

Statistical Assessment of Physico-chemical Parameters of Water from Bore Holes and Shallow Wells in Agateeswaram and Kalkulam Taluks of Kanyakumari District, India

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Abstract A systematic study has been carried out to explore physico-chemical parameters of drinking water from bore holes and shallow wells in five different stations (sites) of Agateeswaram and Kalkulam Taluks in Kanyakumari District of South India. Water samples from bore holes and shallow wells in five stations were collected 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. Comparative studies of parameters in different stations and in different Taluks were also carried out. 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 stations and in different Taluks. 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.

Keywords Bore Hole, Shallow Well, Agateeswaram Taluk, Kalkulam Taluk, Physico-chemical Parameters, Basic Statistics, Correlation Matrix, Hierarchical Cluster Analysis

1. Introduction

The life of living organism depends on water^[1-4]. The main source of life for many people in the world is the

ground water^[5]. The pollution of surface and ground water is a major problem due to rapid urbanization and industrialization^[6]. The water demand is continuously increasing mainly due to population growth and raising needs in agriculture, industrial uses and domestic services^[7]. Several studies on the ground water quality have been carried out in different parts of India^[8-11]. Kanyakumari district is divided into four Taluks. The district is part of the composite east flowing river basin "between Pazhayar and Tamirabarani" as per the irrigation Atlas of India^[12]. People in Kanya Kumari district depends on bore holes and shallow wells for domestic purpose. The quality of water from bore holes and shallow wells are to be analyzed. The objective of this study is to investigate physico-chemical analysis and statistical analysis of parameters of water from bore holes and shallow wells in our study area. Study area consists of four Taluks namely Agateeswaram, Kalkulam, Vilavamcode and Thovalai. But at present, we liberate the results of the Agateeswaram and Kalkulam Taluks.

2. Material and Methods

Study Area (Figure 1).

Kanyakumari district is the southernmost district of the state of Tamil Nadu, and the southernmost tip of peninsular India. It is located between 77°15' and 77° 36' of east of longitudes and 8° 03' and 8° 35' north of latitudes. Agateeswaram and Kalkulam Taluks are situated near to Thovalai and Vilavamcode respectively.

Collection of samples

Bore hole water samples were collected from five stations namely Agateeswaram, Kanyakumari, Nagercoil,

Suchindrum and Vadasery of Agateeswaram Taluk. The above stations are hereafter referred as B1, B2, B3, B4, B5. Bore hole water samples were collected from five villages namely Colachel, Kurunthencode, Manavalakurich, Thukalay and Vellimalai of Kalkulam Taluk. These stations are hereafter referred as B6, B7, B8, B9, B10. Similarly shallow well water samples were also collected from the above said villages and were labeled as Agateeswaram (S1), Kanyakumari (S2), Nagercoil (S3), Suchindrum (S4) and Vadasery (S5) of Agateeswaram Taluk and Colachel(S6), Kurunthencode(S7), Manavalakurichi (S8), Thukalay (S9) and Vellimalai (S10) of Kalkulam Taluk. Sample from all the above stations were collected in pre-cleaned to polyethylene bottles and labeled as said above.



Figure 1. Study Area

Physico-Chemical Analysis

Samples collected from all the stations were analysed for physico-chemical analysis using standard methods^[13]. 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 titrimetrically. 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 analyse nitrate. Salinity was estimated by Argentometric titration method. The dissolved oxygen was estimated by Winkler's method. The findings of the present investigation were summarized and compared with standards^[14,15].

Reagents and Classware

All reagents used in our work were of analytical grade. Double distilled water was used to prepare all the reagents and calibration standards.

Statistical Analysis

The correlation between various physico-chemical parameters of water samples analysed 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) and the relation between various parameters were also studied by Microsoft office Excel 2007.

2. Result and Discussion

The physical and 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 of the drinking water samples collected from five different stations in bore holes in Agateeswaram Taluk, bore holes in Kalkulam Taluk, shallow wells in Agateeswaram Taluk and shallow wells in Kalkulam Taluk were given in Tables: 1, 3, 5 and 7 respectively.

In this study the tools used for data analysis are mainly experimental aimed at defining possible trends, relationships or interactions among the measured parameters.

Descriptive statistics in the forms of mean, SD, median, minimum, maximum, variance (V), Kurtosis (K), Skewness(S), standard error of mean (SEM), standard error of kurtosis (SEK), standard error of skewness (SES) were calculated and summarized in Tabular form in Tables 2, 4, 6 and 8 respectively.

The physico-chemical parameters were also analysed through graphical representation using Microsoft office Excel 2007 to know the relation between the parameters for samples taken from bore hole of Agateeswaram Taluk (Figures 2 to 7), for samples taken from bore hole of Kalkulam Taluk (Figures 8 to 13), for shallow well of Agateeswaram Taluk (Figures 14 to 19), for samples taken from shallow well of Kalkulam Taluk (Figures 20 to 25).

Table 1. Physical and Chemical Parameters of bore hole water from Agasteeswaram Taluk (Stations B1 to B5)

Stations	Parameters							
	Temp(°C)	pH	Turbidity	EC (MicS/cm)	TDS (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)
B1	26	6.8	7.92	721	62	19.85	14.75	180
B2	27	6.2	7.7	720	61	18.2	13.71	183
B3	28	7.6	7.7	680	64	18.7	14.72	180
B4	26	6.3	7.7	730	62	19.7	12.92	189
B5	27	7.7	7.6	625	63	19	12.98	191
Stations	Hardness Ca (mg/L)	Hardness Mg (mg/L)	Fluoride (ppm)	Chloride (mg/L)	Total N (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Ammonia (mg/L)
B1	60	1.5	0.8	250	4.2	0.6	5.8	5.85
B2	65	1.5	0.8	255	4	0.5	5.5	6
B3	69	1.4	0.7	265	4.3	0.5	5.4	8
B4	62	1.6	0.8	280	4.2	0.62	5.2	5.2
B5	60	1.5	0.7	260	4.3	0.8	5	5
Stations	Phosphate (mg/L)	Total P (mg/L)	Salinity (ppm)	DO (mg/L)	BOD (mg/L)	OXREDPot (mV)		
B1	0.9	0.7	70	5.4	4.5	650		
B2	0.8	0.6	83	6	4.8	620		
B3	0.8	0.7	80	5.3	5	610		
B4	0.92	0.7	79	6	5.2	600		
B5	0.85	0.65	70	5.2	5	620		

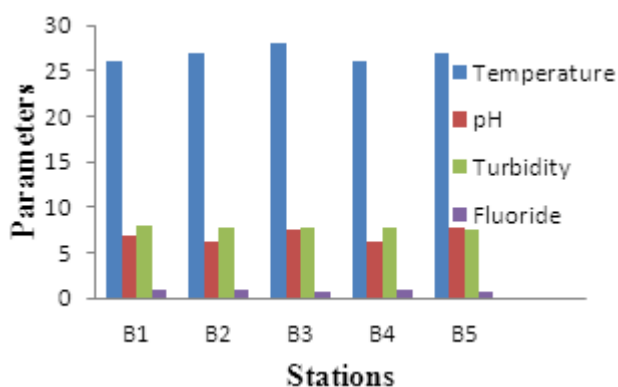


Figure 2. Relation between Temperature, pH, Turbidity, Fluoride bore hole water of Agasteeswaram Taluk

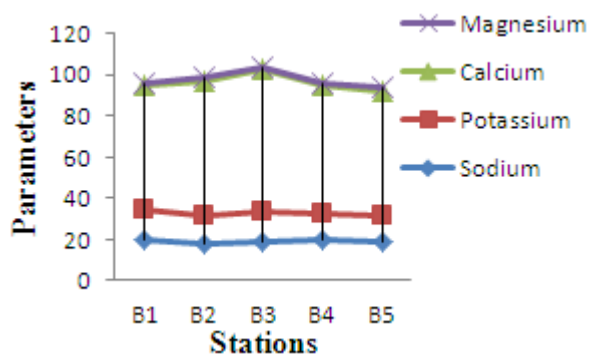


Figure 3. Relation between Na, K, Ca, Mg of bore hole water from Agasteeswaram Taluk

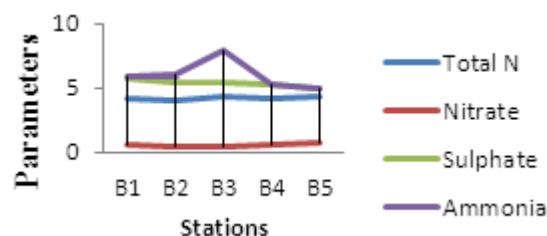


Figure 4. Relation between Total N, Nitrate, Sulphate, Ammonia of bore hole water from Agasteeswaram Taluk

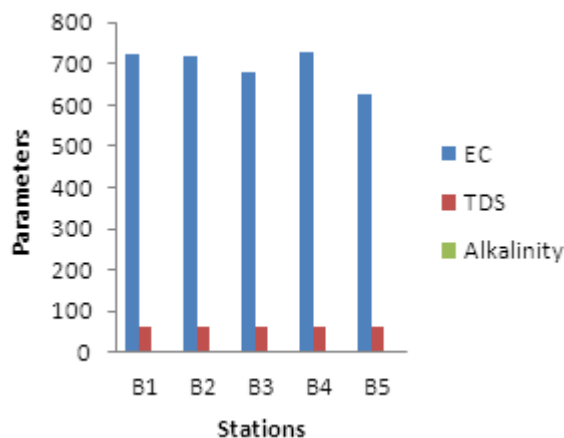


Figure 5. Relation between EC, TDS, Alkalinity of bore hole water of Agasteeswaram Taluk

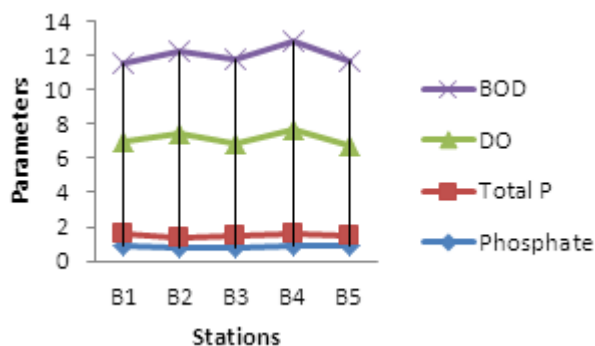


Figure 6. Relation between Phosphate, Total P, DO, BOD of bore hole water of Agateeswaram Taluk

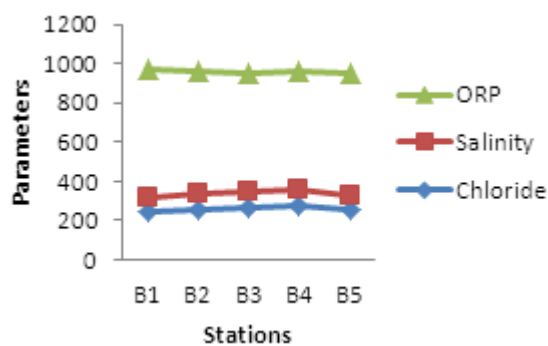


Figure 7. Relation between Chloride, Salinity, ORP of bore hole water of Agateeswaram Taluk

Table 2. Statistics of Physico-Chemical parameters of bore hole water from Agateeswaram Taluk (Stations B1 to B5)

Parameters	Mean	N	SD	Median	SEM	Minimum	Maximum	V	Kurtosis	SEK	S	SES
Temperature	26.80	5	0.836	27.00	0.374	26.0	28.0	0.700	-0.612	2.0	0.512	0.913
pH	6.92	5	0.704	6.80	0.315	6.2	7.7	0.497	-2.936	2.0	0.209	0.913
Turbidity	7.72	5	0.111	7.70	0.052	7.6	7.9	0.014	3.116	2.0	1.422	0.913
EC	695.20	5	43.734	720.00	19.558	625.0	730.0	1912.700	1.098	2.0	-1.369	0.913
TDS	62.40	5	1.140	62.00	0.509	61.0	64.0	1.300	-0.178	2.0	0.405	0.913
Sodium	19.09	5	0.689	19.00	0.308	18.2	19.8	0.476	-1.793	2.0	-0.126	0.913
Potassium	13.81	5	0.894	13.71	0.400	12.9	14.7	0.801	-3.004	2.0	0.145	0.913
Alkalinity	184.60	5	5.128	183.00	2.293	180.0	191.0	26.300	-2.661	2.0	0.459	0.913
HardnessCa	63.20	5	3.834	62.00	1.714	60.0	69.0	14.700	-0.168	2.0	0.988	0.913
HardnessMg	1.50	5	0.070	1.50	0.031	1.4	1.6	0.005	2.000	2.0	0.000	0.913
Fluoride	0.76	5	0.054	0.80	0.024	0.7	0.8	0.003	-3.333	2.0	-0.609	0.913
Chloride	262.00	5	11.510	260.00	5.147	250.0	280.0	132.500	1.129	2.	1.033	0.913
TotalN	4.20	5	0.122	4.20	0.054	4.0	4.3	0.015	2.000	2.0	-1.361	0.913
Nitrate	0.60	5	0.122	0.60	0.054	0.5	0.8	0.015	1.399	2.0	1.189	0.913
Sulphate	5.38	5	0.303	5.40	0.135	5.0	5.8	0.092	-0.139	2.0	0.226	0.913
Ammonia	6.01	5	1.189	5.85	0.532	5.0	8.0	1.415	2.702	2.0	1.562	0.913
Phosphate	0.85	5	0.055	0.85	0.024	0.8	0.9	0.003	-2.669	2.0	0.170	0.913
TotalP	0.67	5	0.044	0.70	0.020	0.6	0.7	0.002	0.313	2.0	-1.258	0.913
Salinity	76.40	5	6.024	79.00	2.694	70.0	83.0	36.300	-2.814	2.0	-0.329	0.913
DO	5.58	5	0.389	5.40	0.174	5.2	6.0	0.152	-3.115	2.0	0.461	0.913
BOD	4.90	5	0.264	5.00	0.118	4.5	5.2	0.070	0.673	2.0	-0.810	0.913
OXREDPot	620.00	5	18.708	620.00	8.366	600.0	650.0	350.000	2.000	2.0	1.145	0.913

Table 3. Physical and Chemical Parameters of bore hole water from Kalkulam Taluk (Stations B6 to B10)

Stations	Parameters							
	Temp(°C)	pH	Turbidity	EC (MicS/cm)	TDS (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)
B6	26	7.2	7.3	600	69	17.9	13.97	194
B7	28	7.9	7.3	720	80	18	15.5	200
B8	28	7.6	7.2	720	74	19.2	15	198
B9	27	7	7	690	78	19.8	14.7	197
B10	28	7.2	7.6	790	62	18.2	13.9	190
Stations	Hardness Ca (mg/L)	Hardness Mg (mg/L)	Fluoride (ppm)	Chloride (mg/L)	Total N (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Ammonia (mg/L)
B6	69	2	0.6	235	4.6	0.7	5.9	5.9
B7	71	2.2	0.8	230	4.8	0.8	6.7	6.7
B8	70	1.5	0.7	240	4.3	0.6	6	6
B9	63	1.6	0.8	225	4.5	0.8	6.5	6.5
B10	68	2	0.6	230	4.2	0.8	6.2	6.2
Stations	Phosphate (mg/L)	Total P (mg/L)	Salinity (ppm)	DO (mg/L)	BOD (mg/L)	OXREDPot (mV)		
B6	0.87	0.6	81	5.8	4.9	610		
B7	0.79	0.72	70	6.9	4.6	630		
B8	1	0.8	70	6	5.4	635		
B9	0.9	0.8	82	6.2	5.6	625		
B10	1.1	0.78	70	7	5.8	615		

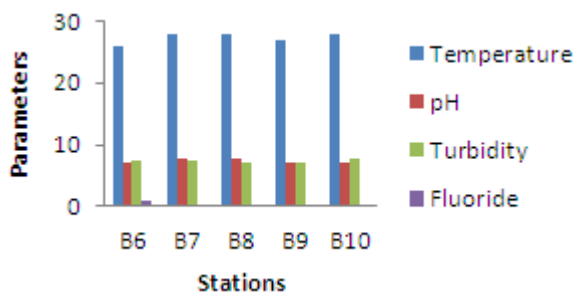


Figure 8. Relation between Temperature pH, Turbidity, Fluoride of bore hole water of kalkulam Taluk

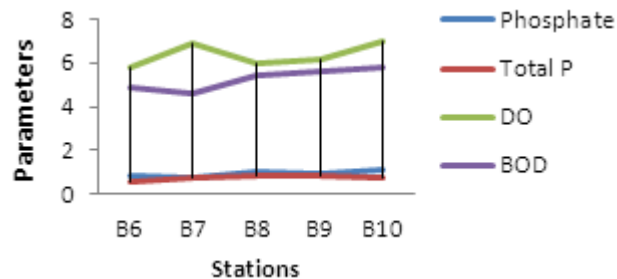


Figure 12. Relation between Phosphate, Total P, DO, BOD of bore hole water of Kalkulam Taluk

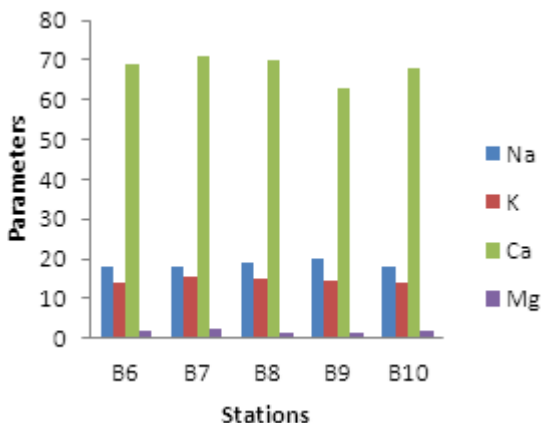


Figure 9. Relation between Na, K, Ca, Mg of bore hole water of Kalkulam Taluk

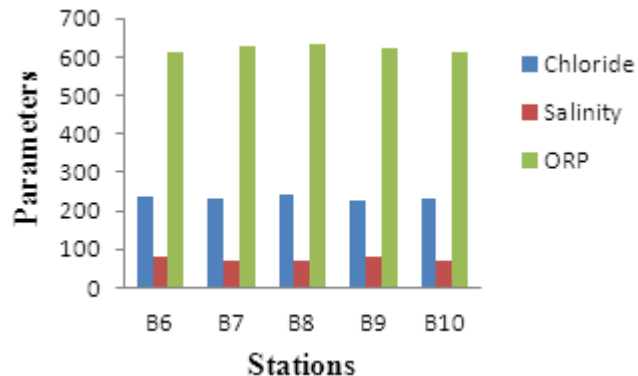


Figure 13. Relation between Chloride, Salinity, ORP of bore hole water of Kalkulam Taluk

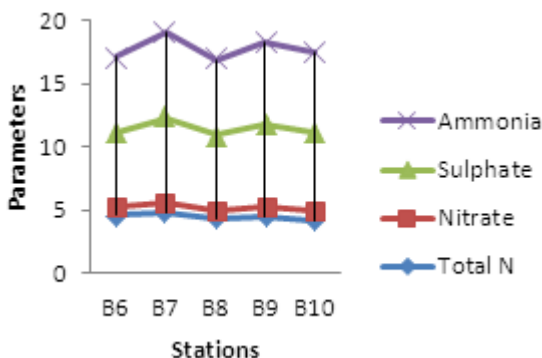


Figure 10. Relation between Total N, Nitrate, Sulphate, Ammonia of bore hole water of Kalkulam taluk

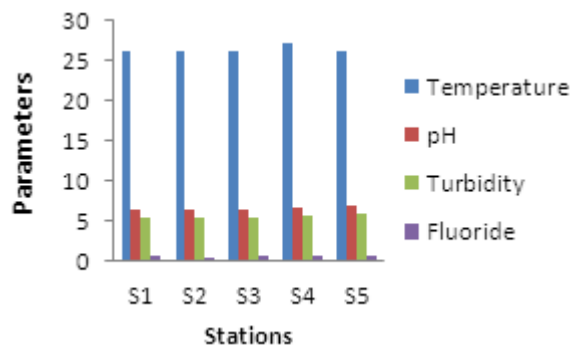


Figure 14. Relation between Temperature, pH, Turbidity, Fluoride of shallow well water of Agateeswaram taluk

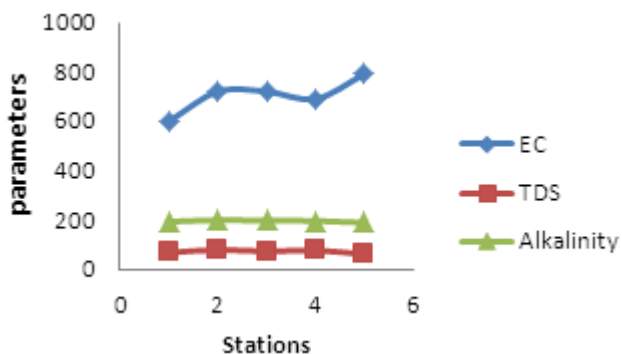


Figure 11. Relation between EC, TDS, Alkalinity of bore hole water of Kalkulam taluk

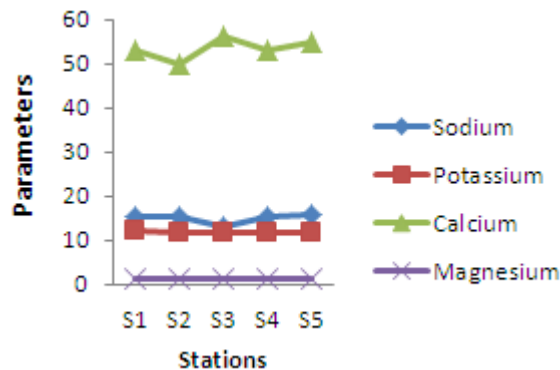


Figure 15. Relation between Na, K, ca, Mg of shallow well water of Agateeswaram Taluk

Table 4. Statistics of Physico-Chemical Parameters of Bore Hole water from Kalkulam Taluk (Stations B6 to B10)

	Mean	N	Std. Deviation	Median	SEM	Minimum	Maximum	Variance	Kurtosis	SEK	Skewness	SEK
Temp	27.40	5	0.894	28.00	0.400	26.00	28.00	.800	0.313	2.0	-1.258	0.913
pH	7.38	5	0.363	7.20	0.162	7.00	7.90	.132	-0.940	2.0	0.736	0.913
Turbidity	7.20	5	0.216	7.30	0.096	7.00	7.60	.047	1.435	2.0	0.422	0.913
EC	704.00	5	68.775	720.00	30.757	600.00	790.00	4730.000	1.602	2.0	-0.619	0.913
TDS	72.60	5	7.266	74.00	3.249	62.00	80.00	52.800	-0.537	2.0	-0.730	0.913
Sodium	18.62	5	0.837	18.20	0.374	17.90	19.80	.702	-1.660	2.0	0.816	0.913
Potassium	14.61	5	0.682	14.70	0.305	13.90	15.50	.466	-1.851	2.0	0.160	0.913
Alkalinity	195.80	5	3.898	197.00	1.743	190.00	200.00	15.200	0.001	2.0	-.805	0.913
HardnessCa	68.20	5	3.114	69.00	1.392	63.00	71.00	9.700	2.675	2.0	-1.549	0.913
HardnessMg	1.86	5	0.296	2.00	0.132	1.50	2.20	.088	-2.270	2.0	-.310	0.913
Fluoride	0.70	5	0.100	0.70	0.044	.60	.80	.010	-3.000	2.0	0.000	0.913
Chloride	232.00	5	5.700	230.00	2.549	225.00	240.00	32.500	-0.178	2.0	0.405	0.913
TotalN	4.48	5	0.238	4.50	0.106	4.20	4.80	.057	-1.117	2.0	0.206	0.913
Nitrate	0.74	5	0.089	0.80	0.040	.60	.80	.008	0.312	2.0	-1.258	0.913
Sulphate	6.26	5	0.336	6.20	0.150	5.90	6.70	.113	-1.913	2.0	0.379	0.913
Ammonia	6.26	5	0.336	6.20	0.150	5.90	6.70	.113	-1.913	2.0	0.379	0.913
Phosphate	0.93	5	0.120	0.90	0.053	.79	1.10	.014	-0.595	2.0	0.460	0.913
TotalP	0.740	5	0.084	0.78	0.037	.60	.80	.007	1.954	2.0	-1.539	0.913
Salinity	74.60	5	6.308	70.00	2.821	70.00	82.00	39.800	-3.250	2.0	0.623	0.913
DO	6.38	5	0.540	6.20	0.241	5.80	7.00	.292	-2.782	2.0	0.325	0.913
BOD	5.26	5	0.498	5.40	0.222	4.60	5.80	.248	-1.795	2.0	-0.454	0.913
OXREDPot	623.00	5	10.368	625.00	4.636	610.00	635.00	107.500	-1.963	2.0	-0.236	0.913

Table 5. Physical and Chemical Parameters of Shallow well water from Agateeswaram Taluk (Stations S1 to S5)

Stations	Parameters							
	Temp(°C)	pH	Turbidity	EC (MicS/cm)	TDS (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)
S1	26	6.4	5.4	650	36	15.2	12.2	140
S2	26	6.3	5.4	625	37	15.3	11.5	150
S3	26	6.4	5.4	600	36	13	11.8	142
S4	27	6.5	5.5	632	36.5	15.2	11.9	160
S5	26	6.8	5.8	635	37	16	11.8	143
Stations	Hardness Ca (mg/L)	Hardness Mg (mg/L)	Fluoride (ppm)	Chloride (mg/L)	Total N (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Ammonia (mg/L)
S1	53	1.3	0.5	230	3.8	0.5	4.42	5
S2	50	1.25	0.4	220	3.4	0.4	4.38	5.2
S3	56	1.3	0.5	210	4	0.5	4.48	5.4
S4	53	1.27	0.5	220	4.2	0.5	4.5	5
S5	55	1.25	0.6	209	4	0.5	4.6	5
Stations	Phosphate (mg/L)	Total P (mg/L)	Salinity (ppm)	DO (mg/L)	BOD (mg/L)	OXREDPot (mV)		
S1	0.7	0.5	30	7.2	5	600		
S2	0.6	0.4	28	6.8	4	560		
S3	0.75	0.5	42	6.5	5.3	570		
S4	0.6	0.5	52	6.4	5.2	570		
S5	0.6	0.55	38	6.3	5	580		

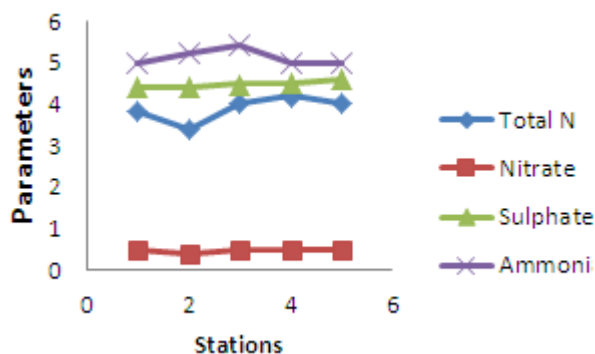


Figure 16. Relation between Total N, Nitrate, Sulphate, Ammonia of shallow well water of Agateeswaram taluk

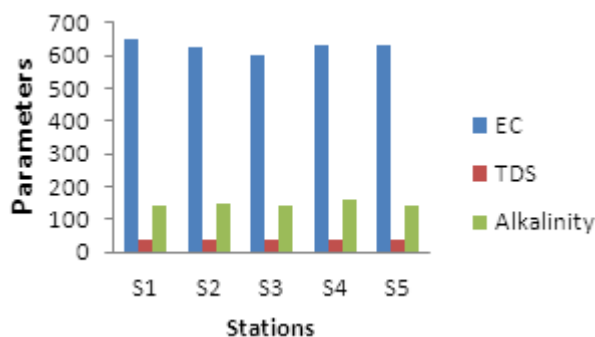


Figure 17. Relation between EC, TDS, Alkalinity of shallow well water of Agateeswaram taluk

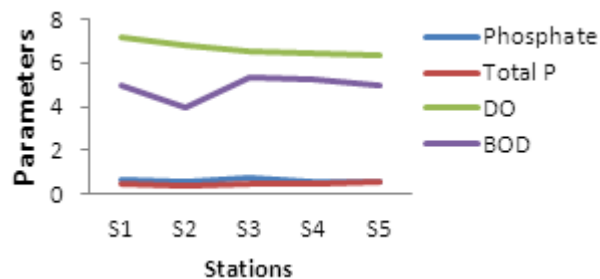


Figure 18. Relation between Phosphate, Total P, DO, BOD of shallow well water of Agateeswaram taluk

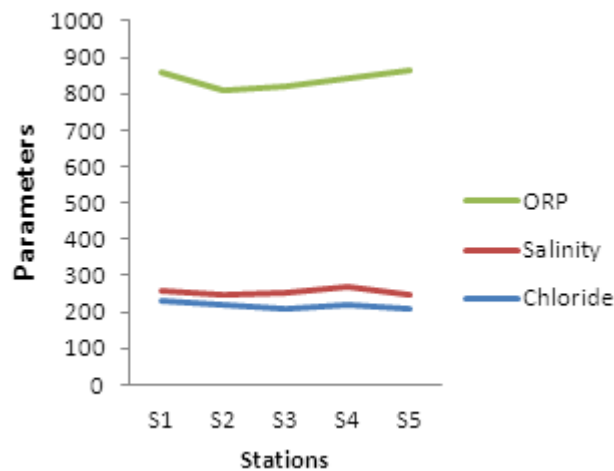


Figure 19. Relation between Chloride, Salinity, ORP of shallow well water of Agateeswaram taluk

Table 6. Statistics of Physico-Chemical parameters of shallow wells water from Agateeswaram Taluk (S1 to S5)

	Mean	N	SD	Median	SEM	Minimum	Maximum	Variance	Kurtosis	SEK	Skewness	SEK
Temp	26.20	5	0.447	26.00	0.200	26.00	27.00	0.200	5.000	2.0	2.236	0.913
pH	6.48	5	0.192	6.40	0.086	6.30	6.80	0.037	2.608	2.0	1.517	0.913
Turbidity	5.50	5	0.173	5.40	0.077	5.40	5.80	0.030	3.667	2.0	1.925	0.913
EC	628.40	5	18.311	632.00	8.189	600.00	650.00	335.300	1.678	2.0	-851	0.913
TDS	36.50	5	0.500	36.50	0.223	36.00	37.00	0.250	-3.000	2.0	0.000	0.913
Sodium	14.94	5	1.134	15.20	0.507	13.00	16.00	1.288	3.644	2.0	-1.718	0.913
Potassium	11.84	5	0.251	11.80	0.112	11.50	12.20	0.063	1.504	2.0	0.196	0.913
Alkalinity	147.00	5	8.185	143.00	3.660	140.00	160.00	67.000	0.890	2.0	1.286	0.913
HardnessCa	53.40	5	2.302	53.00	1.029	50.00	56.00	5.300	0.274	2.0	0-.606	0.913
HardnessMg	1.27	5	0.025	1.27	0.011	1.25	1.30	0.001	-3.031	2.0	0.196	0.913
Fluoride	0.50	5	0.070	0.50	0.031	0.40	0.60	0.005	2.000	2.0	0.000	0.913
Chloride	217.80	5	8.613	220.00	3.852	209.00	230.00	74.200	-0.758	2.0	0.444	0.913
TotalN	3.88	5	0.303	4.00	0.135	3.40	4.20	0.092	1.456	2.0	-1.118	0.913
Nitrate	0.48	5	0.044	0.50	0.020	0.40	0.50	0.002	5.000	2.0	-2.236	0.913
Sulphate	4.47	5	0.084	4.48	0.037	4.38	4.60	0.007	0.267	2.0	0.602	0.913
Ammonia	5.12	5	0.178	5.00	0.080	5.00	5.40	0.032	0.313	2.0	1.258	0.913
Phosphate	0.65	5	0.070	0.60	0.031	0.60	0.75	0.005	-1.750	2.0	0.884	0.913
TotalP	0.49	5	0.054	0.50	0.024	0.40	0.55	0.003	2.917	2.0	-1.293	0.913
Salinity	38.00	5	9.695	38.00	4.335	28.00	52.00	94.000	-0.535	2.0	0.593	0.913
DO	6.64	5	0.364	6.50	0.163	6.30	7.20	0.133	0.202	2.0	1.064	0.913
BOD	4.90	5	0.519	5.00	0.232	4.00	5.30	0.270	3.831	2.0	-1.889	0.913
OXREDPot	583.00	5	23.345	570.00	10.440	560.00	615.00	545.000	-1.818	2.0	0.692	0.913

Table 7. Physical and Chemical Parameters of Shallow Well water from Kalkulam Taluk (Stations S6 to S10)

Stations	Parameters							
	Temp(°C)	pH	Turbidity	EC (MicS/cm)	TDS (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)
S6	26	6.8	5	631	37	15	11.2	140
S7	26	6.2	5.8	328	37.5	15.8	12.9	152
S8	27	6.1	5.4	620	36.5	15.7	12.8	150
S9	26	6	5	625	36	16	13.9	151
S10	26	6	5.2	600	35.8	15.1	12.9	153
Stations	Hardness Ca (mg/L)	Hardness Mg (mg/L)	Fluoride (ppm)	Chloride (mg/L)	Total N (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Ammonia (mg/L)
S6	56	1.7	0.6	210	3.9	0.4	4.7	5
S7	52	1.8	0.4	208	3.8	0.5	4.8	4.8
S8	55	1.3	0.6	206	3.8	0.5	4.4	4.8
S9	57	1.4	0.6	205	3.6	0.5	4.8	5.2
S10	56	1.2	0.5	203	3.9	0.6	4.4	5.3
Stations	Phosphate (mg/L)	Total P (mg/L)	Salinity (ppm)	DO (mg/L)	BOD (mg/L)	OXREDPot (mV)		
S6	0.72	0.54	25	7	5.8	580		
S7	0.8	0.53	54	7.2	5.5	590		
S8	0.4	0.5	42	7.4	6	582		
S9	0.5	0.48	72	6.8	6.4	576		
S10	0.7	0.4	42	6	4.6	572		

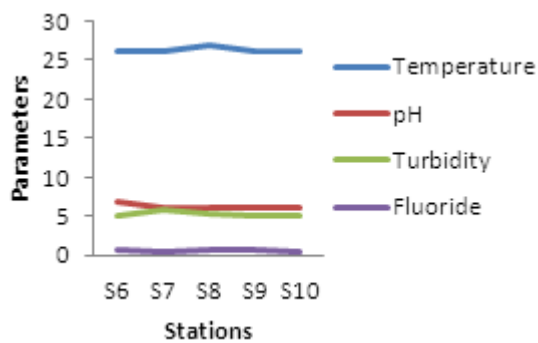


Figure 20. Relation between Temperature, pH, turbidity, Fluoride of shallow well water of Kalkulam taluk

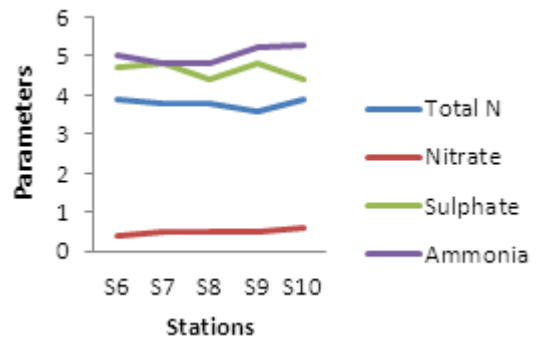


Figure 22. Relation between Total N Nitrate, Sulphate, Ammonia of Shallow well water of Kalkulam taluk

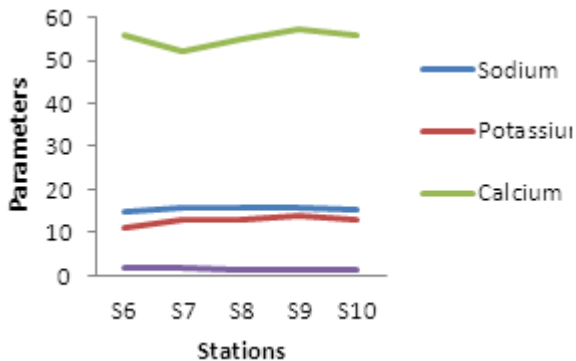


Figure 21. Relation between Na, K, Ca, Mg of shallow well water of Kalkulam taluk

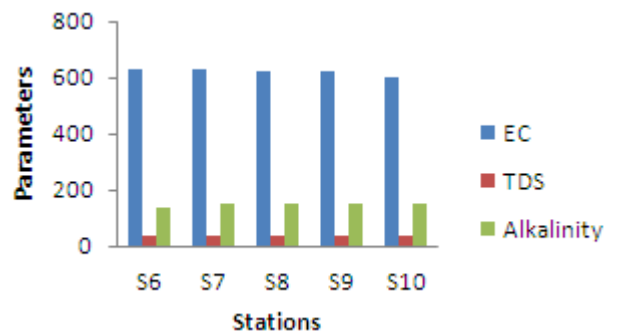


Figure 23. Relation between EC, TDS, Alkalinity of shallow well water of Kalkulam taluk

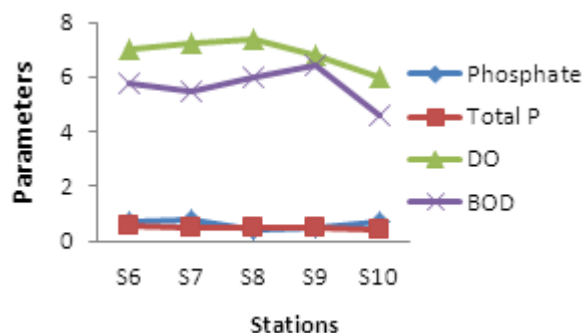


Figure 24. Relation between Phosphate, Total P, DO, BOD of shallow well water of Kalkulam taluk

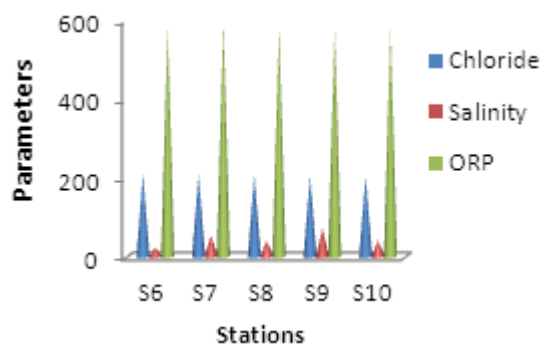


Figure 25. Relation between Chloride, Salinity, ORP of Shallow well water of Kalkulam taluk

Table 8. Statistics of Physico-Chemical Parameters of Shallow well water from Kalkulam Taluk (Stations S6 to S10)

	Mean	N	Std. Deviation	Median	SEM	Minimum	Maximum	Variance	Kurtosis	SEK	Skewness	SEK
Temp	26.20	5	0.447	26.00	0.200	26.00	27.00	0.200	5.000	2.0	2.236	0.913
pH	6.22	5	0.334	6.10	0.149	6.00	6.80	0.112	3.764	2.0	1.913	0.913
Turbidity	5.28	5	0.334	5.20	0.149	5.00	5.80	0.112	.536	2.0	1.089	0.913
EC	620.80	5	12.316	625.00	5.508	600.00	631.00	151.700	2.918	2.0	-1.670	0.913
TDS	36.56	5	0.702	36.50	0.314	35.80	37.50	0.493	-1.570	2.0	0.362	0.913
Sodium	15.52	5	0.443	15.70	0.198	15.00	16.00	0.197	-2.701	2.0	-.364	0.913
Potassium	12.74	5	0.971	12.90	0.434	11.20	13.90	0.943	2.453	2.0	-0.948	0.913
Alkalinity	149.20	5	5.263	151.00	2.353	140.00	153.00	27.700	4.128	2.0	-1.988	0.913
HardnessCa	55.20	5	1.923	56.00	0.860	52.00	57.00	3.700	2.608	2.0	-1.517	0.913
HardnessMg	1.48	5	0.258	1.40	0.115	1.20	1.80	0.067	-2.413	2.0	0.363	0.913
Fluoride	0.54	5	0.089	0.60	0.040	0.40	0.60	0.008	0.312	2.0	-1.258	0.913
Chloride	206.40	5	2.701	206.00	1.208	203.00	210.00	7.300	-0.681	2.0	0.183	0.913
TotalN	3.80	5	0.122	3.80	0.054	3.60	3.90	0.015	2.000	2.0	-1.361	0.913
Nitrate	0.50	5	0.070	0.50	0.031	0.40	0.60	0.005	2.000	2.0	0.000	0.913
Sulphate	4.62	5	0.204	4.70	0.091	4.40	4.80	0.042	-3.163	2.0	-0.441	0.913
Ammonia	5.02	5	0.228	5.00	0.101	4.80	5.30	.052	-2.507	2.0	0.228	0.913
Phosphate	0.62	5	0.166	0.70	0.074	0.40	0.80	.028	-1.838	2.0	-0.570	0.913
TotalP	0.49	5	0.055	0.50	0.024	0.40	0.54	.003	1.683	2.0	-1.304	0.913
Salinity	47.00	5	17.378	42.00	7.771	25.00	72.00	302.000	0.614	2.0	0.403	0.913
DO	6.88	5	0.540	7.00	0.241	6.00	7.40	.292	2.021	2.0	-1.339	0.913
BOD	5.66	5	0.676	5.80	0.302	4.60	6.40	.458	1.396	2.0	-1.005	0.913
OXREDPot	580.00	5	6.782	580.00	3.033	572.00	590.00	46.000	0.488	2.0	0.577	0.913

Temperature

The temperature was found to be range between 26 to 28°C during study.

pH

pH is an indicative of acidity or basicity of water. The pH values of bore holes water varied between 6.2 to 7.7 for B1 to B5, 7.0 to 7.9 for B6 to B10 (Tables 1, 3), 6.3 to 6.8 for S1 to S5, 6.0 to 6.8 for S6 to S10 (Tables 5,7). The mean pH of bore hole water found to be 6.92 for B1 to B5 and 7.38 for B6 to B10. This shows that water samples from bore hole of Agateeswaram Taluk is almost neutral but water samples from Kalkulam Taluk is slightly alkaline trend. The mean pH of shallow wells water found to be 6.48 for S1 to S5 and 6.42 for S6 to S10. This shows that water samples from shallow wells of both Taluks are slightly acidic trend. The pH of water is influenced by geology of catchments area and buffering capacity of water.

Turbidity

Turbidity is a measure of the light scattering potential of water caused by the presence of colloidal and suspended material. The turbidity values of bore holes water varied between 7.6 to 7.9 for B1 to B5, 7.0 to 7.6 for B6 to B10 (Tables 1, 3), 5.4 to 5.8 for S1 to S5, 5.0 to 5.8 for S6 to S10 (Tables 5, 7). The mean turbidity of bore hole water found to be 7.72 for B1 to B5 and 7.20 for B6 to B10. The mean turbidity of shallow wells water found to be 5.50 for S1 to S5 and 5.28 for S6 to S10. The limit of turbidity value for drinking water is specified as 5 to 10 NTU. The observed turbidity values are within the permissible limits.

Electrical conductivity

The EC values of bore holes water varied between 625 to 730 for B1 to B5, 600 to 790 for B6 to B10 (Tables 1, 3), 600 to 650 for S1 to S5, 600 to 631 for S6 to S10 (Tables 5,7). The mean EC of bore hole water found to be 695.20 for B1 to B5 and 704 for B6 to B10. The mean EC of shallow wells water found to be 628.40 for S1 to S5 and 620.80 for S6 to S10. The observed values are within the permissible limits.

Total dissolved solids (TDS)

ISI prescribed desirable limit of TDS is 500 mg/L. TDS values observed in B1 to B10 and S1 to S10 were low and with the desirable limit. The low value indicates that there is not much pollution by particles. The TDS values of bore holes water varied between 61 to 64 for B1 to B5, 62 to 80.0 for B6 to B10 (Tables 1, 3), 36 to 37 for S1 to S5, 35.80 to 37.50 for S6 to S10 (Tables 5, 7). The mean TDS of bore hole water found to be 62.4 for B1 to B5 and 72.60 for B6 to B10. The mean TDS of shallow wells water found to be 36.50 for S1 to S5 and 36.56 for S6 to S10.

Sodium (Na⁺) and potassium (K⁺)

The concentration of Na values of bore holes water varied between 18.2 to 19.8 for B1 to B5, 17.9 to 19.80 for

B6 to B10 (Tables 1, 3), 13.00 to 16.00 for S1 to S5, 15.0 to 16.0 for S6 to S10 (Tables 5, 7). The mean concentration of Na of bore hole water found to be 19.09 for B1 to B5 and 18.62 for B6 to B10. The mean concentration of Na of shallow wells water found to be 14.94 for S1 to S5 and 15.52 for S6 to S10. The observed values are within the permissible limits.

The concentration of K values of bore holes water varied between 12.9 to 14.7 for B1 to B5, 13.90 to 15.50 for B6 to B10 (Tables 1, 3), 11.50 to 12.20 for S1 to S5, 11.20 to 13.90 for S6 to S10 (Tables 5, 7). The mean concentration of K of bore hole water found to be 13.81 for B1 to B5 and 14.61 for B6 to B10. The mean concentration of K of shallow wells water found to be 11.84 for S1 to S5 and 12.74 for S6 to S10. The observed values are within the permissible limits.

Alkalinity

Alkalinity of water is a measure of its capacity to neutralize acids and provides an index for the nature of salts present in the water samples. The standard desirable limit of alkalinity in drinking water is 120 mg/L. The maximum permissible level is 600 mg/L. The alkalinity values of bore holes water varied between 180 to 191 for B1 to B5, 190 to 200 for B6 to B10 (Tables 1, 3), 140 to 160 for S1 to S5, 140 to 153 for S6 to S10 (Tables 5, 7). The mean alkalinity of bore hole water found to be 184.6 for B1 to B5 and 195.80 for B6 to B10. The mean alkalinity of shallow wells water found to be 147 for S1 to S5 and 149.20 for S6 to S10. The observed alkalinity values are within the permissible limits.

Calcium and Magnesium

The upper limit of calcium concentration in drinking water is specified as 75 mg/L (ISI, 1983). The Ca values of bore holes water varied between 60.0 to 69.0 for B1 to B5, 63.0 to 71.0 for B6 to B10 (Tables 1, 3), 50 to 56 for S1 to S5, 52 to 57 for S6 to S10 (Tables 5, 7). The mean Ca of bore hole water found to be 63.20 for B1 to B5 and 68.20 for B6 to B10. The mean Ca of shallow wells water found to be 53.40 for S1 to S5 and 55.20 for S6 to S10. observed values are within the permissible limits.

The upper limit of magnesium concentration in drinking water is specified as 30 mg/L (ISI, 1983). The Mg values of bore holes water varied between 1.4 to 1.6 for B1 to B5, 1.5 to 2.20 for B6 to B10 (Tables 1, 3), 1.25 to 1.40 for S1 to S5, 1.20 to 1.80 for S6 to S10 (Tables 5, 7). The mean Mg of bore hole water found to be 1.50 for B1 to B5 and 1.86 for B6 to B10. The mean Mg of shallow wells water found to be 1.27 for S1 to S5 and 1.48 for S6 to S10. The observed values are within the permissible limits.

Fluoride

Fluoride content is an important factor in the development of normal bones and teeth. The desirable limit is 1 to 1.5 mg/L for drinking purpose. Fluoride values observed in B1 to B10 and S1 to S10 were low and with the desirable limit. The Fluoride values of bore holes water varied between 0.7

to 0.8 for B1 to B5, 0.6 to 0.80 for B6 to B10 (Tables 1, 3), 0.4 to 0.60 for S1 to S5, 0.4 to 0.60 for S6 to S10 (Tables 5, 7). The mean Fluoride of bore hole water found to be 0.76 for B1 to B5 and 0.70 for B6 to B10. The mean Fluoride of shallow wells water found to be 0.50 for S1 to S5 and 0.54 for S6 to S10.

Chloride

Chloride is a most common inorganic anion present in water to it through biogenic sources and indicates the state of contamination. The chloride values of bore holes water varied between 250 to 280 for B1 to B5, 225 to 240 for B6 to B10 (Tables 1, 3), 209 to 230 for S1 to S5, 203 to 210 for S6 to S10 (Tables 5, 7). The mean chloride of bore hole water found to be 262 for B1 to B5 and 232 for B6 to B10. The mean chloride of shallow wells water found to be 217.80 for S1 to S5 and 206.40 for S6 to S10. The observed values are within the permissible limits.

Nitrate

The nitrate values of bore holes water varied between 0.5 to 0.8 for B1 to B5, 0.6 to 0.8 for B6 to B10 (Tables 1, 3), 0.4 to 0.50 for S1 to S5, 0.4 to 0.6 for S6 to S10 (Tables 5, 7). The mean nitrate of bore hole water found to be 0.60 for B1 to B5 and 0.74 for B6 to B10. The mean nitrate of shallow wells water found to be 0.48 for S1 to S5 and 0.50 for S6 to S10. The observed values are within the permissible limits.

Sulphate

Sulphate is the major anion occurring in natural waters. The upper limit for sulphate concentration for drinking water is 150 mg/L. The Sulphate values of bore holes water varied between 5.0 to 5.8 for B1 to B5, 5.90 to 6.70 for B6 to B10 (Tables 1, 3), 4.38 to 4.60 for S1 to S5, 4.40 to 4.80 for S6 to S10 (Tables 7, 10). The mean Sulphate of bore hole water found to be 5.38 for B1 to B5 and 6.26 for B6 to B10. The mean Sulphate of shallow wells water found to be 4.47 for S1 to S5 and 4.62 for S6 to S10. The observed values are within the permissible limits.

Phosphate

The phosphate ion in the water samples due to agriculture land composition of organic matter. The Phosphate values of bore holes water varied between 0.8 to 0.9 for B1 to B5, 0.79 to 1.10 for B6 to B10 (Tables 1, 3), 0.60 to 0.75 for S1 to S5, 0.40 to 0.80 for S6 to S10 (Tables 5, 7). The mean Phosphate of bore hole water found to be 0.85 for B1 to B5 and 0.93 for B6 to B10. The mean Phosphate of shallow wells water found to be 0.65 for S1 to S5 and 0.65 for S6 to S10. These values are within the permissible limits.

Salinity

The salinity values of bore holes water varied between

70.0 to 83.0 for B1 to B5, 70.0 to 82.0 for B6 to B10 (Tables 1, 3), 28 to 52 for S1 to S5, 25 to 72 for S6 to S10 (Tables 5, 7). The mean salinity of bore hole water found to be 76.4 for B1 to B5 and 74.6 for B6 to B10. This shows that water samples from bore holes of both Taluks are slightly alkaline trend. The mean salinity of shallow wells water found to be 38 for S1 to S5 and 47 for S6 to S10. The observed values are within the permissible limits.

Dissolved Oxygen

It is one of the most fundamental parameters in water, as it is to the metabolism of all aerobic aquatic organisms. The permissible limit of DO for drinking water is 6 mg/L. DO values observed in B1 to B10 and S1 to S10 were low and with the desirable limit. The pH values of bore holes water varied between 5.2 to 6.0 for B1 to B5, 5.80 to 7.0 for B6 to B10 (Tables 1, 3), 6.3 to 7.2 for S1 to S5, 6.0 to 7.4 for S6 to S10 (Tables 5, 7). The mean DO of bore hole water found to be 5.58 for B1 to B5 and 6.38 for B6 to B10. The mean DO of shallow wells water found to be 6.64 for S1 to S5 and 6.88 for S6 to S10.

Biochemical oxygen demand

The permissible limit for BOD as per WHO is 5 mg/L. The BOD values of bore holes water varied between 4.5 to 5.2 for B1 to B5, 4.60 to 5.80 for B6 to B10 (Tables 1, 3), 4.00 to 5.30 for S1 to S5, 4.60 to 6.4 for S6 to S10 (Tables 5, 7). The mean BOD of bore hole water found to be 4.90 for B1 to B5 and 5.26 for B6 to B10. The mean BOD of shallow wells water found to be 4.90 for S1 to S5 and 5.66 for S6 to S10.

Oxidation Reduction potential

The ORP values of bore holes water varied between 600 to 650 for B1 to B5, 610 to 635 for B6 to B10 (Tables 1, 3), 560 to 615 for S1 to S5, 572 to 590 for S6 to S10 (Tables 5, 7). The mean ORP of bore hole water found to be 620 for B1 to B5 and 623 for B6 to B10. The mean ORP of shallow wells water found to be 583 for S1 to S5 and 580 for S6 to S10. The shallow well water samples have less ORP value as compared to bore hole water samples. This indicates more oxygen present in bore hole water.

The **Pearson correlation analysis** was performed for measured parameters to determine the relation between these variables and given in Tables 9, 10, 11, and 12 respectively. 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.

Statistical Assessment of Physico-chemical Parameters of Water from Bore Holes and Shallow Wells
in Agateeswaram and Kalkulam Taluks of Kanyakumari District, India

Table 9. Correlations status for the measured Physico-chemical parameters of water from bore holes in Agateeswaram Taluk.

	Temp	pH	Turbidity	EC	TDS	Sodium	Potassium	Alkalinity	Hardness Ca	Hardness Mg	Fluoride	Chloride	TotalN	Nitrate	Sulphate	Ammonia	Phosphate	Total P	Salinity	DO	BOD	OXRED Pot
Temp	1	.602	-.497	-.518	.629	-.763	.289	-.256	.795	-.845*	-.764	-.078	.244	-.282	-.217	.743	-.894*	-.200	.367	-.399	.226	-.319
		.141	.197	.186	.128	.067	.318	.339	.054	.036	.066	.450	.346	.323	.363	.075	.020	.373	.272	.253	.357	.300
pH	.602	1	-.314	-.873*	.890*	-.084	.191	.058	.118	-.652	-.945**	-.129	.840*	.426	-.360	.326	-.303	.262	-.479	-.935**	.107	.038
	.141		.303	.027	.022	.446	.379	.463	.425	.117	.008	.418	.038	.237	.276	.296	.310	.335	.207	.010	.432	.476
Turbidity	-.497	-.314	1	.616	-.275	.542	.686	-.684	-.213	.000	.573	-.450	-.173	-.354	.912*	.117	.402	.408	-.270	-.009	-.786	.749
	.197	.303		.134	.327	.173	.101	.102	.366	.500	.156	.224	.390	.279	.015	.425	.251	.248	.330	.494	.057	.073
EC	-.518	-.873*	.616	1	-.629	.257	.225	-.429	.085	.404	.891*	.118	-.630	-.666	.639	.039	.334	.132	.459	.752	-.236	.070
	.186	.027	.134		.128	.338	.358	.236	.446	.250	.021	.425	.127	.110	.123	.475	.291	.416	.219	.071	.351	.455
TDS	.629	.890*	-.275	-.629	1	.006	.264	-.051	.377	-.620	-.881*	.210	.895*	.164	-.333	.549	-.229	.539	-.211	-.765	.331	-.234
	.128	.022	.327	.128		.496	.334	.467	.266	.132	.024	.368	.020	.396	.292	.169	.355	.174	.367	.066	.293	.352
Sodium	-.763	-.084	.542	.257	.006	1	-.008	.129	-.637	.513	.318	.224	.385	.361	.154	-.394	.945**	.758	-.601	-.103	-.110	.281
	.067	.446	.173	.338	.496		.495	.418	.124	.189	.301	.359	.261	.275	.402	.256	.008	.069	.142	.434	.430	.323
Potassium	.289	.191	.686	.225	.264	-.008	1	-.958**	.424	-.711	-.035	-.539	.064	-.603	.807*	.756	-.282	.327	-.019	-.376	-.660	.551
	.318	.379	.101	.358	.334	.495		.005	.239	.089	.478	.174	.459	.141	.049	.069	.323	.295	.488	.267	.113	.168
Alkalinity	-.256	.058	-.684	-.429	-.051	.129	-.958**	1	-.516	.620	-.160	.504	.199	.789	-.874*	-.755	.341	-.174	-.220	.108	.645	-.469
	.339	.463	.102	.236	.467	.418	.005		.187	.132	.398	.193	.374	.056	.026	.070	.287	.390	.361	.432	.120	.213
HardnessCa	.795	.118	-.213	.085	.377	-.637	.424	-.516	1	-.645	-.310	.159	-.053	-.756	.090	.890*	-.733	-.029	.764	.070	.246	-.453
	.054	.425	.366	.446	.266	.124	.239	.187		.120	.306	.399	.466	.070	.443	.022	.079	.481	.066	.455	.345	.222
HardnessMg	-.845*	-.652	.000	.404	-.620	.513	-.711	.620	-.645	1	.645	.461	-.289	.345	-.233	-.832*	.764	.000	-.059	.635	.267	-.189
	.036	.117	.500	.250	.132	.189	.089	.132	.120		.120	.217	.319	.285	.353	.040	.066	.500	.463	.125	.332	.380
Fluoride	-.764	-.945**	.573	.891*	-.881*	.318	-.035	-.160	-.310	.645	1	-.040	-.745	-.342	.542	-.376	.477	-.102	.212	.773	-.345	.244
	.066	.008	.156	.021	.024	.301	.478	.398	.306	.120		.475	.074	.287	.173	.266	.208	.435	.366	.063	.285	.346
Chloride	-.078	-.129	-.450	.118	.210	.224	-.539	.504	.159	.461	-.040	1	.266	.064	-.594	-.084	.337	.389	.364	.373	.903*	-.871*
	.450	.418	.224	.425	.368	.359	.174	.193	.399	.217	.475		.333	.459	.145	.447	.290	.259	.273	.268	.018	.027
TotalN	.244	.840*	-.173	-.630	.895*	.385	.064	.199	-.053	-.289	-.745	.266	1	.499	-.404	.172	.184	.685	-.542	-.785	.309	-.109
	.346	.038	.390	.127	.020	.261	.459	.374	.466	.319	.074	.333		.196	.250	.391	.384	.101	.173	.058	.307	.431
Nitrate	-.282	.426	-.354	-.666	.164	.361	-.603	.789	-.756	.345	-.342	.064	.499	1	-.628	-.712	.415	.027	-.760	-.426	.200	.065
	.323	.237	.279	.110	.396	.275	.141	.056	.070	.285	.287	.459	.196		.128	.089	.243	.483	.068	.237	.373	.458
Sulphate	-.217	-.360	.912*	.639	-.333	.154	.807*	-.874*	.090	-.233	.542	-.594	-.404	-.628	1	.347	.021	.129	.019	.080	-.841*	.705

	.363	.276	.015	.123	.292	.402	.049	.026	.443	.353	.173	.145	.250	.128		.284	.487	.418	.488	.449	.037	.092
Ammonia	.743	.326	.117	.039	.549	-.394	.756	-.755	.890*	-.832*	-.376	-.084	.172	-.712	.347	1	-.620	.242	.435	-.264	-.064	-.095
	.075	.296	.425	.475	.169	.256	.069	.070	.022	.040	.266	.447	.391	.089	.284		.132	.347	.232	.334	.460	.439
Phosphate	-.894*	-.303	.402	.334	-.229	.945**	-.282	.341	-.733	.764	.477	.337	.184	.415	.021	-.620	1	.564	-.484	.155	.017	.144
	.020	.310	.251	.291	.355	.008	.323	.287	.079	.066	.208	.290	.384	.243	.487	.132		.161	.204	.402	.489	.408
TotalP	-.200	.262	.408	.132	.539	.758	.327	-.174	-.029	.000	-.102	.389	.685	.027	.129	.242	.564	1	-.315	-.330	.106	.000
	.373	.335	.248	.416	.174	.069	.295	.390	.481	.500	.435	.259	.101	.483	.418	.347	.161		.303	.294	.433	.500
Salinity	.367	-.479	-.270	.459	-.211	-.601	-.019	-.220	.764	-.059	.212	.364	-.542	-.760	.019	.435	-.484	-.315	1	.685	.376	-.621
	.272	.207	.330	.219	.367	.142	.488	.361	.066	.463	.366	.273	.173	.068	.488	.232	.204	.303		.101	.266	.132
DO	-.399	-.935**	-.009	.752	-.765	-.103	-.376	.108	.070	.635	.773	.373	-.785	-.426	.080	-.264	.155	-.330	.685	1	.218	-.377
	.253	.010	.494	.071	.066	.434	.267	.432	.455	.125	.063	.268	.058	.237	.449	.334	.402	.294	.101		.362	.266
BOD	.226	.107	-.786	-.236	.331	-.110	-.660	.645	.246	.267	-.345	.903*	.309	.200	-.841*	-.064	.017	.106	.376	.218	1	-.960**
	.357	.432	.057	.351	.293	.430	.113	.120	.345	.332	.285	.018	.307	.373	.037	.460	.489	.433	.266	.362		.005
OXREDPot	-.319	.038	.749	.070	-.234	.281	.551	-.469	-.453	-.189	.244	-.871*	-.109	.065	.705	-.095	.144	.000	-.621	-.377	-.960**	1
	.300	.476	.073	.455	.352	.323	.168	.213	.222	.380	.346	.027	.431	.458	.092	.439	.408	.500	.132	.266	.005	

*. Correlation is significant at the 0.05 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

c. Listwise N=5

Table 10. Correlations status for the measured Physico-chemical parameters of water from bore holes in Kalkulam Taluk.

	Temp	pH	Turbidity	EC	TDS	Sodium	Potassium	Alkalinity	Hardness Ca	Hardness Mg	Fluoride	Chloride	Total N	Nitrate	Sulphate	Ammonia	Phosphate	TotalP	Salinity	DO	BOD	OXREDPot
Temp	1	.569	.309	.902*	.069	.087	.492	.172	.323	-.019	.280	.049	-.304	.063	.399	.399	.362	.725	-.895*	.693	.213	.647
		.158	.306	.018	.456	.445	.200	.391	.298	.488	.324	.469	.309	.460	.253	.253	.274	.083	.020	.097	.365	.119
pH	.569	1	.121	.204	.441	-.360	.763	.632	.822*	.339	.344	.386	.427	-.200	.319	.319	-.376	-.016	-.713	.316	-.655	.617
	.158		.423	.371	.228	.276	.067	.126	.044	.289	.285	.260	.237	.374	.300	.300	.266	.490	.088	.302	.115	.134
Turbidity	.309	.121	1	.476	-.784	-.740	-.470	-.686	.489	.606	-.692	.142	-.348	.180	-.220	-.220	.510	-.163	-.574	.593	.107	-.467
	.306	.423		.209	.058	.076	.212	.100	.202	.139	.098	.410	.283	.386	.361	.361	.190	.397	.156	.146	.432	.214
EC	.902*	.204	.476	1	-.236	.094	.132	-.211	.054	.010	.073	-.185	-.527	.293	.344	.344	.609	.763	-.756	.796	.517	.330
	.018	.371	.209		.351	.440	.416	.367	.466	.494	.454	.383	.181	.316	.285	.285	.138	.067	.070	.053	.186	.294
TDS	.069	.441	-.784	-.236	1	.396	.879*	.958**	-.062	-.160	.929*	-.187	.686	.031	.626	.626	-.768	.138	.137	-.136	-.503	.700
	.456	.228	.058	.351		.255	.025	.005	.461	.399	.011	.382	.101	.480	.129	.129	.065	.413	.413	.414	.194	.094
Sodium	.087	-.360	-.740	.094	.396	1	.236	.292	-.701	-.891*	.507	-.194	-.310	-.147	.128	.128	.158	.710	.295	-.330	.554	.509
	.445	.276	.076	.440	.255		.351	.317	.093	.021	.192	.377	.306	.407	.419	.419	.400	.089	.315	.294	.166	.190
Potassium	.492	.763	-.470	.132	.879*	.236	1	.936**	.277	-.062	.853*	.013	.519	-.052	.637	.637	-.555	.311	-.351	.155	-.482	.886*

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	.200	.067	.212	.416	.025	.351		.010	.326	.461	.033	.491	.185	.467	.124	.124	.166	.305	.281	.401	.206	.023
Alkalinity	.172	.632	-.686	-.211	.958**	.292	.936**	1	.189	-.160	.834*	.079	.639	-.186	.488	.488	-.719	.106	-.055	-.169	-.585	.792
	.391	.126	.100	.367	.005	.317	.010		.380	.399	.040	.450	.123	.382	.202	.202	.086	.433	.465	.393	.150	.055
Hardness Ca	.323	.822*	.489	.054	-.062	-.701	.277	.189	1	.471	-.241	.676	.208	-.395	-.181	-.181	-.128	-.359	-.682	.166	-.606	.170
	.298	.044	.202	.466	.461	.093	.326	.380		.212	.348	.105	.368	.255	.385	.385	.419	.276	.102	.395	.139	.392
Hardness Mg	-.019	.339	.606	.010	-.160	-.891*	-.062	-.160	.471	1	-.169	-.237	.515	.546	.306	.306	-.347	-.576	-.211	.571	-.572	-.439
	.488	.289	.139	.494	.399	.021	.461	.399	.212		.393	.351	.187	.170	.308	.308	.283	.155	.367	.157	.157	.230
Fluoride	.280	.344	-.692	.073	.929*	.507	.853*	.834*	-.241	-.169	1	-.439	.524	.280	.818*	.818*	-.582	.412	.040	.139	-.251	.723
	.324	.285	.098	.454	.011	.192	.033	.040	.348	.393		.230	.183	.324	.045	.045	.152	.245	.475	.412	.342	.084
Chloride	.049	.386	.142	-.185	-.187	-.194	.013	.079	.676	-.237	-.439	1	-.239	-.932*	-.731	-.731	.193	-.207	-.355	-.471	-.185	.190
	.469	.260	.410	.383	.382	.377	.491	.450	.105	.351	.230		.349	.011	.080	.080	.378	.369	.279	.212	.383	.380
TotalN	-.304	.427	-.348	-.527	.686	-.310	.519	.639	.208	.515	.524	-.239	1	.281	.517	.517	-.982**	-.543	.259	-.023	-.892*	.081
	.309	.237	.283	.181	.101	.306	.185	.123	.368	.187	.183	.349		.324	.186	.186	.001	.172	.337	.485	.021	.449
Nitrate	.063	-.200	.180	.293	.031	-.147	-.052	-.186	-.395	.546	.280	-.932*	.281	1	.732	.732	-.172	.066	.124	.693	.045	-.297
	.460	.374	.386	.316	.480	.407	.467	.382	.255	.170	.324	.011	.324		.080	.080	.391	.458	.421	.097	.471	.314
Sulphate	.399	.319	-.220	.344	.626	.128	.637	.488	-.181	.306	.818*	-.731	.517	.732	1	1.000**	-.467	.333	-.127	.628	-.221	.402
	.253	.300	.361	.285	.129	.419	.124	.202	.385	.308	.045	.080	.186	.080		.000	.214	.292	.419	.129	.360	.251
Ammonia	.399	.319	-.220	.344	.626	.128	.637	.488	-.181	.306	.818*	-.731	.517	.732	1.000**	1	-.467	.333	-.127	.628	-.221	.402
	.253	.300	.361	.285	.129	.419	.124	.202	.385	.308	.045	.080	.186	.080	.000		.214	.292	.419	.129	.360	.251
Phosphate	.362	-.376	.510	.609	-.768	.158	-.555	-.719	-.128	-.347	-.582	.193	-.982*	-.172	-.467	-.467	1	.500	-.351	.178	.857*	-.156
	.274	.266	.190	.138	.065	.400	.166	.086	.419	.283	.152	.378	.001	.391	.214	.214		.196	.281	.387	.032	.401
TotalP	.725	-.016	-.163	.763	.138	.710	.311	.106	-.359	-.576	.412	-.207	-.543	.066	.333	.333	.500	1	-.383	.338	.674	.625
	.083	.490	.397	.067	.413	.089	.305	.433	.276	.155	.245	.369	.172	.458	.292	.292	.196		.262	.289	.106	.130
Salinity	-.895*	-.713	-.574	-.756	.137	.295	-.351	-.055	-.682	-.211	.040	-.355	.259	.124	-.127	-.127	-.351	-.383	1	-.626	.010	-.455
	.020	.088	.156	.070	.413	.315	.281	.465	.102	.367	.475	.279	.337	.421	.419	.419	.281	.262		.129	.494	.221
DO	.693	.316	.593	.796	-.136	-.330	.155	-.169	.166	.571	.139	-.471	-.023	.693	.628	.628	.178	.338	-.626	1	.080	.058
	.097	.302	.146	.053	.414	.294	.401	.393	.395	.157	.412	.212	.485	.097	.129	.129	.387	.289	.129		.449	.463
BOD	.213	-.655	.107	.517	-.503	.554	-.482	-.585	-.606	-.572	-.251	-.185	-.892*	.045	-.221	-.221	.857*	.674	.010	.080	1	-.092
	.365	.115	.432	.186	.194	.166	.206	.150	.139	.157	.342	.383	.021	.471	.360	.360	.032	.106	.494	.449		.442
OXREDP ot	.647	.617	-.467	.330	.700	.509	.886*	.792	.170	-.439	.723	.190	.081	-.297	.402	.402	-.156	.625	-.455	.058	-.092	1
	.119	.134	.214	.294	.094	.190	.023	.055	.392	.230	.084	.380	.449	.314	.251	.251	.401	.130	.221	.463	.442	

*. Correlation is significant at the 0.05 level (1-tailed).

**.. Correlation is significant at the 0.01 level (1-tailed).

c. Listwise N=5

Table 11. Correlations status for the measured Physico-chemical parameters of water from shallow wells in Agateeswaram Taluk.

	Temp	pH	Turbidity	EC	TDS	Sodium	Potassium	Alkalinity	Hardness Ca	Hardness Mg	Fluoride	Chloride	Total N	Nitrate	Sulphate	Ammonia	Phosphate	TotalP	Salinity	DO	BOD	OXREDPot
Temp	1	.058	.000	.110	.000	.128	.134	.888	-.097	-.089	.000	.143	.590	.250	.159	-.375	-.395	.102	.807	-.368	.323	-.311
		.463	.500	.430	.500	.419	.415	.022	.438	.443	.500	.409	.148	.343	.399	.267	.255	.435	.049	.271	.298	.305
pH	.058	1	.975	.237	.390	.474	.124	-.095	.531	-.394	.919	-.531	.548	.523	.951	-.494	-.368	.807	.322	-.627	.400	.768
	.463		.002	.351	.258	.210	.421	.439	.179	.256	.014	.179	.169	.183	.006	.199	.271	.049	.299	.129	.252	.065
Turbidity	.000	.975	1	.236	.577	.572	-.058	-.053	.376	-.575	.816	-.553	.381	.323	.892	-.484	-.510	.659	.208	-.633	.194	.711
	.500	.002		.351	.154	.157	.463	.466	.266	.155	.046	.167	.264	.298	.021	.204	.190	.113	.368	.126	.377	.089
EC	.110	.237	.236	1	.137	.811	.545	.002	-.366	-.146	.193	.677	-.070	.104	-.015	-.919	-.405	.167	-.284	.465	-.116	.573
	.430	.351	.351		.413	.048	.171	.499	.272	.408	.378	.104	.455	.434	.490	.014	.249	.394	.321	.215	.427	.157
TDS	.000	.390	.577	.137	1	.683	-.697	.336	-.434	-.996	.000	-.319	-.330	-.559	.238	-.280	-.884	-.228	-.155	-.411	-.625	.054
	.500	.258	.154	.413		.102	.095	.290	.232	.000	.500	.300	.294	.164	.350	.324	.023	.356	.402	.246	.130	.466
Sodium	.128	.474	.572	.811	.683	1	.019	.218	-.457	-.692	.218	.264	-.157	-.177	.212	-.867	-.826	.068	-.223	.031	-.377	.490
	.419	.210	.157	.048	.102		.488	.362	.219	.098	.362	.334	.401	.388	.366	.029	.043	.457	.359	.480	.266	.201
Potassium	.134	.124	-.058	.545	-.697	.019	1	-.292	.355	.683	.423	.513	.473	.757	.104	-.468	.423	.582	.123	.415	.652	.529
	.415	.421	.463	.171	.095	.488		.317	.279	.102	.239	.188	.211	.069	.434	.213	.239	.152	.422	.244	.117	.180
Alkalinity	.888	-.095	-.053	.002	.336	.218	-.292	1	-.425	-.414	-.302	.085	.222	-.205	-.036	-.239	-.626	-.279	.592	-.377	-.112	-.549
	.022	.439	.466	.499	.290	.362	.317		.238	.244	.310	.446	.360	.370	.477	.349	.129	.325	.146	.266	.429	.169
HardnessCa	-.097	.531	.376	-.366	-.434	-.457	.355	-.425	1	.441	.768	-.600	.730	.826	.707	.219	.538	.833	.470	-.470	.857	.437
	.438	.179	.266	.272	.232	.219	.279	.238		.228	.065	.142	.081	.043	.091	.362	.175	.040	.212	.212	.032	.231
HardnessMg	-.089	-.394	-.575	-.146	-.996	-.692	.683	-.414	.441	1	.000	.305	.276	.535	-.251	.312	.916	.218	.082	.442	.594	-.026
	.443	.256	.155	.408	.000	.098	.102	.244	.228		.500	.309	.327	.177	.342	.305	.015	.362	.448	.228	.145	.484
Fluoride	.000	.919	.816	.193	.000	.218	.423	-.302	.768	.000	1	-.451	.699	.791	.924	-.395	.000	.968	.365	-.485	.680	.833
	.500	.014	.046	.378	.500	.362	.239	.310	.065	.500		.223	.094	.056	.012	.255	.500	.003	.273	.204	.103	.040
Chloride	.143	-.531	-.553	.677	-.319	.264	.513	.085	-.600	.305	-.451	1	-.318	-.143	-.677	-.435	.021	-.350	-.359	.855	-.229	-.065
	.409	.179	.167	.104	.300	.334	.188	.446	.142	.309	.223		.301	.409	.104	.232	.487	.282	.276	.033	.355	.459
TotalN	.590	.548	.381	-.070	-.330	-.157	.473	.222	.730	.276	.699	-.318	1	.885	.721	-.221	.117	.813	.884	-.579	.920	.275
	.148	.169	.264	.455	.294	.401	.211	.360	.081	.327	.094	.301		.023	.085	.360	.426	.047	.023	.153	.013	.327
Nitrate	.250	.523	.323	.104	-.559	-.177	.757	-.205	.826	.535	.791	-.143	.885	1	.638	-.250	.395	.919	.577	-.245	.968	.551
	.343	.183	.298	.434	.164	.388	.069	.370	.043	.177	.056	.409	.023		.123	.343	.255	.014	.154	.345	.003	.168
Sulphate	.159	.951	.892	-.015	.238	.212	.104	-.036	.707	-.251	.924	-.677	.721	.638	1	-.292	-.210	.857	.539	-.776	.583	.619

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	.399	.006	.021	.490	.350	.366	.434	.477	.091	.342	.012	.104	.085	.123		.317	.367	.032	.174	.062	.151	.133
Ammonia	-.375	-.494	-.484	-.919	-.280	-.867	-.468	-.239	.219	.312	-.395	-.435	-.221	-.250	-.292	1	.593	-.357	-.058	-.092	-.054	-.587
	.267	.199	.204	.014	.324	.029	.213	.349	.362	.305	.255	.232	.360	.343	.317		.146	.278	.463	.442	.466	.149
Phosphate	-.395	-.368	-.510	-.405	-.884	-.826	.423	-.626	.538	.916	.000	.021	.117	.395	-.210	.593	1	.161	-.073	.339	.476	-.038
	.255	.271	.190	.249	.023	.043	.239	.129	.175	.015	.500	.487	.426	.255	.367	.146		.398	.454	.288	.209	.476
TotalP	.102	.807	.659	.167	-.228	.068	.582	-.279	.833	.218	.968	-.350	.813	.919	.857	-.357	.161	1	.471	-.413	.834	.763
	.435	.049	.113	.394	.356	.457	.152	.325	.040	.362	.003	.282	.047	.014	.032	.278	.398		.212	.245	.039	.067
Salinity	.807	.322	.208	-.284	-.155	-.223	.123	.592	.470	.082	.365	-.359	.884	.577	.539	-.058	-.073	.471	1	-.707	.695	-.155
	.049	.299	.368	.321	.402	.359	.422	.146	.212	.448	.273	.276	.023	.154	.174	.463	.454	.212		.091	.096	.402
DO	-.368	-.627	-.633	.465	-.411	.031	.415	-.377	-.470	.442	-.485	.855	-.579	-.245	-.776	-.092	.339	-.413	-.707	1	-.330	-.003
	.271	.129	.126	.215	.246	.480	.244	.266	.212	.228	.204	.033	.153	.345	.062	.442	.288	.245	.091		.294	.498
BOD	.323	.400	.194	-.116	-.625	-.377	.652	-.112	.857	.594	.680	-.229	.920	.968	.583	-.054	.476	.834	.695	-.330	1	.340
	.298	.252	.377	.427	.130	.266	.117	.429	.032	.145	.103	.355	.013	.003	.151	.466	.209	.039	.096	.294		.288
OXREDPot	-.311	.768	.711	.573	.054	.490	.529	-.549	.437	-.026	.833	-.065	.275	.551	.619	-.587	-.038	.763	-.155	-.003	.340	1
	.305	.065	.089	.157	.466	.201	.180	.169	.231	.484	.040	.459	.327	.168	.133	.149	.476	.067	.402	.498	.288	

Table 12. Correlations status for the measured Physico-chemical parameters of water from shallow wells in Kalkulam Taluk.

	Temp	pH	Turbidity	EC	TDS	Sodium	Potassium	Alkalinity	Hardness Ca	Hardness Mg	Fluoride	Chloride	Total N	Nitrate	Sulphate	Ammonia	Phosphate	TotalP	Salinity	DO	BOD	OXREDPot
Temp	1	-.200	.200	-.036	-.048	.227	.035	.085	-.058	-.389	.375	-.083	.000	.000	-.600	-.539	-.750	.100	-.161	.538	.281	.165
		.373	.373	.477	.470	.357	.478	.446	.463	.259	.267	.447	.500	.500	.142	.174	.072	.436	.398	.175	.324	.396
pH	-.200	1	-.241	.577	.568	-.576	-.919*	-.954**	-.008	.641	.217	.874*	.488	-.845*	.284	-.269	.401	.657	-.718	.293	.126	.242
	.373		.348	.154	.159	.155	.014	.006	.495	.122	.363	.026	.202	.036	.321	.331	.252	.114	.086	.316	.420	.347
Turbidity	.200	-.241	1	.078	.613	.357	.142	.471	-.963**	.369	-.802	.122	.122	.211	.044	-.681	.297	.242	.112	.398	-.225	.793
	.373	.348		.451	.136	.278	.410	.212	.004	.270	.051	.423	.423	.366	.472	.103	.314	.348	.429	.253	.358	.055
EC	-.036	.577	.078	1	.716	.335	-.273	-.562	-.251	.798	.145	.852*	-.315	-.890*	.755	-.595	.039	.955**	.046	.792	.755	.658
	.477	.154	.451		.087	.291	.328	.162	.342	.053	.408	.033	.303	.022	.070	.145	.475	.006	.471	.055	.070	.113
TDS	-.048	.568	.613	.716	1	.059	-.477	-.363	-.789	.916*	-.446	.854*	.233	-.604	.493	-.806*	.496	.851*	-.266	.683	.148	.924*
	.470	.159	.136	.087		.462	.208	.274	.056	.014	.226	.033	.353	.140	.199	.050	.197	.034	.332	.102	.406	.012
Sodium	.227	-.576	.357	.335	.059	1	.781	.533	-.240	.048	-.088	-.154	-.874*	.080	.407	-.301	-.447	.202	.862*	.471	.619	.382
	.357	.155	.278	.291	.462		.060	.178	.349	.470	.444	.402	.026	.449	.248	.311	.225	.372	.030	.212	.133	.263
Potassium	.035	-.919*	.142	-.273	-.477	.781	1	.849*	.062	-.434	-.138	-.713	-.778	.619	.083	.266	-.408	-.444	.932*	-.160	.178	-.159
	.478	.014	.410	.328	.208	.060		.034	.461	.233	.412	.088	.061	.133	.447	.332	.247	.227	.011	.399	.387	.399

Alkalinity	.085	-.954*	.471	-.562	-.363	.533	.849*	1	-.252	-.455	-.499	-.781	-.349	.873*	-.213	.162	-.143	-.597	.667	-.288	-.292	-.056
	.446	.006	.212	.162	.274	.178	.034		.341	.221	.196	.060	.282	.027	.365	.397	.409	.144	.109	.319	.317	.464
Hardness Ca	-.058	-.008	-.963**	-.251	-.789	-.240	.062	-.252	1	-.592	.814*	-.356	-.212	.000	-.203	.730	-.470	-.420	.015	-.452	.200	-.881*
	.463	.495	.004	.342	.056	.349	.461	.341		.146	.047	.278	.366	.500	.372	.081	.212	.241	.490	.222	.374	.024
Hardness Mg	-.389	.641	.369	.798	.916*	.048	-.434	-.455	-.592	1	-.389	.872*	.079	-.683	.763	-.542	.615	.833*	-.128	.515	.223	.769
	.259	.122	.270	.053	.014	.470	.233	.221	.146		.259	.027	.450	.102	.067	.173	.135	.040	.419	.187	.359	.064
Fluoride	.375	.217	-.802	.145	-.446	-.088	-.138	-.499	.814*	-.389	1	.021	-.228	-.395	-.191	.196	-.716	.050	-.145	.124	.570	-.495
	.267	.363	.051	.408	.226	.444	.412	.196	.047	.259		.487	.356	.255	.379	.376	.087	.468	.408	.421	.158	.199
Chloride	-.083	.874*	.122	.852*	.854*	-.154	-.713	-.781	-.356	.872*	.021	1	.227	-.916*	.524	-.625	.350	.931*	-.447	.658	.366	.655
	.447	.026	.423	.033	.033	.402	.088	.060	.278	.027	.487		.357	.014	.183	.130	.282	.011	.225	.114	.272	.115
TotalN	.000	.488	.122	-.315	.233	-.874*	-.778	-.349	-.212	.079	-.228	.227	1	.000	-.498	-.090	.513	-.073	-.904*	-.227	-.724	.000
	.500	.202	.423	.303	.353	.026	.061	.282	.366	.450	.356	.357		.500	.197	.443	.188	.453	.017	.357	.083	.500
Nitrate	.000	-.845*	.211	-.890*	-.604	.080	.619	.873*	.000	-.683	-.395	-.916*	.000	1	-.518	.465	-.042	-.889*	.346	-.654	-.627	-.417
	.500	.036	.366	.022	.140	.449	.133	.027	.500	.102	.255	.014	.500		.186	.215	.473	.022	.284	.115	.129	.242
Sulphate	-.600	.284	.044	.755	.493	.407	.083	-.213	-.203	.763	-.191	.524	-.498	-.518	1	-.118	.362	.592	.435	.298	.494	.432
	.142	.321	.472	.070	.199	.248	.447	.365	.372	.067	.379	.183	.197	.186		.425	.274	.147	.232	.313	.199	.234
Ammonia	-.539	-.269	-.681	-.595	-.806*	-.301	.266	.162	.730	-.542	.196	-.625	-.090	.465	-.118	1	.050	-.768	.196	-.909*	-.334	-.905*
	.174	.331	.103	.145	.050	.311	.332	.397	.081	.173	.376	.130	.443	.215	.425		.468	.065	.376	.016	.292	.017
Phosphate	-.750	.401	.297	.039	.496	-.447	-.408	-.143	-.470	.615	-.716	.350	.513	-.042	.362	.050	1	.108	-.279	-.293	-.582	.265
	.072	.252	.314	.475	.197	.225	.247	.409	.212	.135	.087	.282	.188	.473	.274	.468		.432	.325	.316	.151	.333
TotalP	.100	.657	.242	.955*	.851*	.202	-.444	-.597	-.420	.833*	.050	.931*	-.073	-.889*	.592	-.768	.108	1	-.173	.864*	.610	.781
	.436	.114	.348	.006	.034	.372	.227	.144	.241	.040	.468	.011	.453	.022	.147	.065	.432		.390	.029	.137	.059
Salinity	-.161	-.718	.112	.046	-.266	.862*	.932*	.667	.015	-.128	-.145	-.447	-.904*	.346	.435	.196	-.279	-.173	1	-.016	.381	.000
	.398	.086	.429	.471	.332	.030	.011	.109	.490	.419	.408	.225	.017	.284	.232	.376	.325	.390		.490	.264	.500
DO	.538	.293	.398	.792	.683	.471	-.160	-.288	-.452	.515	.124	.658	-.227	-.654	.298	-.909*	-.293	.864*	-.016	1	.695	.791
	.175	.316	.253	.055	.102	.212	.399	.319	.222	.187	.421	.114	.357	.115	.313	.016	.316	.029	.490		.097	.055
BOD	.281	.126	-.225	.755	.148	.619	.178	-.292	.200	.223	.570	.366	-.724	-.627	.494	-.334	-.582	.610	.381	.695	1	.251
	.324	.420	.358	.070	.406	.133	.387	.317	.374	.359	.158	.272	.083	.129	.199	.292	.151	.137	.264	.097		.342
OXREDPot	.165	.242	.793	.658	.924*	.382	-.159	-.056	-.881*	.769	-.495	.655	.000	-.417	.432	-.905*	.265	.781	.000	.791	.251	1
	.396	.347	.055	.113	.012	.263	.399	.464	.024	.064	.199	.115	.500	.242	.234	.017	.333	.059	.500	.055	.342	

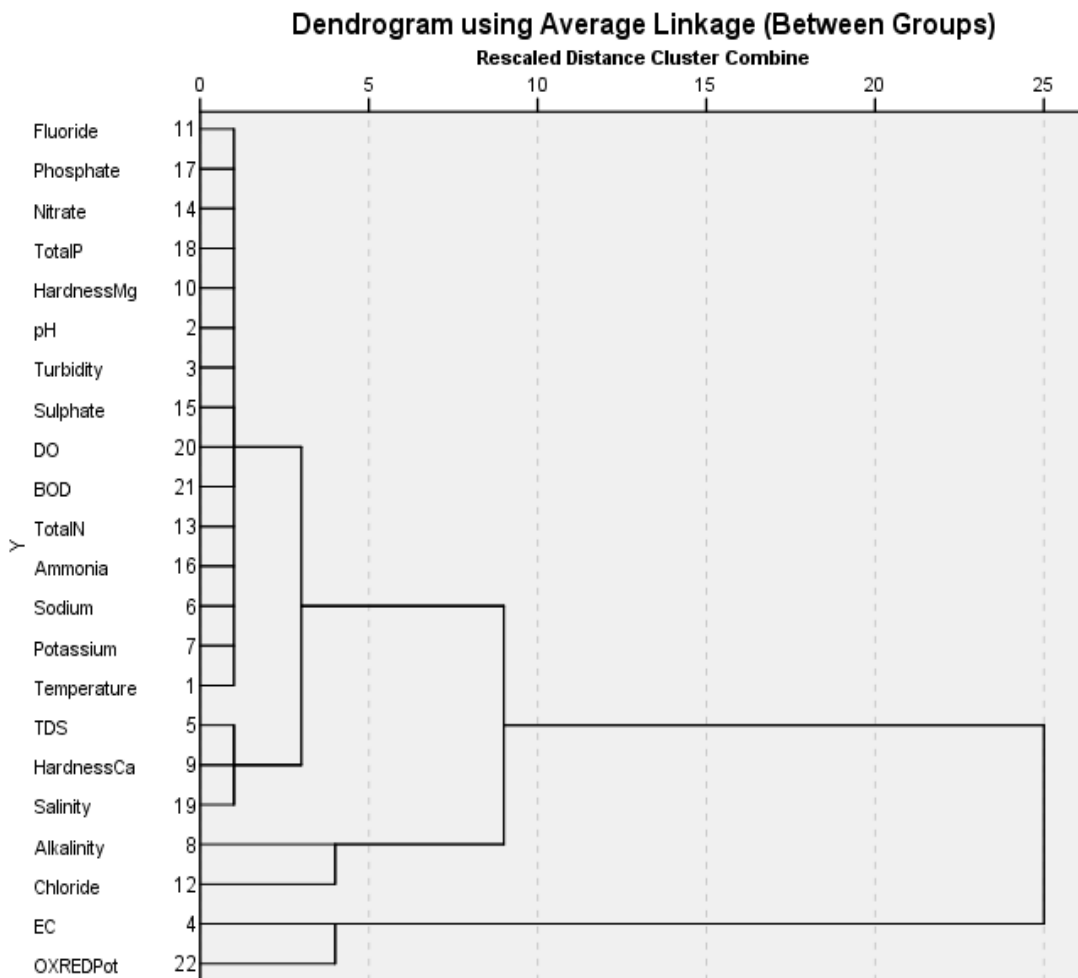


Figure 26. Dendrogram for Physico-chemical parameters of bore hole water of Agateeswaram Taluk.

Cluster analysis (CA) was used for multivariate modeling of the input data^[16]. 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 26, 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 (indicated in Table 1). It could be concluded that the one big cluster and three small clusters are formed. Additionally sub clusters are also formed.

Cluster 1(fifteen parameters are included)

Fluoride, Phosphate, Nitrate, Total N, hardness Mg, pH, turbidity, sulphate, DO, BOD, Total N, Ammonia, Sodium, Potassium, temperature.

Sub cluster 1: DO, Hardness Ca

Cluster 2 (three parameters are included): TDS, hardness Ca, Salinity

Sub cluster 2: Sodium, alkalinity

Cluster 3 (two parameters are included): Alkalinity, Chloride

Sub cluster 3: EC, Hardness Ca

Cluster 4 (two parameters are included): EC and OXREDPOT

In figure 27, 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 (indicated in Table 3). It could be concluded that the one big cluster and two small clusters are formed. Additionally sub clusters are also formed.

Cluster 1(Eighteen parameters are included)

Sulphate, Ammonia, DO, pH, turbidity, Total N, BOD, Fluoride, Total P, Nitrate, Phosphate, hardness Mg, Sodium, Potassium, temperature, TDS, Salinity, hardness Ca.

Sub cluster 1: Sodium, alkalinity

Cluster 2 (two parameters are included): Alkalinity, chloride

Sub cluster 2: EC, TDS

Cluster 3 (two parameters are included): EC, OXREDPot.

In figure 28, 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 dissimilarity measure, standardization of the input data). For clustering altogether 22 physical and chemical parameters were chosen (indicated in Table 5). It could be concluded that the one big cluster and three small clusters are formed. Additionally sub clusters are also formed. Cluster 1(fourteen parameters are included)

Fluoride, Total P, Nitrate, Phosphate, hardness Mg, Sodium, Potassium, pH, DO, turbidity, Ammonia, Sulphate, BOD, Total N.

Sub cluster 1: Hardness Mg, temperature

Cluster 2 (four parameters are included): TDS, Salinity,

Temperature, hardness Ca

Sub cluster 2: Ammonia, alkalinity

Cluster 3 (two parameters are included): Alkalinity, Chloride,

Sub cluster 3: EC, TDS

Cluster 4 (two parameters are included): EC, OXREDPot

In figure 29, 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 dissimilarity measure, standardization of the input data). For clustering altogether 22 physical and chemical parameters were chosen (indicated in Table 7). It could be concluded that the one big cluster and three small clusters are formed. Additionally sub clusters are also formed.

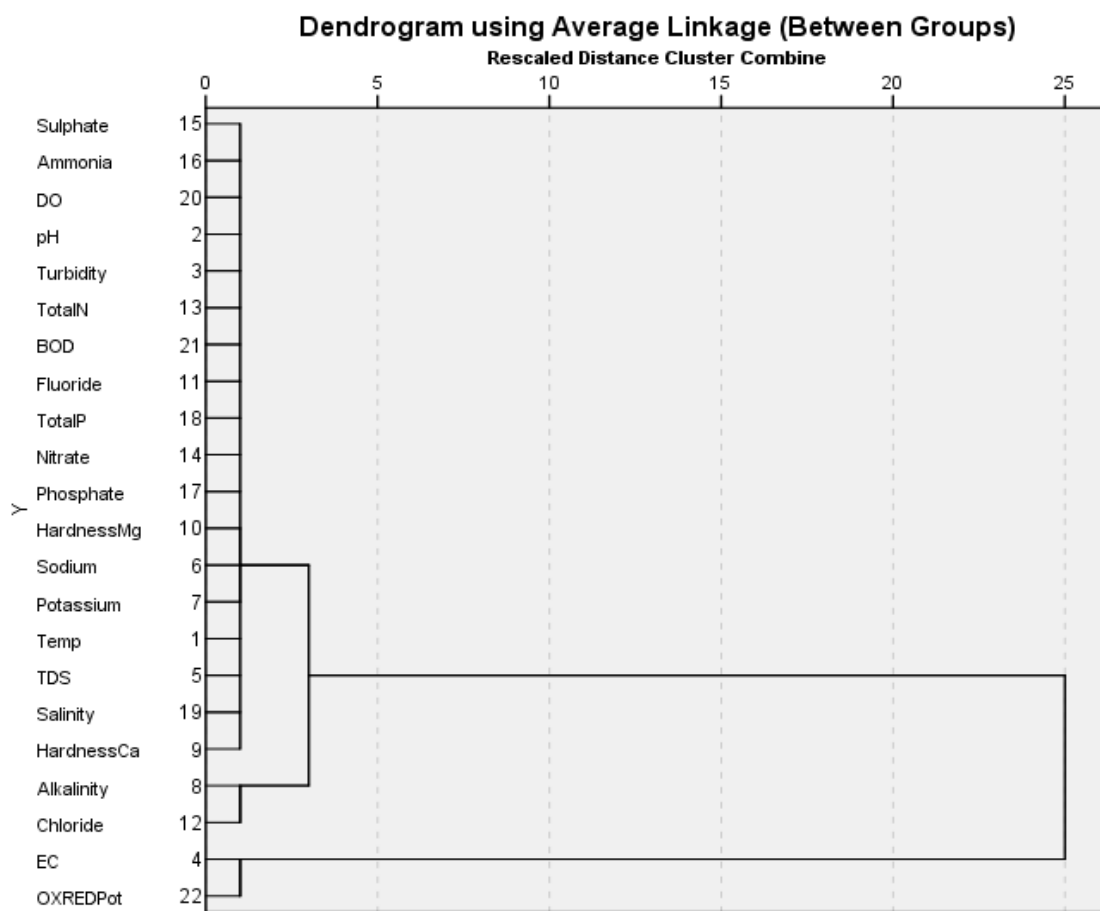


Figure 27. Dendrogram for Physico-chemical parameters of bore hole water of Kalkulam Taluk.

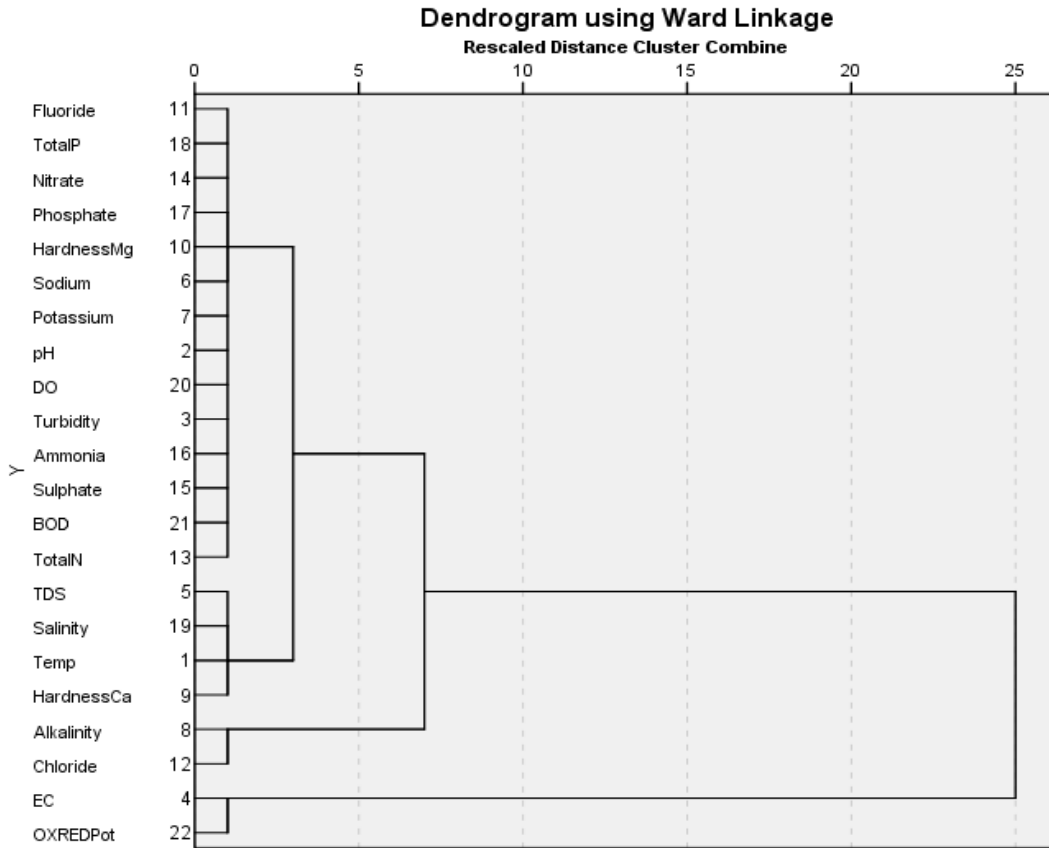


Figure 28. Dendrogram for Physico-chemical parameters of shallow hole water of Agateeswaram Taluk

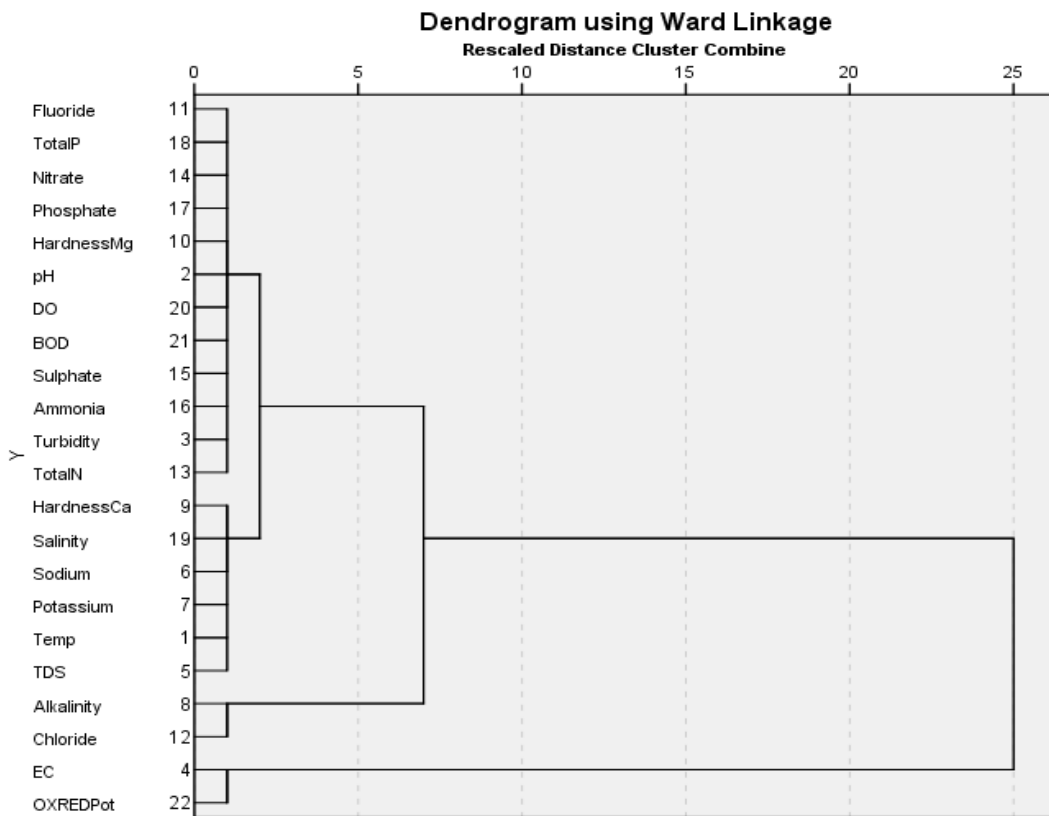


Figure 29. Dendrogram for Physico-chemical parameters of shallow hole water of Kalkulam Taluk.

Cluster 1 (twelve parameters are included)
 Fluoride, Total P, Nitrate, Phosphate, hardness Mg, pH, DO, BOD, Sulphate, Ammonia turbidity, Total N.
 Sub cluster 1: pH, Salinity
 Cluster 2 (six parameters are included): Hardness ca, Salinity, Sodium, Potassium, temperature, TDS
 Sub cluster 2: Ammonia, alkalinity
 Cluster 3 (two parameters are included)
 Sub cluster 3: Alkalinity, chloride
 Cluster 4 (two parameters are included): EC, OXREDPot.

3. Conclusions

The physio-chemical analysis of borewell water samples from five different stations in Agasteeswaram and Kalkulam Taluk, shallow well water samples from five different stations in Agasteeswaram and Kalkulam Taluk were carried out. Also the statistical assessment is also carried out for the Physico-chemical parameter. 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 borewell water from both Taluks and shallow well water from both Taluks 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.

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