

A Statistical Study on the ground water quality and its scale forming nature in Srirangam Taluk, Tiruchirappalli, Tamil Nadu, India

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Abstract --- Ground waters from Open Well (OW), Hand Pump (HW) and Bore well (BW) were collected in and around Srirangam Taluk, an island surrounded by two rivers viz., Cauvery and Kollidam during January-March 2012. They were analysed for physico-chemical parameters such as pH, EC (Electrical Conductivity), TDS (Total Dissolved Solids), TA (Total Alkalinity), CH (Calcium Hardness), MH (Magnesium Hardness), TH (Total Hardness) and F (Fluoride). Multivariate analysis (MVA) is based on the statistical principle of multivariate statistics, which involves observation and analysis of more than one statistical variable at a time. This paper presents the results of the statistical analysis of a set of physico-chemical water quality parameters. Factor analysis (FA) was applied to analyze a ground water quality data in and around Srirangam Taluk, Tiruchirappalli District, Tamil Nadu, India. The calculated WQI and LSI expose the potability and the scale forming nature of the collected ground water samples in various sites of the study area. Pearson Correlation matrix was used to compare the relationship between the water quality parameters. FA in three latent factors accounting for 66.87 % of cumulative percentage. This study presents usefulness of multivariate statistical techniques for evaluation and interpretation of large complex water quality data sets and sharing out of pollution sources/factors.

Keywords- Srirangam sites; Ground water quality; LSI; WQI; FA; Correlation Analysis;

I. INTRODUCTION

The ground water quality depends not only on natural processes such as precipitation inputs, erosion and weathering of crustal material and biota interrelationships but also on

anthropogenic influences such as urban, industrial and agricultural activities (6). Water quality depends on chemical, physical and bacterial constituents. The importance of water for sustenance of life cannot be overemphasized and ground water being a part of the hydrological cycle needs attention for the proper evaluation and management not only to meet one need for the present but also for the future generations to come (14). The discharge of toxic heavy metals into the environment from industrial activities such as mining and metal processing can lead to numerous environmental problems (12). In a large number of underdeveloped and developing countries, there is a scarcity of safe drinking water particularly in summer when there is a plenty of sunlight (1). Management of health hazardous ions such as fluoride is of public health interest since fluoride is responsible for teeth mottling and bone fluorosis (2). The fluoride research in past decades suggests that concentrations below 1 mg/l are beneficial in the prevention of dental caries or tooth decay but above 1.20 mg/l (BIS standard) increase the severity of the incurable disease fluorosis (11). Multivariate analysis techniques are very useful in the analysis of data corresponding to a large number of variables. Multivariate data consists of observations on several variables for the number of samples. A wide variety of multivariate analysis techniques is available. The choice of the most appropriate technique depends on the nature of the data, problem and objectives. A number of studies on ground water quality done in different parts of the country (8, 4, 5, 18, 15).

ABOUT THE STUDY AREA

Srirangam is an island and a part of the city of Tiruchirappalli in South India. Srirangam is bounded by the Kaveri River (also known as Cauvery River) on one side, and the Kaveri distributary Kollidam (Coleroon) on the other side. It is one of the most important among the 108 pilgrim centres in the whole of India.

The study area Srirangam Fig.1 is geographically situated between the North latitudes $10^{\circ} 16'$ to $11^{\circ} 22'$ and East longitudes $78^{\circ} 15'$ to $79^{\circ} 16'$ covering an area of about 23.26 sq.km.



FIGURE 1. MAP OF THE STUDY AREA

II. MATERIALS AND METHODS

During January to March 2012, 100 ground water samples from various sites of Srirangam Taluk (Tiruchirappalli District) were collected in pre-cleaned 500 ml containers with necessary precautions. The temperature of the water samples was measured on the spot. The collected ground water samples were tightly corked without any entry of foreign particles and brought to the laboratory for further investigation of other water quality parameters.

The parametric studies carried out were pH, Electrical Conductivity (EC), Total Alkalinity (TA), Calcium Hardness (CH), Magnesium Hardness (MH), Total Hardness (TH), Total Dissolved Solids (TDS) and Fluoride (F) using the standard procedures (3)

A. Data Processing

Data obtained from the laboratory analysis were used as variable inputs for Factor Analysis (FA) and was performed using the SPSS package version 20(8).

B. Statistical Analysis-Factor Analysis

Factor Analysis (10) can be considered as data reduction technique because it reduces a large number of variables that often overlap to a smaller number of factors. Usually, the minor Principal Components (PC) can be eliminated to simplify the analysis because of their poor interpretation of the data structures. Though the significant PCs are fewer, they can still provide information on the most meaningful parameters. In this study, the Eigen value one criterion used to find the numbers of PCs based on the assumption that only Eigen values greater than one considered important (8) and the higher Eigen values are more significant. Varimax

normalization was then applied as the rotation method in the analysis on the PCs for better interpretation of results. Varimax factor loadings of 0.75 were considered strong, although the terms 'strong', 'moderate' and 'weak' as applied to loadings, refer to absolute loading values of >0.75 , $0.75-0.50$ and $0.50-0.30$ respectively.

III. RESULTS & DISCUSSION

The Physico-chemical parameters of the 100 groundwater samples have been shown in Table 1.

The pH of drinking water is an important index of acidity or alkalinity (7). In Srirangam, it varied between 7 and 8 respectively that witnessed their alkaline character. The Electrical conductivity values in the Srirangam Taluk were recorded very low values with 0.092 mS at hand pump source of Burma Colony. The bore well source taken from the Srinivasa Nagar (Ist Cross) showed the higher Electrical conductivity value of 5.862 mS. The higher electrical conductivity value indicates the total ionic composition of water.

The TDS values of the samples ranged between 51.8 mg/l at V.O.C. Street-IV and 3776.7 mg/l at Srinivasa Nagar (3rd Cross)-I. Around 23 samples were registered with very low TDS values within the desirable limit of WHO (500 mg/l) and 24 samples shown the TDS value within the maximum permissible limit of 1000 mg/l (WHO). A total number of 53 samples have shown the TDS values crossing more than the desirable limit of WHO (20).

The minimum and maximum values of were observed between 0 mg/l and 45.85 mg/l for the groundwater samples. In the present study area, the Total Alkalinity was measured from 229.25 mg/l (Hand pump) to 825.3 mg/l (open well) at T.V coil and Thiruvalluvar Street-II respectively. The calcium content in the Srirangam area was ranged from 39.2 mg/l at Burma Colony-II (open well) to 519.4 mg/l at V.O.C. Street-I (open well). Only 7 samples showed calcium hardness within the recommended limit of 75 mg/l (WHO), In Srirangam, the magnesium content in the groundwater samples were ranged from 39.2 mg/l (Bore well) at Salai Road to 519.4 mg/l (Bore well) at Nelson Road. In Srirangam, there were 12 out of 100 samples exceeded the permissible limit of total hardness (500 mg/l).

The fluoride content of the groundwater samples in Srirangam were recorded between 0.02 mg/l at Kelakondaiyanpettai (Bore well) and 1.82 mg/l at Thiruvalluvar St-IV (Bore well). In the present study area, 17 out of 100 samples exceeded the permissible limit of fluoride (1.5 mg/l).

The Pearson correlation matrix has been calculated for the water quality parameters (Table 2). The parameters EC and TDS were found to exist in good correlation with respect to each other, $R^2 = 0.9530$ (Fig 2). The values evidence the Electrical conductance is due to the total dissolved ions in the water.

TABLE 1 THE PHYSICO-CHEMICAL PARAMETERS OF THE GROUND WATER SAMPLES
IN THE SRIRANGAM TALUK, TAMIL NADU, INDIA

Sl.no	Places	Sources	Temp	pH	EC	TA	CH	MH	TH	TDS	F
1	Sathara Street-I	BW	31	7.1	1.12	504.4	353.0	88.2	441	723	1.40
2	East Chitra Street-I	OW	27	7.2	2.02	412.7	157.0	98.0	255	1200	0.62
3	East Chitra Street-II	BW	30	7.3	0.40	687.8	265.0	206.0	470	151	0.62
4	South Chitra Street-II	BW	29	7.4	1.35	321.0	147.0	68.6	216	855	0.10
5	Nehru Street-I	BW	30	7.1	2.13	596.1	284.0	137.0	421	1344	0.38
6	Renga Nagar-I	BW	31	7	3.32	366.8	186.0	255.0	441	2000	0.04
7	North Chitra Street-I	HP	28	7.1	1.73	275.1	58.8	186.0	245	1101	1.28
8	V.O.C. Street-I	OW	27	7.4	2.79	596.1	519.0	78.4	598	1699	1.08
9	North Chitra Street-II	OW	26	7.1	0.85	550.2	284.0	196.0	480	540	0.82
10	Devi Street-I	BW	31	7.3	4.29	458.5	304.0	108.0	412	2701	1.62
11	West Chitra Street-I	OW	25	7	1.73	550.2	255.0	216.0	470	1172	0.36
12	Uthara Street-I	HP	27	7.8	3.87	550.2	186.0	265.0	451	2501	0.78
13	Nelson Road-I	BW	29	7.5	0.51	458.5	235.0	255.0	490	320	0.84
14	Salai Road-I	BW	32	7	1.51	366.8	176.0	39.2	216	950	0.76
15	Srinivasa Nagar (1st Cross)-I	BW	31	7.3	2.06	321.0	314.0	58.8	372	1377	0.82
16	North Chitra Street-III	BW	30	7.2	1.51	550.2	304.0	137.0	441	950	0.78
17	Sakthi Nagar-I	BW	29	7.1	0.67	412.7	363.0	108.0	471	431	1.24
18	Thiruvalluvar Street-I	BW	28	7	0.74	321.0	98.0	127.0	225	476	0.22
19	Nehru Street-II	OW	27	7.5	0.84	366.8	216.0	118.0	333	550	0.24
20	Nehru Street-III	OW	26	7.5	0.76	275.1	284.0	88.2	372	474	0.20
21	Srinivasa Nagar (2nd Cross)	HP	25	7.2	1.19	504.4	196.0	118.0	314	771	1.24
22	Melakondaiyanpettai-I	BW	32	7.1	1.02	550.2	284.0	108.0	392	676	1.06
23	Burma Colony-I	BW	31	7.2	2.95	458.5	118.0	108.0	225	1857	0.14
24	West Chitra Street-II	BW	30	7.5	3.51	596.1	421.0	147.0	568	2271	0.22
25	Rajaji Street-I	BW	29	7.3	4.12	275.1	206.0	186.0	392	2658	1.22
26	Sathara Street-II	BW	28	7.5	0.85	412.7	304.0	421.0	725	568	0.26
27	Manickam Pillai Street	OW	27	7.9	1.06	641.9	196.0	245.0	441	654	1.26
28	Kumaran Nagar-I	BW	30	7.9	0.75	458.5	284.0	284.0	568	437	1.40
29	Kumaran Nagar-II	OW	28	7.1	2.05	275.1	127.0	98.0	225	1336	0.36
30	Srinivasa Nagar (1st Cross)-II	OW	25	7.2	3.01	504.4	157.0	137.0	294	1949	0.18
31	Srinivasa Nagar (4th Cross)	HP	28	7.5	1.19	458.5	314.0	323.0	637	786	0.34
32	Rajaji Street-II	BW	29	7.4	1.09	550.2	206.0	255.0	461	669	0.32
33	Thiruvalluvar Street-II	OW	28	7.9	0.85	825.3	323.0	167.0	490	567	0.30
34	V.O.C. Street-II	HP	25	7.8	0.52	550.2	333.0	206.0	539	356	0.12
35	Devi Street-II	HP	26	7.2	3.71	641.9	216.0	304.0	519	2349	0.46
36	West Chitra Street-III	BW	32	7.3	2.02	550.2	127.0	294.0	421	1270	0.54
37	Morakara Street-I	BW	30	7.1	2.18	412.7	206.0	235.0	441	1372	0.58
38	Sathara Street-III	BW	29	7.8	3.19	504.4	216.0	245.0	461	2066	0.24
39	Melakondaiyanpettai – II	BW	31	7.9	1.01	321.0	147.0	127.0	274	672	1.28
40	Morakara Street-II	BW	29	7.5	1.58	275.1	78.4	78.4	157	1033	1.30
41	Sathara Street-IV	OW	27	7.2	2.77	458.5	68.6	147.0	216	1755	0.30
42	Melakondaiyanpettai -II	BW	32	7.2	2.32	366.8	127.0	235.0	363	1459	0.28
43	South Chitra Street-II	BW	30	7.3	3.02	458.5	78.4	167.0	245	1957	0.56
44	North Chitra Street-IV	BW	29	7.6	1.08	504.4	196.0	88.2	284	660	0.04
45	V.O.C. Street-III	BW	31	7.6	2.52	550.2	216.0	196.0	412	1635	0.30
46	East Chitra Street-III	HP	28	7.3	1.72	504.4	147.0	343.0	490	1127	0.68
47	Burma Colony-II	BW	30	7.2	2.89	550.2	39.2	372.0	412	1877	0.50
48	South Chitra Street-III	OW	27	7.1	0.64	412.7	127.0	118.0	245	436	0.22
49	Nelson Road-II	OW	26	7.1	0.79	321.0	49.0	372.0	421	531	0.34
50	Uthara Street-II	BW	32	7.5	1.02	229.3	274.0	108.0	382	679	0.44
51	T.V.Kovil	HP	30	7.1	1.04	458.5	157.0	363.0	519	691	0.12
52	West Chitra Street-IV	BW	29	7.9	2.81	550.2	265.0	196.0	461	1771	1.24
53	Burma Colony-III	HP	31	7.3	0.09	412.7	157.0	167.0	323	81.2	1.26
54	Devi Street-III	OW	28	7.3	2.89	458.5	216.0	265.0	480	1824	0.12
55	Renga Nagar-II	BW	30	7.2	3.36	275.1	206.0	216.0	421	2125	0.38

56	Kumaran Nagar-III	BW	27	7.4	2.19	321.0	108.0	274.0	382	306	0.36
57	Renga Nagar-III	BW	26	7.5	0.19	458.5	274.0	147.0	421	126	0.28
58	Sakthi Nagar-II	OW	32	7.4	0.99	412.7	167.0	157.0	323	656	0.24
59	Salai Road-II	BW	27	7.1	1.22	321.0	245.0	127.0	372	749	0.30
60	Sathara Street-V	BW	26	7.2	2.71	412.7	304.0	304.0	608	1759	0.18
61	Uthara Street-III	HP	32	8	1.81	366.8	265.0	274.0	539	1188	0.14
62	Sakthi Nagar-III	OW	27	7.8	2.73	229.3	284.0	137.0	421	1722	0.12
63	East Chitra Street-IV	BW	32	7.3	3.69	321.0	78.4	265.0	343	2325	0.52
64	North Chitra Street-V	BW	30	7.7	1.08	458.5	88.2	186.0	274	669	0.32
65	South Chitra Street-IV	HP	28	7.1	1.99	550.2	245.0	245.0	490	1255	0.30
66	Nehru Street-IV	BW	31	7	1.72	596.1	167.0	225.0	392	1073	0.28
67	Rajaji Street-III	BW	30	7.4	2.09	504.4	196.0	147.0	343	1362	0.22
68	North Chitra Street-VI	BW	29	7.9	3.08	458.5	206.0	284.0	490	1937	0.38
69	Kelakondaiyanpettai-I	BW	28	7.1	2.98	412.7	167.0	225.0	392	1931	0.16
70	Manickampillai Street-I	BW	25	7.1	1.81	366.8	206.0	137.0	343	1186	0.30
71	Devi Street-IV	OW	29	7.9	3.00	321.0	108.0	284.0	392	1934	0.28
72	Rajaji Street-IV	OW	30	7.4	2.81	504.4	58.8	382.0	441	1827	0.02
73	Salai Road-III	OW	28	7.4	2.93	366.8	304.0	88.2	392	1852	0.46
74	Thiruvalluvar Street-III	HP	25	7.8	1.98	275.1	137.0	206.0	343	1242	0.34
75	Srinivasa Nagar (3rd Cross)-I	BW	31	7.1	5.86	504.4	235.0	254.0	490	3777	0.68
76	Melakondaiyanpettai-III	HP	27	7.1	3.35	321.0	118.0	127.0	245	2122	0.52
77	Renga Nagar-IV	OW	26	7.1	2.10	275.1	68.6	176.0	245	1376	0.94
78	Devi Street-V	OW	25	8	2.98	229.3	245.0	245.0	490	1932	0.66
79	Kumaran Nagar-IV	HP	28	7.8	1.54	366.8	176.0	118.0	294	962	0.92
80	Srinivasa Nagar (1st Cross)-III	OW	27	7.7	2.61	458.5	167.0	78.4	245	1640	0.54
81	Melakondaiyanpettai-IV	BW	31	7.5	1.43	641.9	176.0	167.0	343	943	0.02
82	Kelakondaiyanpettai-II	BW	30	7	1.89	321.0	157.0	284.0	441	1249	0.96
83	Rajaji Street-V	BW	29	7.3	1.29	275.1	176.0	216.0	392	857	0.82
84	Srinivasa Nagar (3rd Cross)-II	HP	28	7.1	1.85	641.9	176.0	167.0	343	1166	0.28
85	East Chitra Street-V	BW	32	7.9	3.36	321.0	186.0	78.4	265	2176	0.36
86	Srinivasa Nagar (2nd Cross)	OW	27	7.9	3.98	504.4	108.0	274.0	382	2524	0.94
87	Nelson Road-III	BW	32	7.7	2.05	458.5	78.4	519.0	598	1338	0.86
88	Srinivasa Nagar, (1st Cross)	OW	25	7.4	2.15	412.7	118.0	147.0	265	1359	0.34
89	Morakara Street-III	BW	31	7.3	2.71	275.1	206.0	225.0	431	204	0.26
90	Burma Colony-IV	BW	32	7.1	2.73	504.4	147.0	157.0	304	191	0.52
91	West Chitra Street-V	HP	28	7.3	2.23	458.5	167.0	127.0	294	82.4	0.46
92	Kelakondaiyanpettai-III	OW	26	7.1	1.46	229.3	323.0	314.0	637	281	0.32
93	Salai Road-IV	BW	32	7.7	1.83	458.5	245.0	147.0	392	168	0.52
94	East Chitra Street-VI	BW	29	7.7	2.05	550.2	167.0	176.0	343	209	1.26
95	Thiruvalluvar Street-IV	BW	30	7.8	1.48	550.2	304.0	284.0	588	239	1.82
96	Manickampillai Street-II	HP	29	7.2	1.70	366.8	68.6	274.0	343	252	0.54
97	V.O.C. Street-IV	BW	31	7.2	0.60	275.1	147.0	108.0	255	51.8	1.32
98	Srinivasa Nagar (4th Cross)	OW	27	7.3	1.60	504.4	216.0	225.0	441	213	1.50
99	Nelson Road-IV	BW	32	7.1	2.06	550.2	176.0	186.0	363	230	1.82
100	Thiruvalluvar Street-V	BW	30	7.1	3.14	412.7	206.0	196.0	402	175	0.94

OW-open well; BW-bore well; HP-hand pump
Except pH and EC, all other parameters are measured in mg/l.

TABLE 2 PEARSON CORRELATION MATRIX FOR THE GROUND WATER SAMPLES
IN SRIRANGAM TALUK, TAMIL NADU, INDIA

Quality parameters	pH	EC	TA	TH	CH	MH	TDS	F
pH	1.000							
EC	0.002	1.000						
TA	0.072	0.008	1.000					
TH	0.185	-0.058	0.234	1.000				
CH	0.110	0.042	0.047	0.623	1.000			
MH	0.114	-0.115	0.239	0.591	-0.263	1.000		
TDS	-0.006	0.953	-0.042	-0.038	0.065	-0.115	1.000	
F	0.050	-0.128	0.106	0.028	-0.081	0.117	-0.097	1.000

**Correlation is significant at the 0.01 level (2-tailed).

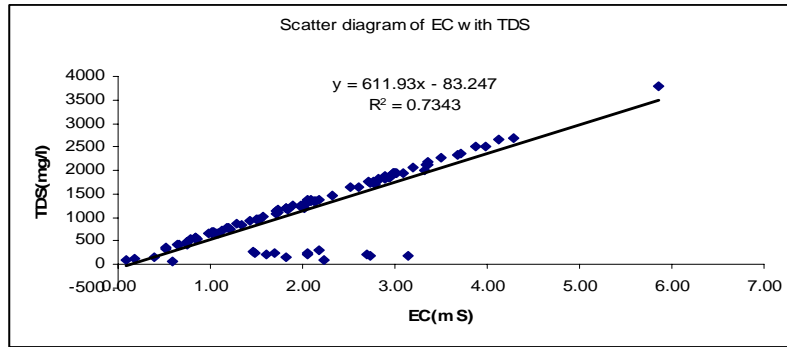


FIGURE 2. CORRELATION BETWEEN EC & TDS IN SRIRANGAM TALUK

TABLE 3 THE DATA OF LSI AND WQI FOR THE GROUND WATER SAMPLES OF THE SRIRANGAM TALUK, TAMIL NADU, INDIA

Sl.no	Places	Source	LSI	WQI
1	Sathara Street-I	BW	-0.2	63.00
2	East Chitra Street-I	OW	-0.2	35.28
3	East Chitra Street-II	BW	0.4	37.64
4	South Chitra Street-II	BW	-0.2	8.52
5	Nehru Street-I	BW	-0.1	21.33
6	Renga Nagar-I	BW	0.0	3.61
7	North Chitra Street-I	HP	-0.1	57.99
8	V.O.C. Street-I	OW	-0.3	62.48
9	North Chitra Street-II	OW	0.0	40.40
10	Devi Street-I	BW	0.1	83.62
11	West Chitra Street-I	OW	0.0	20.38
12	Uthara Street-I	HP	0.8	52.68
13	Nelson Road-I	BW	0.6	52.08
14	Salai Road-I	BW	-0.9	37.66
15	Srinivasa Nagar (1st Cross)-I	BW	-0.3	47.21
16	North Chitra Street-III	BW	0.0	42.92
17	Sakthi Nagar-I	BW	-0.1	56.80
18	Thiruvalluvar Street-I	BW	-0.4	13.39
19	Nehru Street-II	OW	0.1	18.30
20	Nehru Street-III	OW	-0.2	15.68
21	Srinivasa Nagar (2nd Cross)	HP	-0.1	62.96
22	Melakondaiyanpettai-I	BW	-0.1	49.99
23	Burma Colony-I	BW	0.7	10.24
24	West Chitra Street-II	BW	0.3	17.18
25	Rajaji Street-I	BW	0.0	65.68
26	Sathara Street-II	BW	0.8	19.65
27	Manickam Pillai Street	OW	0.9	79.88
28	Kumaran Nagar-I	BW	1.0	86.95
29	Kumaran Nagar-II	OW	-0.6	20.17
30	Srinivasa Nagar (1st Cross)-II	OW	-0.1	12.64
31	Srinivasa Nagar (4th Cross)	HP	0.7	24.59
32	Rajaji Street-II	BW	0.5	22.63
33	Thiruvalluvar Street-II	OW	1.1	24.26
34	V.O.C. Street-II	HP	0.8	31.42
35	Devi Street-II	HP	0.4	27.75
36	West Chitra Street-III	BW	0.4	33.55
37	Morakara Street-I	BW	0.2	30.22
38	Sathara Street-III	BW	0.9	19.73
39	Melakondaiyanpettai – II	BW	0.6	80.20
40	Morakara Street-II	BW	-0.1	74.27
41	Sathara Street-IV	OW	-0.1	19.30
42	Melakondaiyanpettai –II	BW	0.2	18.21
43	South Chitra Street –II	BW	0.3	34.45

44	North Chitra Street-IV	BW	0.3	4.24
45	V.O.C. Street-III	BW	0.6	22.78
46	East Chitra Street-III	HP	0.5	40.63
47	Burma Colony-II	BW	0.5	29.66
48	South Chitra Street-III	W	-0.2	13.43
49	Nelson Road-II	OW	0.2	19.30
50	Uthara Street-II	BW	0.0	30.18
51	T.V.Kovil	HP	0.4	52.30
52	West Chitra Street-IV	BW	0.9	78.81
53	Burma Colony-III	HP	0.3	67.40
54	Devi Street-III	OW	0.3	9.59
55	Renga Nagar-II	BW	0.0	23.44
56	Kumaran Nagar-III	BW	0.3	24.78
57	Renga Nagar-III	BW	0.2	20.83
58	Sakthi Nagar-II	OW	0.4	17.73
59	Salai Road-II	BW	-0.3	17.39
60	Sathara Street-V	BW	0.4	12.65
61	Uthara Street-III	HP	1.0	12.98
62	Sakthi Nagar-III	OW	0.2	10.98
63	East Chitra Street-IV	BW	0.3	32.33
64	North Chitra Street-V	BW	0.7	24.47
65	South Chitra Street-IV	HP	0.1	17.51
66	Nehru Street-IV	BW	0.1	16.53
67	Rajaji Street-III	BW	0.2	16.55
68	North Chitra Street-VI	BW	1.0	29.41
69	Kelakondaiyanpettai-I	BW	0.1	10.34
70	Manickampillai Street-I	BW	-0.3	17.41
71	Devi Street-IV	OW	0.9	22.70
72	Rajaji Street-IV	OW	0.7	2.25
73	Salai Road-III	OW	-0.1	30.50
74	Thiruvalluvar Street-III	HP	0.5	26.15
75	Srinivasa Nagar (3rd Cross)-I	BW	0.2	34.62
76	Melakondaiyanpettai-III	HP	-0.3	27.47
77	Renga Nagar-IV	OW	-0.3	44.86
78	Devi Street-V	OW	0.7	46.94
79	Kumaran Nagar-IV	HP	0.4	60.01
80	Srinivasa Nagar (1st Cross)-III	OW	0.3	37.85
81	Melakondaiyanpettai-IV	BW	0.5	2.33
82	Kelakondaiyanpettai-II	BW	0.0	45.83
83	Rajaji Street-V	BW	0.1	47.12
84	Srinivasa Nagar (3rd Cross)-II	HP	0.0	16.54
85	East Chitra Street-V	BW	0.5	27.94
86	Srinivasa Nagar (2nd Cross)	OW	0.9	62.51
87	Nelson Road-III	BW	1.1	55.95
88	Srinivasa Nagar, (1st Cross)	OW	0.1	23.70
89	Morakara Street-III	BW	0.1	18.09
90	Burma Colony-IV	BW	0.1	27.54
91	West Chitra Street-V	HP	0.0	29.16
92	Kelakondaiyanpettai-III	OW	0.0	18.30
93	Salai Road-IV	BW	0.5	36.65
94	East Chitra Street-VI	BW	0.7	76.67
95	Thiruvalluvar Street-IV	BW	0.9	106.45
96	Manickampillai Street-II	HP	0.2	31.39
97	V.O.C. Street-IV	BW	-0.3	65.63
98	Srinivasa Nagar (4th Cross)	OW	0.3	78.29
99	Nelson Road-IV	BW	0.1	78.27
100	Thiruvalluvar Street-V	BW	0.1	45.03

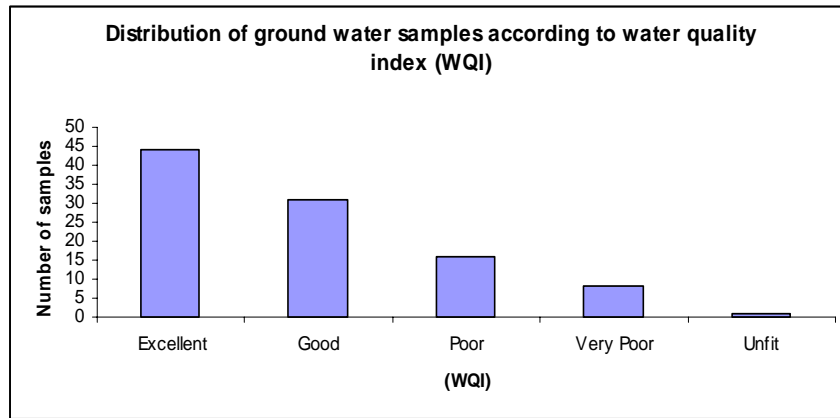


FIGURE 2. DISTRIBUTION OF GROUND WATER SAMPLES ACCORDING TO WQI

TABLE 4 DESCRIPTIVE STATISTICS OF GROUNDWATER SAMPLES SRIRANGAM TALUK

Quality Parameters	Minimum	Maximum	Mean	Std. Deviation
Ph	7	8	7.38	0.29
EC	0.09	5.86	2.02	1.05
TA	229.3	825.3	437.43	119.34
CH	39.2	519.4	199.33	86.93
MH	39.2	519.4	196.38	89.28
TH	39.2	519.4	196.38	89.28
TDS	51.8	3776.7	1152.47	754.47
F	0.02	1.82	0.59	0.44

TABLE 5 FACTOR ANALYSIS OF THE WATER QUALITY PARAMETERS OF THE GROUNDWATER SAMPLES IN SRIRANGAM TALUK

Principal components	PC-1	PC-2	PC-3	Communality
Principal component loadings				
Ph	.149	.086	.482	.149
EC	.053	.952	-.033	.053
TA	.174	-.011	.697	.174
CH	-.284	-.052	.735	-.284
MH	.986	.052	.019	.986
TH	.986	.052	.019	.986
TDS	.039	.964	-.012	.039
F	-.162	-.171	.317	-.162
Eigen value	2.272	1.737	1.342	
% Variance	28.399	21.709	16.770	
Cumulative %	28.399	50.108	66.877	

A. Water Quality Index (WQI)

Water Quality Index (WQI) is a very useful and efficient tool for communicating the overall quality of water to determine the suitability of the groundwater for drinking purposes.

Water Quality Index is computed by adopting the method (16) which is formulated as,

$$WQI = \text{Antilog}[SW_{n=1}^n \log_{10} q_n]$$

Where, W_n , Weightage = K/S_n and K , Constant = $1/(S_{n=1}^n 1/S_i)$

S_n and S_i correspond to the WHO/ICMR standard value of the parameters.

Quality rating (q) is calculated as

$$Q_{ni} = [(V_{\text{actual}} - V_{\text{ideal}}) / (V_{\text{standard}} - V_{\text{ideal}})] \times 100$$

Where, q_{ni} = quality rating of i th parameter for a total of n water samples

V_{actual} = Value of the water quality parameter obtained from the laboratory analysis.

V_{standard} = Value of the water quality parameter obtained from the standard tables.

V_{ideal} for pH = 7 and for the other parameters it is equivalent to zero.

The WQI has been calculated (Table 3 & Fig 2) for the Ground water samples in Srirangam. The samples have been classified in to five different categories namely Excellent(E), Good(G), Poor(P), Very Poor(VP) and Unfit(U).

Samples under Excellent (E) category: (WQI < 25)

The Excellent quality of the groundwater samples were observed in 44 samples out of 100 samples in Srirangam

Samples under Good (G) category: (WQI = 26 – 50)

There were 31 samples, found to be under the category of Good out of 100 samples.

Samples under Poor (P) category: (WQI = 51 – 75)

From the investigated 100 samples in Srirangam, 16 samples have been found under the Poor category.

Samples under Very Poor (VP) category: (WQI = 76 – 100)

Eight samples were registered to have a Very Poor quality. Three samples under the Very Poor category were found to have excess fluoride, TH and TDS content.

Samples under the Unfit (U) category: (WQI > 100)

One sample from bore well, considered to be Unfit for drinking. The highest value of fluoride (1.82 mg/l) along with high value of TH and TDS also witnessed the unfit category of the particular water sample.

B. LANGELEIR SATURATION INDEX (LSI)

The LSI values (19) for the samples were calculated to determine the scaling potential nature of the groundwater samples in Srirangam. The LSI values for all the groundwater samples and the number of samples under the positive, negative values very close to zero have been shown (Table 3).

Out of 100 samples, 24 samples were found with negative LSI values, 65 samples with positive LSI values and 11 samples with LSI value zero.

Negative LSI values convey the corrosive nature of the ground water samples.

Positive LSI values with a strong indication of scaling potential nature due to $CaCO_3$ precipitation. This may be accounted with respect to greater temperature and TDS content.

The LSI value of zero highlights the nature of borderline scaling potential. This type is subject to change with the effect of water quality and temperature.

C. FACTOR ANALYSIS

The descriptive statistics of the studied groundwater samples are given in Table 4.

The first three factors viz., PC1, PC2, PC3 show Eigen values > 1, thus these three factors were chosen for subsequent factor analysis.

The cumulative variance explained by the three components was 66.87%. The PC1, PC2 and PC3 explains 28.39%, 21.71% and 16.77% of the total variance respectively. The first component correlates strongly with MH and TH. The second component correlates strongly with TDS and EC and the third component correlated with TA and CH. The study suggests that all the parameters influence strongly on the ground water quality of Srirangam Taluk.

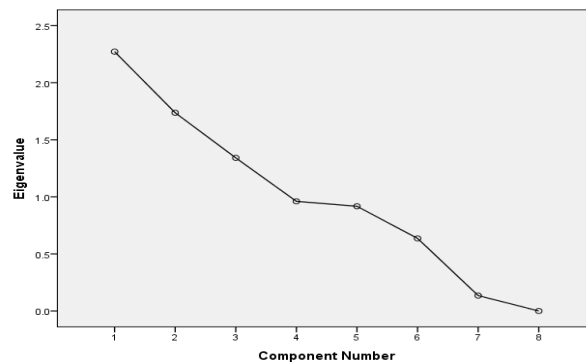


FIGURE 3. SCREE PLOT BASED ON PCA

IV. CONCLUSION

The study indicates that most of the ground water samples were found within the recommended limit of WHO in the assessed quality parameters viz., pH, TA, TH, TDS and Fluoride.

In the areas, where the fluoride content of water is more than the permissible limit of 1.5 mg/l, defluoridation (using certain conventional techniques like adsorption, Nalgonda method etc) has to be done and supplied to the public.

The deficiency of essential nutrients namely calcium, magnesium, carbonate, bicarbonate etc., was proved by the WQI values. The same also evidenced the deteriorated quality of ground water samples in the land area.

According to LSI values, the ground water found to have scale forming and corrosive nature (17). The zero value of LSI witnessed that the nature of ground water may vary according to temperature and other properties. FA proves that the hardness influences more on the potable nature of ground water quality. Hence the Factor Analysis is important analytical techniques for the processing of water quality parameters and power full tools for classification as well as identification of possible sources of pollution.

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