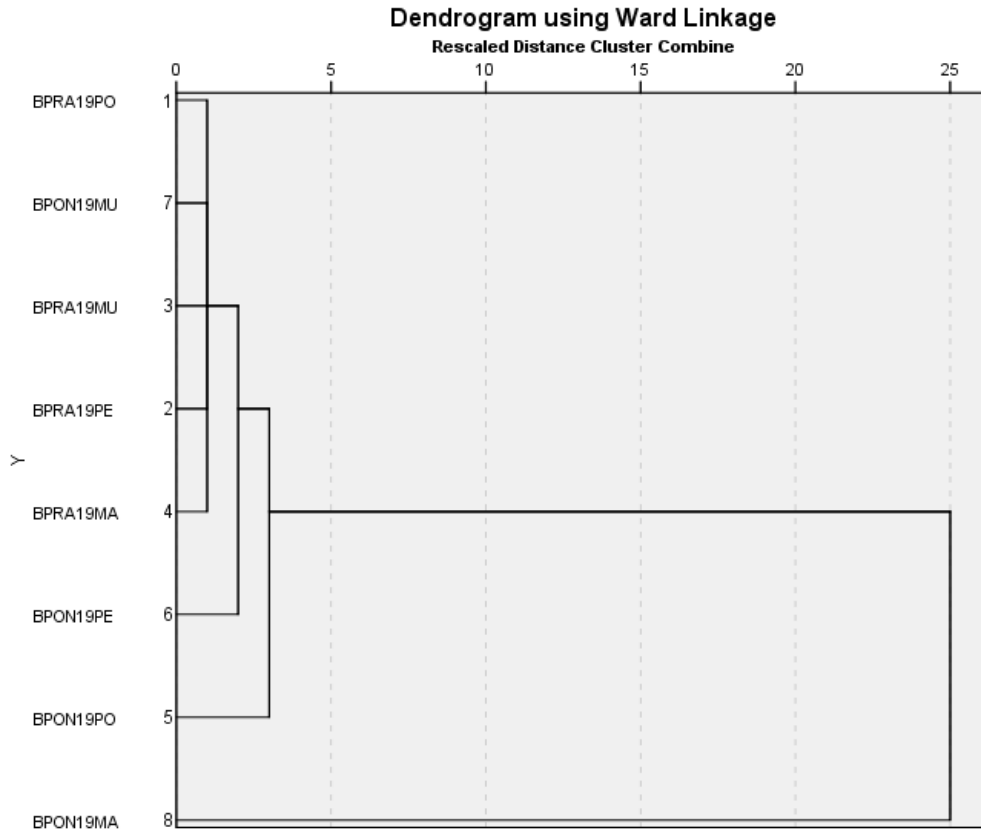

Table 6: Pearson Correlation Coefficient (r) of water quality parameters of well water in Pre monsoon and Post monsoon season during 2019

Correlations[a]

		Temp	pH	Turbidity	Alkalinity	HardnessCa	HardnessMg	Salinity	Fluoride	Chloride	TDS	DO	BOD	EC	TotNitrogen	Nitrate	Sulphate	Ammonia	Phosphate	Totphosphorus	Sodium	Potassium	ORP
Temp	Pearson Correlation	1	.391	.783	.478	.489	.172	.624	.000	-.590	.221	-.500	-.479	.431	.000	.246	-.534	.436	.447	-.009	-.027	.380	.522
	Sig. (1-tailed)		.169	.011	.115	.109	.342	.049	.500	.062	.299	.104	.115	.143	.500	.278	.087	.140	.133	.491	.475	.177	.092
pH	Pearson Correlation	.391	1	.626	.422	.107	.110	.569	.369	-.739	-.022	-.053	-.662	-.210	-.645	.428	-.068	.330	-.238	-.651	-.635	.595	.632
	Sig. (1-tailed)	.169		.048	.149	.400	.398	.071	.184	.018	.480	.450	.037	.309	.042	.145	.436	.213	.285	.040	.045	.060	.046
Turbidity	Pearson Correlation	.783	.626	1	.724	.661	.263	.771	.039	-.828	-.270	.011	-.814	.434	.009	.144	-.212	.435	.242	-.004	.018	.699	.827
	Sig. (1-tailed)	.011	.048		.021	.037	.265	.013	.463	.006	.259	.489	.007	.141	.492	.367	.307	.141	.281	.496	.483	.027	.006
Alkalinity	Pearson Correlation	.478	.422	.724	1	.341	.613	.898	-.346	-.901	-.329	.235	-.941	.436	.384	.489	-.251	.046	.560	.381	.400	.960	.960
	Sig. (1-tailed)	.115	.149	.021		.204	.053	.001	.200	.001	.213	.288	.000	.140	.174	.110	.274	.457	.075	.176	.163	.000	.000
HardnessCa	Pearson Correlation	.489	.107	.661	.341	1	-.246	.461	-.127	-.392	-.586	.016	-.435	.163	.226	-.221	.369	-.107	-.094	.220	.242	.310	.426
	Sig. (1-tailed)	.109	.400	.037	.204		.278	.125	.382	.169	.063	.485	.141	.350	.295	.300	.184	.400	.413	.300	.282	.227	.146
HardnessMg	Pearson Correlation	.172	.110	.263	.613	-.246	1	.401	-.447	-.395	.270	.387	-.441	.509	.293	.586	-.502	.306	.693	.280	.314	.526	.487
	Sig. (1-tailed)	.342	.398	.265	.053	.278		.163	.133	.167	.259	.172	.137	.099	.241	.063	.103	.230	.028	.251	.224	.090	.110
Salinity	Pearson Correlation	.624	.569	.771	.898	.461	.401	1	-.115	-.915	-.267	.080	-.915	.142	.105	.578	-.208	-.077	.338	.111	.118	.895	.922
	Sig. (1-tailed)	.049	.071	.013	.001	.125	.163		.393	.001	.261	.426	.001	.369	.402	.067	.310	.428	.206	.397	.390	.001	.001
Fluoride	Pearson Correlation	.000	.369	.039	-.346	-.127	-.447	-.115	1	.140	-.015	.000	.179	-.355	-.655	-.335	-.137	.220	-.516	-.635	-.657	-.282	-.205
	Sig. (1-tailed)	.500	.184	.463	.200	.382	.133	.393		.370	.486	.500	.336	.194	.039	.209	.373	.300	.095	.045	.038	.249	.313
Chloride	Pearson Correlation	-.590	-.739	-.828	-.901	-.392	-.395	-.915	.140	1	.261	-.016	.977	-.212	-.012	.161	-.140	-.288	-.006	-.006	-.021	-.951	-.976
	Sig. (1-tailed)	.062	.018	.006	.001	.169	.167	.001	.370		.266	.485	.000	.307	.488	.089	.351	.370	.245	.494	.480	.000	.000
TDS	Pearson Correlation	.221	-.022	-.270	-.329	-.586	.270	-.267	-.015	.261	1	-.523	.408	.019	-.338	.395	.161	.395	.274	-.347	-.373	-.368	-.366
	Sig. (1-tailed)	.299	.480	.259	.213	.063	.259	.261	.486	.266		.092	.158	.482	.207	.167	.059	.166	.256	.200	.182	.185	.187
DO	Pearson Correlation	-.500	-.053	.011	.235	.016	.387	.080	.000	-.016	-.523	1	-.213	.031	.189	-.079	.288	-.147	-.112	.195	.254	.244	.194
	Sig. (1-tailed)	.104	.450	.489	.288	.485	.172	.426	.500	.485	.092		.306	.471	.327	.426	.245	.364	.396	.322	.272	.280	.322
BOD	Pearson Correlation	-.479	-.662	-.814	-.941	-.435	-.441	-.915	.179	.977	.408	-.213	1	-.239	-.117	-.467	.072	-.070	-.278	-.112	-.138	-.981	-.996
	Sig. (1-tailed)	.115	.037	.007	.000	.141	.137	.001	.336	.000	.158	.306		.284	.391	.122	.433	.434	.253	.396	.372	.000	.000
EC	Pearson Correlation	.431	-.210	.434	.436	.163	.509	.142	-.355	-.212	.019	.031	-.239	1	.651	-.208	-.545	.595	.798	.631	.639	.223	.304
	Sig. (1-tailed)	.143	.309	.141	.140	.350	.099	.369	.194	.307	.482	.471	.284		.040	.311	.081	.060	.009	.047	.044	.298	.232
TotNitrogen	Pearson Correlation	.000	-.645	.009	.384	.226	.293	.105	-.655	-.012	-.338	.189	-.117	.651	1	-.180	-.087	-.210	.676	.999	.997	.185	.159
	Sig. (1-tailed)	.500	.042	.492	.174	.295	.241	.402	.039	.488	.207	.327	.391	.040		.335	.419	.309	.033	.000	.000	.331	.353
Nitrate	Pearson Correlation	.246	.428	.144	.489	-.221	.586	.578	-.335	.161	.395	-.079	-.467	-.208	-.180	1	-.239	-.163	.283	-.179	-.174	.559	.475
	Sig. (1-tailed)	.278	.145	.367	.110	.300	.063	.067	.209	.089	.167	.426	.122	.311	.335		.285	.350	.248	.336	.340	.075	.117
Sulphate	Pearson Correlation	-.534	-.068	-.212	-.251	.369	-.502	-.208	-.137	.161	.161	.288	.072	-.545	-.087	-.239	1	-.562	-.728	-.088	-.052	-.085	-.140
	Sig. (1-tailed)	.087	.436	.307	.274	.184	.103	.310	.373	.351	.059	.245	.433	.081	.419	.285		.074	.020	.418	.451	.421	.370
Ammonia	Pearson Correlation	.436	.330	.435	.046	-.107	.306	-.077	.220	-.140	.395	-.147	-.070	.595	-.210	-.163	-.562	1	.273	-.237	-.224	-.013	.108
	Sig. (1-tailed)	.140	.213	.141	.457	.400	.230	.428	.300	.370	.166	.364	.434	.060	.309	.350	.074		.257	.286	.297	.488	.399
Phosphate	Pearson Correlation	.447	-.238	.242	.560	-.094	.693	.338	-.516	-.288	.274	-.112	-.278	.798	.676	.283	-.728	.273	1	.669	.653	.346	.352
	Sig. (1-tailed)	.133	.285	.281	.075	.413	.028	.206	.095	.245	.256	.396	.253	.009	.033	.248	.020	.257		.035	.039	.201	.196
Totphosphorus	Pearson Correlation	-.009	-.651	-.004	.381	.220	.280	.111	-.635	-.006	-.347	.195	-.112	.631	.999	-.179	-.088	-.237	.669	1	.997	.181	.154
	Sig. (1-tailed)	.491	.040	.496	.176	.300	.251	.397	.045	.494	.200	.322	.396	.047	.000	.336	.418	.286	.035		.000	.334	.358
Sodium	Pearson Correlation	-.027	-.635	.018	.400	.242	.314	.118	-.657	-.021	-.373	.254	-.138	.639	.997	-.174	-.052	-.224	.653	.997	1	.206	.178
	Sig. (1-tailed)	.475	.045	.483	.163	.282	.224	.390	.038	.480	.182	.272	.372	.044	.000	.340	.451	.297	.039	.000		.313	.337
Potassium	Pearson Correlation	.380	.595	.699	.960	.310	.526	.895	-.282	-.951	-.368	.244	-.981	.223	.185	.559	-.085	-.013	.346	.181	.206	1	.980
	Sig. (1-tailed)	.177	.060	.027	.000	.227	.090	.001	.249	.000	.185	.280	.000	.298	.331	.075	.421	.488	.201	.334	.313		.000
ORP	Pearson Correlation	.522	.632	.827	.960	.426	.487	.922	-.205	-.976	-.366	.194	-.996	.304	.159	.475	-.140	.108	.352	.154	.178	.980	1
	Sig. (1-tailed)	.092	.046	.006	.000	.146	.110	.001	.313	.000	.187	.322	.000	.232	.353	.117	.370	.399	.196	.358	.337	.000	

a. Listwise N=8

Table 7: Comparison of water quality parameters of well water in Pre monsoon and Post monsoon season during 2020

S.No	Parameters	Sample code							
		WPRA20PO	WPRA20PE	WPRA20MU	WPRA20MA	WPON20PO	WPON20PE	WPON20MU	WPON20MA
1	pH	7.5	7.6	6.5	6.4	7.8	7.8	7.8	7.6
2	Turbidity (NTU)	10	11	9	9.1	6.7	6	6.7	8.9
3	Dissolved oxygen (DO) (ppm)	8.5	7.5	6.5	7.5	8	9	9	9
4	Biological Oxygen Demand (BOD) (ppm)	9	6.4	8	8	7	6	5	8
5	Hardness Mg (mg/L)	21	42	40	70	42	61	61	61
6	Sulphate (mg/L)	2.6	4.7	2.5	0.6	0.4	0.8	6	6.1
7	Total Nitrogen (mg/L)	4.7	2.9	4.8	4.8	4.9	4.9	4.2	4.9
8	Nitrate (mg/L)	0.4	0.2	0.3	0.3	0.3	0.2	0.2	0.8
9	Ammonia (mg/L)	0.6	0.4	0.4	0.9	0.8	0.8	0.8	0.7
10	Phosphate (mg/L)	0.9	0.8	0.8	0.8	6	0.6	0.3	0.5
11	Total Phosphorous (mg/L)	0.5	17..6	0.5	0.9	0.1	1.5	32.1	0.4
12	Fluoride (ppm)	0.4	0.2	0.3	0.4	0.1	0.1	0.1	0.9
13	Chloride (ppm)	180	181	190	192	182	310	360	341
14	Total dissolved solids (TDS)(ppm)	421	282	320	330	415	410	480	468
15	Electrical conductivity (Mics/cm)	422	385	420	420	462	491	471	492
16	Oxidation-Reduction Potential (mV)	571	470	530	560	562	561	570	560
17	Temperature (°C)	28	26	28	28	27	25	28	29
18	Sodium (mg/L)	19.9	12.8	18.3	18.3	33.2	33.1	35.1	32.1
19	Potassium (mg/L)	13.4	18	11.3	11.3	12.9	14.1	12.8	12.4
20	Alkalinity (mg/L)	241	231	240	241	161	219	161	216
21	Hardness Ca (mg/L)	42	31	40	40	61	60	54	59
22	Salinity (ppm)	86	56	85	85	94	92	92	91

Table 5: Descriptive Statistics of water quality parameters of well water in Pre monsoon and Post monsoon season during 2020

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
Temp	8	4	25	29	27.38	.460	1.302	1.696	.222	1.481
pH	8	1.4	6.4	7.8	7.375	.2059	.5825	.339	-.155	1.481
Turbidity	8	5.0	6.0	11.0	8.425	.6261	1.7710	3.136	-1.318	1.481
Alkalinity	8	80	161	241	213.75	12.004	33.953	1152.786	-.475	1.481
HardnessCa	8	30	31	61	48.38	4.057	11.476	131.696	-1.736	1.481
HardnessMg	8	49	21	70	49.75	5.719	16.175	261.643	-.314	1.481
Salinity	8	38	56	94	85.13	4.344	12.287	150.982	6.101	1.481
Fluoride	8	.8	.1	.9	.313	.0953	.2696	.073	3.248	1.481
Chloride	8	180	180	360	242.00	28.258	79.927	6388.286	-1.821	1.481
TDS	8	198	282	480	390.75	25.470	72.041	5189.929	-1.350	1.481
DO	8	2.5	6.5	9.0	8.125	.3239	.9161	.839	-.492	1.481
BOD	8	4.0	5.0	9.0	7.175	.4651	1.3156	1.731	-.650	1.481
EC	8	107	385	492	445.38	13.802	39.038	1523.982	-1.360	1.481
TotNitrogen	8	2.0	2.9	4.9	4.513	.2445	.6917	.478	5.366	1.481
Nitrate	8	.6	.2	.8	.338	.0706	.1996	.040	5.229	1.481
Sulphate	8	5.7	.4	6.1	2.963	.8373	2.3682	5.608	-1.768	1.481
Ammonia	8	.5	.4	.9	.675	.0675	.1909	.036	-1.085	1.481
Phosphate	8	5.7	.3	6.0	1.338	.6697	1.8943	3.588	7.743	1.481
Totphosphorus	8	32.0	.1	32.1	6.700	4.1935	11.8610	140.683	2.699	1.481
Sodium	8	22.3	12.8	35.1	25.350	3.1308	8.8553	78.417	-2.160	1.481
Potassium	8	6.7	11.3	18.0	13.275	.7554	2.1366	4.565	3.820	1.481
ORP	8	101	470	571	548.00	12.007	33.962	1153.429	4.827	1.481
Valid N (listwise)	8									

Figure 5: Cluster Diagram of water quality parameters of well water in Pre monsoon and Post monsoon season during 2020

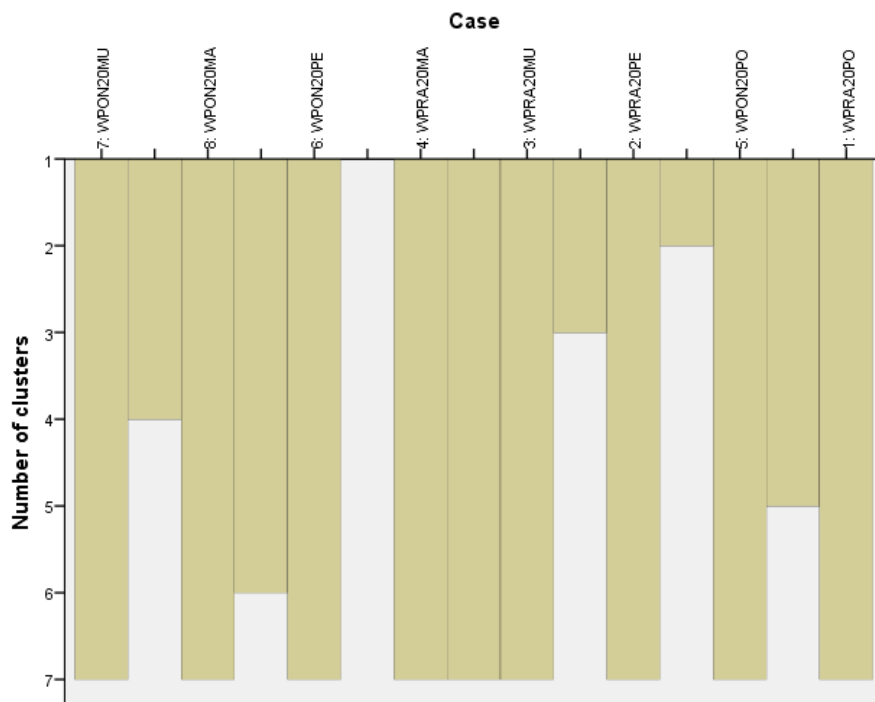**Figure 6: Dendrogram of water quality parameters of well water in Pre monsoon and Post monsoon season during 2020**

Dendrogram using Ward Linkage
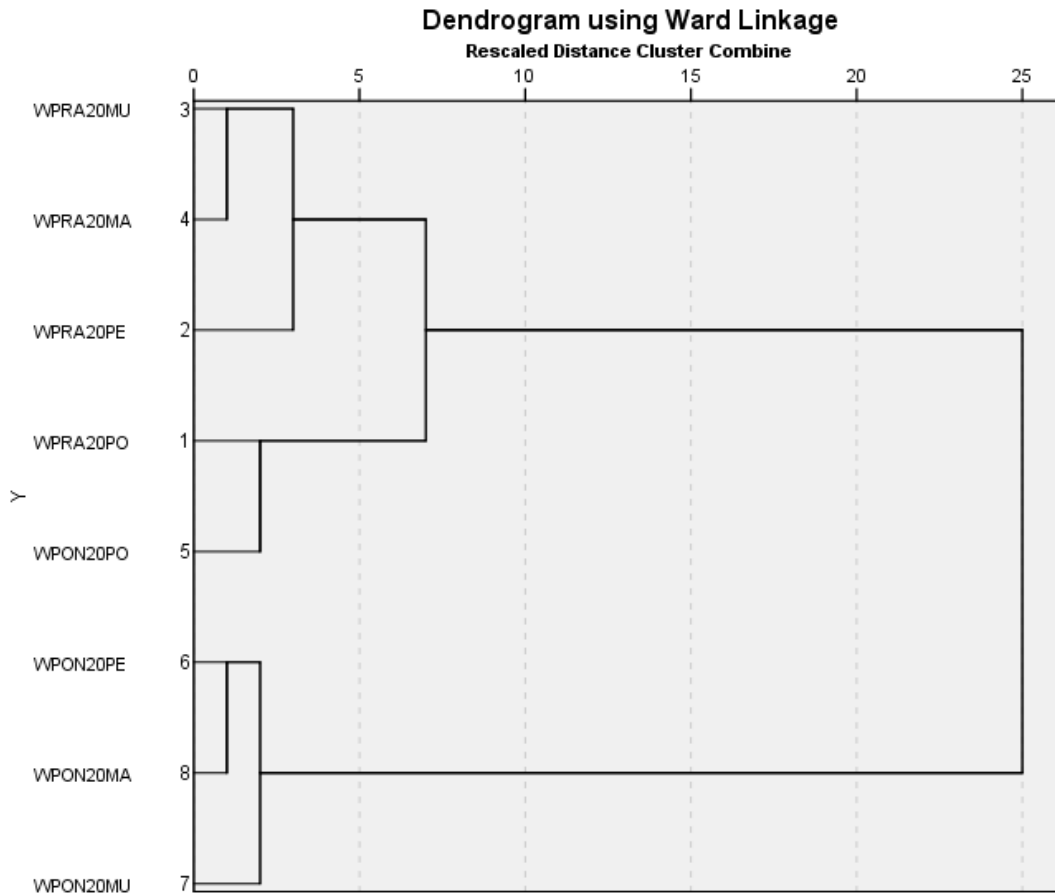Rescaled Distance Cluster Combine

Table 9: Pearson Correlation Coefficient (r) of water quality parameters of well water in Pre monsoon and Post monsoon season during 2020

Correlations[b]

		Temp	pH	Turbidity	Alkalinity	HardnessCa	HardnessMg	Salinity	Fluoride	Chloride	TDS	DO	BOD	EC	TotNitrogen	Nitrate	Sulphate	Ammonia	Phosphate	Totphosphorus	Sodium	Potassium	ORP
Temp	Pearson Correlation	1	-.362	.268	.015	-.020	.005	.309	.676	.106	.324	-.045	.506	.039	.327	.653	.404	.043	-.128	-.055	.009	-.638	.371
	Sig. (1-tailed)		.189	.261	.486	.481	.495	.228	.033	.402	.217	.458	.100	.463	.215	.040	.161	.460	.381	.449	.491	.044	.183
pH	Pearson Correlation	-.362	1	-.384	-.609	.553	-.118	.094	-.207	.456	.593	.756	-.519	.492	-.208	.022	.315	.148	.240	.354	.605	.519	.093
	Sig. (1-tailed)	.189		.174	.054	.078	.391	.412	.311	.128	.061	.015	.094	.108	.310	.480	.224	.363	.283	.195	.056	.094	.413
Turbidity	Pearson Correlation	.268	-.384	1	.692	-.843	-.425	-.754	.427	-.541	-.582	-.473	.564	-.796	-.511	.223	.271	-.657	-.324	-.082	-.871	.338	-.605
	Sig. (1-tailed)	.261	.174		.029	.004	.147	.015	.146	.083	.065	.118	.072	.009	.098	.297	.258	.038	.217	.424	.002	.207	.056
Alkalinity	Pearson Correlation	.015	-.609	.692	1	-.660	-.188	-.434	.392	-.418	-.600	-.428	.640	-.530	-.051	.145	-.152	-.449	-.548	-.474	-.767	.052	-.331
	Sig. (1-tailed)	.486	.054	.029		.038	.328	.141	.168	.151	.058	.145	.044	.088	.452	.366	.359	.132	.080	.118	.013	.451	.212
HardnessCa	Pearson Correlation	-.020	.553	-.843	-.660	1	.343	.806	.031	.632	.804	.681	-.296	.958	.608	.292	-.059	.631	.373	-.123	.965	-.332	.674
	Sig. (1-tailed)	.481	.078	.004	.038		.203	.008	.471	.046	.008	.031	.238	.000	.055	.241	.445	.047	.182	.386	.000	.211	.033
HardnessMg	Pearson Correlation	.005	-.118	-.425	-.188	.343	1	.252	.122	.599	.164	.268	-.435	.468	.157	.056	.069	.632	-.254	.182	.391	-.264	.203
	Sig. (1-tailed)	.495	.391	.147	.328	.203		.273	.387	.058	.349	.261	.140	.121	.355	.447	.435	.046	.272	.333	.169	.263	.315
Salinity	Pearson Correlation	.309	.094	-.754	-.434	.806	.252	1	.086	.446	.746	.443	.037	.791	.896	.266	-.240	.665	.243	-.273	.777	-.779	.934
	Sig. (1-tailed)	.228	.412	.015	.141	.008	.273		.420	.134	.017	.136	.465	.010	.001	.262	.284	.036	.281	.257	.012	.011	.000
Fluoride	Pearson Correlation	.676	-.207	.427	.392	.031	.122	.086	1	.193	.203	.137	.621	.157	.267	.946	.397	-.049	-.314	-.393	-.061	-.292	.136
	Sig. (1-tailed)	.033	.311	.146	.168	.471	.387	.420		.324	.315	.373	.050	.355	.261	.000	.165	.455	.224	.168	.443	.241	.374
Chloride	Pearson Correlation	.106	.456	-.541	-.418	.632	.599	.446	.193	1	.732	.756	-.536	.800	.160	.276	.554	.400	-.397	.414	.746	-.133	.394
	Sig. (1-tailed)	.402	.128	.083	.151	.046	.058	.134	.324		.019	.015	.086	.009	.352	.254	.077	.163	.165	.154	.017	.377	.167
TDS	Pearson Correlation	.324	.593	-.582	-.600	.804	.164	.746	.203	.732	1	.848	-.190	.831	.465	.323	.540	.060	.060	.157	.864	-.328	.771
	Sig. (1-tailed)	.217	.061	.065	.058	.008	.349	.017	.315	.019		.004	.326	.005	.123	.154	.217	.084	.444	.355	.003	.214	.013
DO	Pearson Correlation	-.045	.756	-.473	-.428	.681	.268	.443	.137	.756	.848	1	-.341	.747	.178	.283	.319	.551	-.122	.231	.738	.052	.544
	Sig. (1-tailed)	.458	.015	.118	.145	.031	.261	.136	.373	.015	.004		.204	.017	.337	.248	.221	.078	.386	.291	.018	.423	.082
BOD	Pearson Correlation	.506	-.519	.564	.640	-.296	-.435	.037	.621	-.536	-.190	-.341	1	-.310	.399	.548	-.246	-.219	.020	-.758	-.466	-.370	.134
	Sig. (1-tailed)	.100	.094	.072	.044	.238	.140	.465	.050	.086	.326	.204		.227	.164	.080	.278	.301	.481	.015	.122	.183	.376
EC	Pearson Correlation	.039	.492	-.796	-.530	.958	.468	.791	.157	.800	.831	.747	-.310	1	.596	.365	.090	.609	.093	-.061	.947	-.359	.676
	Sig. (1-tailed)	.463	.108	.009	.088	.000	.121	.010	.355	.009	.005	.017	.227		.060	.187	.416	.054	.413	.443	.000	.191	.033
TotNitrogen	Pearson Correlation	.327	-.208	-.511	-.051	.608	.157	.896	.267	.160	.465	.178	.399	.596	1	.379	-.458	.522	.218	-.647	.485	-.846	.831
	Sig. (1-tailed)	.215	.310	.098	.452	.055	.355	.001	.261	.352	.123	.337	.164	.060		.177	.127	.092	.302	.042	.112	.004	.005
Nitrate	Pearson Correlation	.653	.022	.223	.145	.292	.056	.266	.946	.276	.323	.283	.548	.365	.379	1	.384	.028	-.087	-.415	.189	-.312	.266
	Sig. (1-tailed)	.040	.480	.297	.366	.241	.447	.262	.000	.254	.154	.248	.080	.187	.177		.174	.474	.418	.153	.327	.226	.262
Sulphate	Pearson Correlation	.404	.315	.271	-.152	-.059	.069	-.240	.397	.554	.540	.319	-.246	.090	-.458	.384	1	-.312	-.490	.627	.095	.247	-.219
	Sig. (1-tailed)	.161	.224	.258	.359	.445	.435	.284	.165	.077	.217	.221	.278	.416	.127	.174		.226	.109	.048	.411	.278	.301
Ammonia	Pearson Correlation	.043	.148	-.657	-.449	.631	.632	.665	-.049	.400	.060	.551	-.219	.609	.522	.028	-.312	1	.216	-.037	.638	-.433	.745
	Sig. (1-tailed)	.460	.363	.038	.132	.047	.046	.036	.455	.163	.084	.078	.301	.054	.092	.474	.226		.303	.465	.044	.142	.017
Phosphate	Pearson Correlation	-.128	.240	-.324	-.548	.373	-.254	.243	-.314	-.397	.060	-.122	.020	.093	.218	-.087	-.490	.216	1	-.284	.271	-.057	.129
	Sig. (1-tailed)	.381	.283	.217	.080	.182	.272	.281	.224	.165	.444	.386	.481	.413	.302	.418	.109	.303		.248	.258	.447	.381
Totphosphorus	Pearson Correlation	-.055	.354	-.082	-.474	-.123	.182	-.273	-.393	.414	.157	.231	-.758	-.061	-.647	-.415	.627	-.037	-.284	1	.129	.372	-.223
	Sig. (1-tailed)	.449	.195	.424	.118	.386	.333	.257	.168	.154	.355	.291	.015	.443	.042	.153	.048	.465	.248		.381	.182	.298
Sodium	Pearson Correlation	.009	.605	-.871	-.767	.965	.391	.777	-.061	.746	.864	.738	-.466	.947	.485	.189	.095	.638	.271	.129	1	-.296	.666
	Sig. (1-tailed)	.491	.056	.002	.013	.000	.169	.012	.443	.017	.003	.018	.122	.000	.112	.327	.411	.044	.258	.381		.238	.036
Potassium	Pearson Correlation	-.638	.519	.338	.052	-.332	-.264	-.779	-.292	-.133	-.328	.052	-.370	-.359	-.846	-.312	.247	-.433	-.057	.372	-.296	1	-.727
	Sig. (1-tailed)	.044	.094	.207	.451	.211	.263	.011	.241	.377	.214	.423	.183	.191	.004	.226	.278	.142	.447	.182	.238		.020
ORP	Pearson Correlation	.371	.093	-.605	-.331	.674	.203	.934	.136	.394	.771	.544	.134	.676	.831	.266	-.219	.745	.129	-.223	.666	-.727	1
	Sig. (1-tailed)	.183	.413	.056	.212	.033	.315	.000	.374	.167	.013	.082	.376	.033	.005	.262	.301	.017	.381	.298	.036	.020	

a. Listwise N=8

Table 10: Comparison of water quality parameters of bore hole waterin Pre monsoon and Post monsoon season during 2020

S.No	Parameters	Sample code							
		Pre moon Season				Post moon Season			
		BPRA20PO	BPRA20PE	BPRA20MU	BPRA20MA	BPON20PO	BPON20PE	BPON20MU	BPON20MA
1	pH	7.6	7.5	7.4	7.7	7.1	7.1	7.1	7.8
2	Turbidity (NTU)	11	10	11	11.1	6	6.7	6	8.1
3	Dissolved oxygen (DO) (ppm)	7.5	8.5	7.5	6	9	8	6	7
4	Biological Oxygen Demand (BOD) (ppm)	6.5	9	2.3	8.3	6.3	6.2	5.4	6.8
5	Hardness Mg (mg/L)	31	21	20	40	61	42	42	45
6	Sulphate (mg/L)	4.7	2.6	4.8	0.5	0.6	0.5	6.1	8
7	Total Nitrogen (mg/L)	2.9	4.7	2.8	2.8	4.8	4.6	4.9	4.2
8	Nitrate (mg/L)	0.2	0.4	0.1	0.1	0.1	0.1	0.3	0.1
9	Ammonia (mg/L)	0.4	0.6	0.3	0.8	0.9	0.1	10.3	1.3
10	Phosphate (mg/L)	0.8	0.7	0.7	0.6	7.1	0.5	0.8	0.3
11	Total Phosphorous (mg/L)	0.8	0.5	0.9	0.9	0.9	0.8	31.1	0.9
12	Fluoride (ppm)	0.2	0.4	0.2	0.3	0.8	0.2	0.8	0.3
13	Chloride (ppm)	182	180	170	171	170	370	390	390
14	Total dissolved solids (TDS)(ppm)	321	321	380	240	370	360	360	492
15	Electrical conductivity (Mics/cm)	385	422	375	395	592	581	559	651
16	Oxidation-Reduction Potential (mV)	461	560	461	461	692	621	681	640
17	Temperature (°C)	27	27	29	29	28	27	30	30
18	Sodium (mg/L)	17.9	19.2	17.5	17.5	35.1	31.1	32.1	21.8
19	Potassium (mg/L)	12.9	13.3	12.8	12.3	11.8	15	18	71.1
20	Alkalinity (mg/L)	231	241	230	291	221	161	219	181
21	Hardness Ca (mg/L)	31	42	30	50	54	54	40	60
22	Salinity (ppm)	56	86	55	66	74	75	52	74

Table 11: Descriptive Statistics of water quality parameters of bore hole water in Pre monsoon and post monsoon season during 2020

Descriptive Statistics

|	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
Temp	8	3	27	30	28.38	.460	1.302	1.696	-1.922	1.481
pH	8	.7	7.1	7.8	7.413	.1008	.2850	.081	-1.821	1.481
Turbidity	8	5.1	6.0	11.1	8.738	.8124	2.2978	5.280	-2.246	1.481
Alkalinity	8	130	161	291	221.88	13.809	39.058	1525.554	.919	1.481
HardnessCa	8	30	30	60	45.13	3.934	11.128	123.839	-1.438	1.481
HardnessMg	8	41	20	61	37.75	4.773	13.499	182.214	.012	1.481
Salinity	8	34	52	86	67.25	4.254	12.033	144.786	-1.237	1.481
Fluoride	8	.6	.2	.8	.400	.0906	.2563	.066	-.438	1.481
Chloride	8	220	170	390	252.88	38.289	108.298	11728.411	-2.188	1.481
TDS	8	252	240	492	355.50	25.073	70.916	5029.143	2.262	1.481
DO	8	3.0	6.0	9.0	7.438	.3831	1.0836	1.174	-.943	1.481
BOD	8	6.7	2.3	9.0	6.350	.7119	2.0135	4.054	2.060	1.481
EC	8	276	375	651	495.00	39.430	111.526	12438.000	-2.164	1.481
TotNitrogen	8	2.1	2.8	4.9	3.963	.3386	.9576	.917	-2.186	1.481
Nitrate	8	.3	.1	.4	.175	.0412	.1165	.014	.620	1.481
Sulphate	8	7.5	.5	8.0	3.475	1.0120	2.8624	8.194	-1.337	1.481
Ammonia	8	10.2	.1	10.3	1.838	1.2162	3.4401	11.834	7.713	1.481
Phosphate	8	6.8	.3	7.1	1.438	.8111	2.2941	5.263	7.875	1.481
Totphosphorus	8	30.6	.5	31.1	4.600	3.7860	10.7085	114.671	7.996	1.481
Sodium	8	17.6	17.5	35.1	24.025	2.6350	7.4529	55.545	-1.855	1.481
Potassium	8	59.3	11.8	71.1	20.900	7.2054	20.3800	415.343	7.772	1.481
ORP	8	231	461	692	572.13	35.459	100.294	10058.982	-2.083	1.481
Valid N (listwise)	8									

Figure 7: Cluster Diagram of water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2020
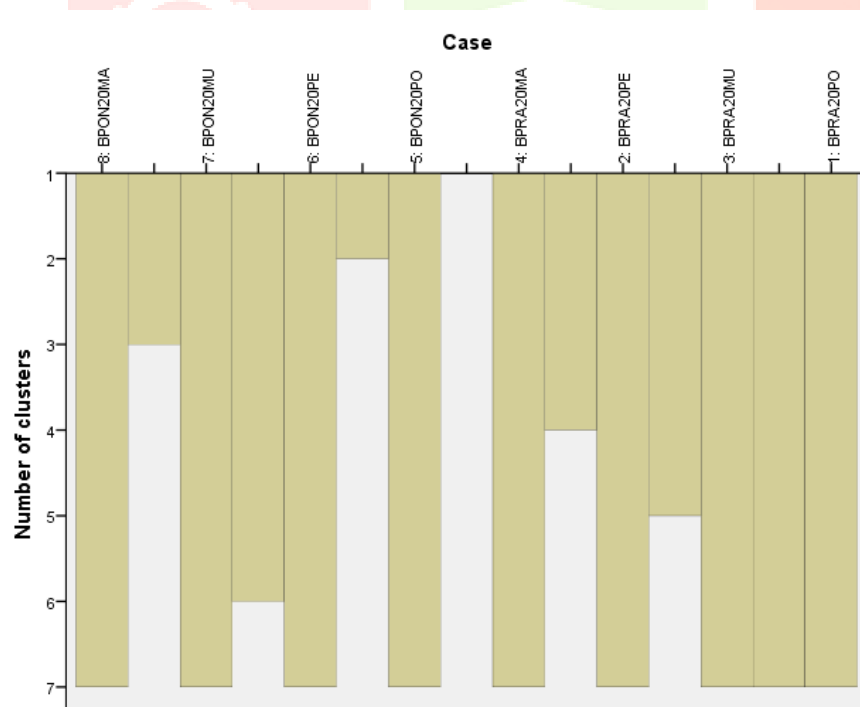
Figure 8: Dendrogram water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2020
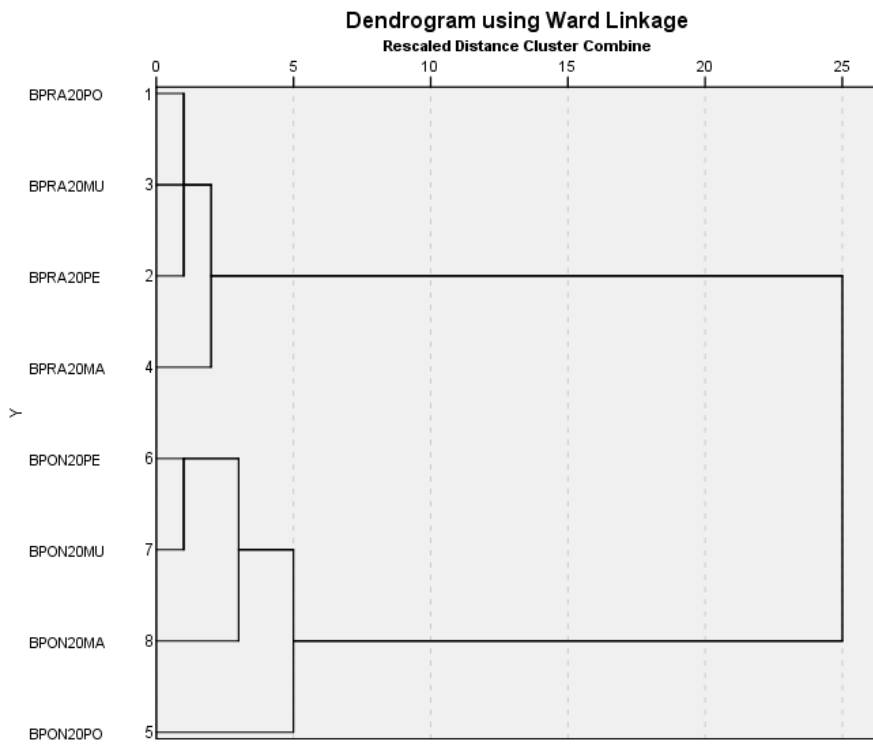

Dendrogram using Ward Linkage

Table 12: Pearson Correlation Coefficient (r) of water quality parameters of bore hole water in Pre monsoon and Post monsoon season during 2020

Correlations[a]

		Temp	pH	Turbidity	Alkalinity	HardnessCa	HardnessMg	Salinity	Fluoride	Chloride	TDS	DO	BOD	EC	TotNitrogen	Nitrate	Sulphate	Ammonia	Phosphate	Totphosphorus	Sodium	Potassium	ORP
Temp	Pearson Correlation	1	.178	-.172	.063	.174	.217	-.417	.300	.416	.395	-.690	-.313	.312	-.033	-.212	.585	.564	-.134	.511	.037	.535	.225
	Sig. (1-tailed)		.337	.342	.441	.340	.303	.152	.236	.153	.166	.029	.225	.226	.469	.307	.064	.073	.375	.098	.465	.086	.296
pH	Pearson Correlation	.178	1	.717	.353	.022	-.333	.091	-.567	-.197	.018	-.321	.350	-.319	-.584	-.075	.358	-.390	-.466	-.443	-.835	.504	-.564
	Sig. (1-tailed)	.337		.023	.196	.479	.210	.416	.071	.320	.483	.219	.198	.221	.064	.430	.192	.170	.122	.136	.005	.101	.073
Turbidity	Pearson Correlation	-.172	.717	1	.616	-.539	-.736	-.151	-.694	-.636	-.427	-.171	.058	-.872	-.854	.031	.033	-.496	-.465	-.483	-.964	-.163	-.961
	Sig. (1-tailed)	.342	.023		.052	.084	.019	.360	.028	.045	.146	.343	.446	.002	.003	.471	.470	.105	.123	.113	.000	.350	.000
Alkalinity	Pearson Correlation	.063	.353	.616	1	-.367	-.260	-.194	.063	-.724	-.755	-.309	.268	-.727	-.525	.191	-.267	-.018	.027	-.031	-.503	-.459	-.583
	Sig. (1-tailed)	.441	.196	.052		.186	.267	.322	.441	.021	.015	.228	.261	.021	.091	.325	.261	.483	.475	.471	.102	.127	.064
HardnessCa	Pearson Correlation	.174	.022	-.539	-.367	1	.720	.626	.180	.441	.333	.090	.447	.774	.488	-.372	-.212	-.122	.261	-.183	.439	.533	.601
	Sig. (1-tailed)	.340	.479	.084	.186		.022	.048	.335	.137	.210	.416	.133	.012	.110	.182	.307	.387	.266	.332	.138	.087	.058
HardnessMg	Pearson Correlation	.217	-.333	-.736	-.260	.720	1	.132	.582	.306	.221	.067	.149	.749	.450	-.441	-.219	.179	.667	.134	.751	.218	.699
	Sig. (1-tailed)	.303	.210	.019	.267	.022		.377	.065	.230	.299	.437	.363	.016	.132	.137	.301	.335	.035	.376	.016	.302	.027
Salinity	Pearson Correlation	-.417	.091	-.151	-.194	.626	.132	1	-.037	-.029	.096	.593	.656	.305	.488	.148	-.393	-.481	.189	-.519	.092	.194	.297
	Sig. (1-tailed)	.152	.416	.360	.322	.048	.377		.465	.472	.411	.061	.039	.232	.110	.363	.168	.114	.327	.094	.414	.322	.238
Fluoride	Pearson Correlation	.300	-.567	-.694	.063	.180	.582	-.037	1	.121	.052	.051	.047	.438	.652	.287	-.033	.666	.649	.631	.722	-.125	-.725
	Sig. (1-tailed)	.236	.071	.028	.441	.335	.065	.465		.388	.451	.452	.456	.139	.040	.245	.469	.036	.041	.047	.022	.384	.021
Chloride	Pearson Correlation	.416	-.197	-.636	-.724	.441	.306	-.029	.121	1	.577	-.353	-.072	.750	.523	-.017	.452	.524	-.341	.513	.456	.585	.619
	Sig. (1-tailed)	.153	.320	.045	.021	.137	.230	.472	.388		.067	.195	.433	.016	.092	.484	.130	.091	.204	.097	.128	.064	.051
TDS	Pearson Correlation	.395	.018	-.427	-.755	.333	.221	.096	.052	.577	1	.163	-.365	.692	.355	-.223	.660	.069	.040	.029	.242	.792	.524
	Sig. (1-tailed)	.166	.483	.146	.015	.210	.299	.411	.451	.067		.350	.187	.029	.194	.298	.037	.436	.462	.473	.282	.010	.091
DO	Pearson Correlation	-.690	-.321	-.171	-.309	.090	.067	.593	.051	-.353	.163	1	.051	.108	.349	.042	-.387	-.551	.579	-.540	.250	-.207	.212
	Sig. (1-tailed)	.029	.219	.343	.228	.416	.437	.061	.452	.195	.350		.453	.399	.199	.460	.171	.078	.066	.083	.275	.311	.307
BOD	Pearson Correlation	-.313	.350	.058	.268	.447	.149	.656	.047	-.072	-.365	.051	1	.046	.246	.378	-.326	-.150	-.023	-.197	-.098	.074	.070
	Sig. (1-tailed)	.225	.198	.446	.261	.133	.363	.039	.456	.433	.187	.453		.457	.279	.178	.215	.362	.478	.320	.409	.430	.435
EC	Pearson Correlation	.312	-.319	-.872	-.727	.774	.749	.305	.438	.750	.692	.108	.046	1	.738	-.221	.182	.281	.305	.235	.741	.599	.906
	Sig. (1-tailed)	.226	.221	.002	.021	.012	.016	.232	.139	.016	.029	.399	.457		.018	.299	.333	.250	.231	.288	.018	.058	.001
TotNitrogen	Pearson Correlation	-.033	-.584	-.854	-.525	.488	.450	.488	.652	.523	.355	.349	.246	.738	1	.387	-.042	.413	.341	.391	.780	.147	.918
	Sig. (1-tailed)	.469	.064	.003	.091	.110	.132	.110	.040	.092	.194	.199	.279	.018		.172	.461	.155	.204	.169	.011	.364	.001
Nitrate	Pearson Correlation	-.212	-.075	.031	.191	-.372	-.441	.148	.287	-.017	-.223	.042	.378	-.221	.387	1	.165	.420	-.221	.423	-.073	-.220	.086
	Sig. (1-tailed)	.307	.430	.471	.325	.182	.137	.363	.245	.484	.298	.460	.178	.299	.172		.348	.150	.300	.148	.432	.300	.420
Sulphate	Pearson Correlation	.585	.358	.033	-.267	-.212	-.219	-.393	-.033	.452	.660	-.387	-.326	.182	-.042	.165	1	.406	-.412	.372	-.230	.673	.080
	Sig. (1-tailed)	.064	.192	.470	.261	.307	.301	.168	.469	.130	.037	.171	.215	.333	.461	.348		.159	.155	.182	.292	.034	.425
Ammonia	Pearson Correlation	.564	-.390	-.496	-.018	-.122	.179	-.481	.666	.524	.069	-.551	-.150	.281	.413	.420	.406	1	-.084	.994	.437	.019	.476
	Sig. (1-tailed)	.073	.170	.105	.483	.387	.335	.114	.036	.091	.436	.078	.362	.250	.155	.150	.159		.422	.000	.139	.482	.117
Phosphate	Pearson Correlation	-.134	-.466	-.465	.027	.261	.667	.189	.649	-.341	.040	.579	-.023	.305	.341	-.221	-.412	-.084	1	-.109	.595	-.236	.460
	Sig. (1-tailed)	.375	.122	.123	.475	.266	.035	.327	.041	.204	.462	.066	.478	.231	.204	.300	.155	.422		.398	.060	.286	.126
Totphosphorus	Pearson Correlation	.511	-.443	-.483	-.031	-.183	.134	-.519	.631	.513	.029	-.540	-.197	.235	.391	.423	.372	.994	-.109	1	.440	-.054	.439
	Sig. (1-tailed)	.098	.136	.113	.471	.332	.376	.094	.047	.097	.473	.083	.320	.288	.169	.148	.182	.000	.398		.138	.449	.138
Sodium	Pearson Correlation	.037	-.835	-.964	-.503	.439	.751	.092	.722	.456	.242	.250	-.098	.741	.780	-.073	-.230	.437	.595	.440	1	-.078	.877
	Sig. (1-tailed)	.465	.005	.000	.102	.138	.016	.414	.022	.128	.282	.275	.409	.018	.011	.432	.292	.139	.060	.138		.427	.002
Potassium	Pearson Correlation	.535	.504	-.163	-.459	.533	.218	.194	-.125	.585	.792	-.207	.074	.599	.147	-.220	.673	.019	-.236	-.054	-.078	1	.318
	Sig. (1-tailed)	.086	.101	.350	.127	.087	.302	.322	.384	.064	.010	.311	.430	.058	.364	.300	.034	.482	.286	.449	.427		.221
ORP	Pearson Correlation	.225	-.564	-.961	-.583	.601	.699	.297	-.725	.619	.524	.212	.070	.906	.918	.086	.080	.476	.460	.439	.877	.318	1
	Sig. (1-tailed)	.296	.073	.000	.064	.058	.027	.238	.021	.051	.091	.307	.435	.001	.001	.420	.425	.117	.126	.138	.002	.221	

a. Listwise N=8

CONCLUSION

The physico-chemical analysis of well and bore hole water samples in and around the villages from Pozhikkarai to Manavalakurichi of Kanyakumari District was done. Water samples from well and bore hole in four sites namely Pozhikkarai, Periyakadu, Muttom, Manavalakurichi were collected in pre monsoon and post monsoon seasons during 2019 and 2020 were carried out. The statistical assessment is also carried out for the Physico-chemical parameters. Most of the parameters are well within the permissible limits. It is concluded that from the results of the present study, it may be said that the water from well and bore hole in and around the villages from Pozhikkarai to Manavalakurichi of Kanyakumari District collected in pre monsoon and post monsoon seasons during 2019 ad 2020 fits for domestic purpose. Statistical analysis results showed that the CA technique is useful in classification of water samples in the study region and the number of parameters. The application of cluster analysis proved that one major group of similarity between twenty two physicochemical parameters are formed in the water samples of well and bore hole in and around the villages namely Pozhikarai, Periyakadu, Muttom, Manavalakurichi.

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