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EVALUATION OF THE WATER QUALITY INDEX AND SEAWATER MIXING INDEX OF THE CUDDALORE DISTRICT IN TAMIL NADU, INDIA

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ABSTRACT

In the present study, the geochemical characteristics of groundwater and drinking water quality have been studied. 100 groundwater samples were collected in the Cuddalore district and analyzed for physico-chemical character. The aim of this study is to determine the water quality index (WQI) and seawater mixing index (SMI) in groundwater chemistry from the Cuddalore district. 100 samples in all were examined for WQI. In the pre-monsoon season, 77% of the 100 samples had bad water quality and 23% had high water quality; in the post-monsoon season, 88% of the samples had poor water quality and 12% had good water quality. In the pre-monsoon season, 95% of the 100 samples fall into the SMI<1 category and 5% into the SMI>1 water quality category; in the post-monsoon season, 91% of the samples fall into the SMI<1 category and 9% into the SMI>1 water quality category, respectively. The majority of the Cuddalore district groundwater samples are falling under the excellent to good category and are suitable for irrigation quality and drinking water purposes.

Keywords: Geochemical, Groundwater, Water Quality Index, Seawater mixing index.

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INTRODUCTION

Groundwater is one of the most precious natural resources, which is exploited throughout the world. The demand of this natural resource is growing haphazardly due to the escalating use of groundwater for human needs such as domestic, irrigation, and industrial purposes. The annual extraction of groundwater is found to be in excess than the recharge from natural sources. Groundwater quality determination is important for assessing the suitability of water for domestic and irrigation needs. Geochemical studies of groundwater provide a better understanding of possible changes in quality (Arumugam and Elangovan 2009) and the geochemical processes are responsible for the seasonal and spatial variation in groundwater chemistry (Sarath Prasanth *et al.*, 2012). The natural chemical quality of groundwater depends on geological as well as geographical arrangement in the region. However, elevated concentrations of various groundwater parameters can cause serious health problems. The ionic variation in groundwater quality is due to rock–water interaction and oxidation–reduction reactions occur during the percolation of water through the aquifer (Krishnakumar *et al.*, 2009). Unsustainable extraction of groundwater may result in declining of water level, crop failure, adverse salt balance, and saline intrusion.

Many factors, including poor infiltration, excessive withdrawal, tidal and estuarine activity, sea level increases, mild coastal hydraulic gradients, and local hydrogeological variables, can be responsible for seawater intrusion (Kim et al., 2009). But seawater seeps into shallow, unconfined aquifers due to natural disasters like tsunamis and

tidal waves (Villholthet al., 2006). Therefore, a periodic investigation of groundwater chemistry is one of the most popular ways to evaluate seawater intrusion into an aquifer in coastal areas (Kim et al., 2009).Groundwater typically shows high concentrations of certain chemical elements, such as Cl-, Na^{+}, Mg^{2+}, and $SO_4$2-, in addition to total dissolved solids (TDS), when saltwater intrusion is the primary source of excessive salinity (Gimenez and Morell, 1997).

For the present study, hundred groundwater samples from the study area were collected during Pre-monsoon and Post-monsoon periods. The collected samples were analyzed for physical and chemical parameters using standard procedures and evaluation of the water quality index (WQI) and Seawater mixing index (SMI) of the Cuddalore district in Tamil Nadu, India

MATERIALS AND METHODS

Study Area

The study area, viz. Cuddalore district lies on the East Coast of Southern India, bound on the north, south and west by Villupuram, Nagapattinam and Perambalur districts and on the east by Bay of Bengal. The district lies between 78^0 42'and 80^0 12'east latitude and 12^0 27'30″and 11^0 10'45″north longitude. The average rainfall is 1164mm per year. There are 7 talukas situated in cuddalore district and the total population is around 2,605,914 according to the census report of 2011. The drinking water source of cuddalore district is mainly ground water for their drinking purpose and for day today activities. Bore well is the only supply of ground water in cuddalore district which is distributed through pipelines. The list of places were listed in Figure 2.

Groundwater samples were collected from 100 representative bore wells, during pre and post moonson 2014. The analysis was carried out systematically both volumetrically and by instrumental techniques. The procedures were followed from standard books and manuals (APHA, 2005; BIS, 2003; APHA, 1985, 1989, 1998, Gloterman *et al.*, (1978) and National Environmental Engineering Research Institute (NEERI, 1988). Hence, the study was designed to evaluate the parameters significant for potability purpose and the concentration in the water was compared with the standards prescribed by WHO (World Health Organization) and BIS (Bureau of Indian Standards).

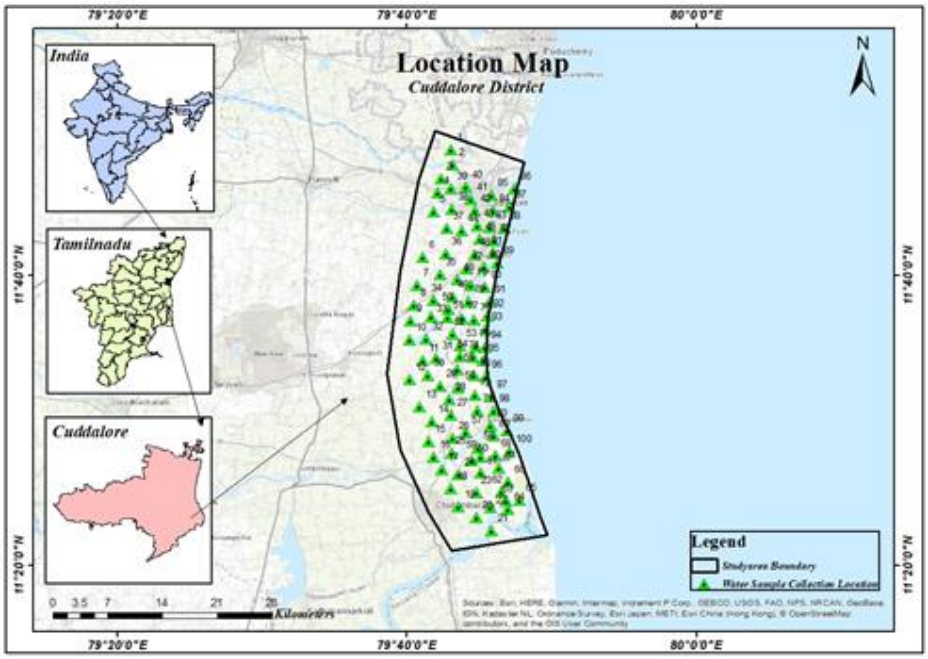

Figure 1: Location of sample collection

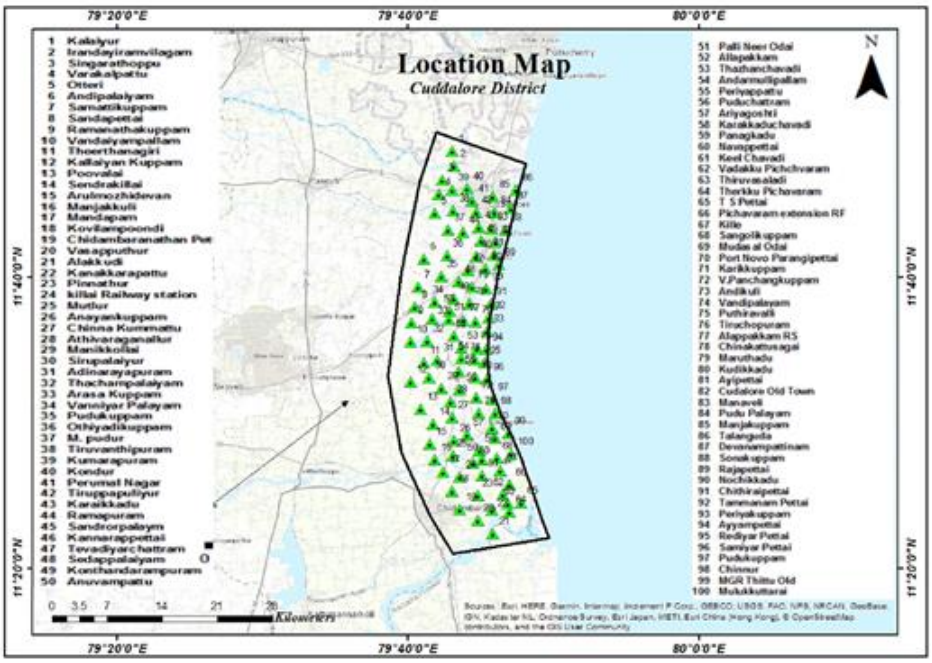

Figure 2: Sample location of the study area

Water quality index calculation (WQI)

The water quality index (WQI) was calculated for evaluating influence of natural and anthropogenic activities based on several key parameters of groundwater chemistry. To calculate the WQI, the weight has been assigned for the physico-chemical parameters according to the parameters relative importance in the overall quality of water for drinking water purposes. The assigned weight ranges from 1 to 5. The maximum weight of 5 has been assigned for nitrate and TDS, 4 for pH, EC, SO_4, 3 for HCO_3, Cl, 2 for Ca, Na, K and weight 1 assigned for Mg (Vasanthavigar *et al.*, 2010).

The relative weight is computed from the following equation.

$$Wi = wi / \sum_{i=1}^{n} wi$$

Wi ***is the relative weight***

wi *is the weight of each parameter*

n *is the number of parameters.*

The quality rating scale for each parameter is calculated by dividing its concentration in each water sample by its respective standards (World Health Organization, 2011) and multiplied the results by 100.

$$qi = (Ci/Si) \times 100$$

qi is the quality rating

Ci is the concentration of each chemical parameter in each sample in milligrams per liter, **Si** is the World Health Organization standard for each chemical parameter in milligrams per liter according to the guidelines of the (WHO, 2011).

For computing the final stage of WQI, the SI is first determined for each parameter. The sum of SI values gives the water quality index for each sample

$$SIi = Wi \times qi$$

$$WQI = \sum_{SIi}$$

SIi is the sub-index of i^{th} parameter

qi is the rating based on concentration of i^{th} parameter

n is the number of parameters

Seawater Mixing Index (SMI)

Seawater Mixing Index (SMI) is first suggested by Park *et al.* (2005). This parameter is based on the concentration of four major ionic constituents in seawater such as Na, Cl, Mg, and SO_4. It can be calculated by following formula.

$$SMI = a \times \frac{C\ Na}{T\ Na} + b \times \frac{C\ Mg}{T\ Mg} + c \times \frac{C\ Cl}{T\ Cl} + d \times \frac{C\ SO4}{T\ SO4}$$

where the constants a, b, c and d denote the relative concentration proportion of Na, Mg, Cl and SO_4 in seawater (a = 0.31, b = 0.04, c = 0.57 and d = 0.08) . C is the measured concentration in mg/L; and T represents the regional threshold values of the considered ions which can be

estimated from the interpretation of cumulative probability curves.

RESULTS AND DISCUSSION

Water quality index calculation (WQI)

The chemistry of groundwater is often used as a tool for discriminating the drinking and irrigation water quality (Subba Rao, 2006; Vasanthavigar *et al*. 2010). Water quality index (WQI) is an important parameter for identifying the water quality and its sustainability for drinking purposes (Subba Rao, 1997; Magesh *et al*. 2013). WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall water quality (Mitra *et al.,* 1998). World Health Organization, standards for drinking water quality have been used to calculate the WQI. The relative weight (*wi*) was assigned for water quality parameters based on their relative importance on water quality for drinking purposes (**Table 1**). The water quality classification based on WQI values is shown in **Table 2**. A total of 100 samples were analyzed for WQI. Among the 100 samples, 77 % of the samples feel poor water category and 23% of the samples showed good water quality respectively in pre-monsoon season while 88% of the samples feel poor water category and 12% of the samples showed good water quality respectively in post-monsoon season. This may be due to various chemical industries, effective leaching and dissolution process of chemical. High concentration of EC, chloride, sodium followed by calcium clearly suggests that various chemical industries are the main source for degrading the water quality in the study area. **Table 3** shows the water quality index (WQI) classification for individual samples.

Table 1: Relative weight of chemical of physico-chemical Parameters

Parameter	Weight (wi) (Vasanthavigar *et al.*, 2010)	Wi	WHO Standard (2011)
pH	4	0.133	6.5 – 8.5
EC (µS/cm)	4	0.133	500
TDS (mg/L)	5	0.166	500
HCO_3 (mg/L)	3	0.100	500
Cl (mg/L)	3	0.100	250
SO_4 (mg/L)	4	0.133	250
Ca (mg/L)	2	0.066	75
Mg (mg/L)	1	0.033	50
Na (mg/L)	2	0.066	200
K (mg/L)	2	0.066	200
	n= 30		

Table 2: Water quality classification ranges and types of water based on WQI values

Range	Type of water
<50	Excellent water
50–100	Good water
100–200	Poor water
200–300	Very poor water
>300	Water unsuitable for drinking purposes

Table 3: Water quality index (WQI)

S. No	Sample Location (Cuddalore District)	Pre-monsoon		Post-monsoon	
		WQI	Type of water	WQI	Type of water
1	**Kalaiyur**	127.02	Poor water	136.35	Poor water
2	**Irandayiramvilagam**	133.53	Poor water	142.46	Poor water
3	**Singarathoppu**	118.17	Poor water	129.56	Poor water
24	**Varakalpattu**	105.78	Poor water	110.94	Poor water
5	**Otteri**	124.84	Poor water	132.04	Poor water
6	**Andipalaiyam**	95.86	Good water	101.01	Poor water

7	**Samattikuppam**	103.78	Poor water	110.46	Poor water
8	**Sandapettai**	108.45	Poor water	113.11	Poor water
9	**Ramanathakuppam**	108.26	Poor water	110.54	Poor water
10	**Vandaiyampallam**	112.02	Poor water	107.82	Poor water
11	**Theerthanagiri**	121.45	Poor water	114.74	Poor water
12	**Kallaiyan Kuppam**	128.66	Poor water	113.52	Poor water
13	**Poovalai**	206.81	Poor water	177.89	Poor water
14	**Sendrakillai**	152.96	Poor water	157.88	Poor water
15	**Arulmozhidevan**	146.91	Poor water	156.01	Poor water
16	**Manjakkuli**	120.19	Poor water	135.68	Poor water
17	**Mandapam**	130.04	Poor water	138.21	Poor water
18	**Kovilampoondi**	125.43	Poor water	128.18	Poor water
19	**Chidambaranathan Pettai**	109.41	Poor water	113.86	Poor water
20	**Vasapputhur**	105.51	Poor water	111.18	Poor water
21	**Alakkudi**	115.02	Poor water	121.87	Poor water
22	**Kanakkarapattu**	112.25	Poor water	115.37	Poor water
23	**Pinnathur**	123.91	Poor water	128.06	Poor water
24	**killai Railway station**	133.59	Poor water	129.63	Poor water
25	**Mutlur**	122.19	Poor water	126.61	Poor water
26	**Anayankuppam**	167.41	Poor water	167.52	Poor water
27	**Chinna Kummattu**	116.11	Poor water	136.79	Poor water
28	**Athivaraganallur**	128.46	Poor water	139.73	Poor water
29	**Manikkollai**	116.94	Poor water	127.03	Poor water
30	**Sirupalaiyur**	115.83	Poor water	127.28	Poor water
31	**Adinarayapuram**	139.26	Poor water	145.58	Poor water
32	**Thachampalaiyam**	129.48	Poor water	127.48	Poor water
33	**Arasa Kuppam**	144.32	Poor water	153.33	Poor water
34	**Vanniyar Palayam**	68.17	Good water	78.92	Good water
35	**Pudukuppam**	85.79	Good water	93.94	Good water
36	**Othiyadikuppam**	91.74	Good water	99.72	Good water
37	**M. pudur**	83.78	Good water	93.69	Good water
38	**Tiruvanthipuram**	101.56	Poor water	109.37	Poor water
39	**Kumarapuram**	123.42	Poor water	123.32	Poor water
40	**Kondur**	121.67	Poor water	130.91	Poor water
41	**Perumal Nagar**	138.86	Poor water	148.23	Poor water
42	**Tiruppapuliyur**	110.27	Poor water	116.94	Poor water
43	**Karaikkadu**	97.8	Good water	105.69	Poor water
44	**Ramapuram**	73.71	Good water	82.91	Good water
45	**Sandrorpalaym**	85.56	Good water	98.17	Good water
46	**Kannarappettai**	97.83	Good water	105.69	Poor water
47	**Tevadiyarchattram**	184.59	Poor water	201.13	Poor water
48	**Sedappalaiyam**	157.67	Poor water	163.63	Poor water
49	**Konthandarampuram**	151.53	Poor water	160.92	Poor water
50	**Anuvampattu**	166.63	Poor water	173.07	Poor water

51	**Palli Neer Odai**	99.47	Good water	104.62	Poor water
52	**Allapakkam**	114.83	Poor water	121.01	Poor water
53	**Thazhanchavadi**	102.51	Poor water	111.03	Poor water
54	**Andarmullipallam**	91.91	Good water	98.53	Good water
55	**Periyappattu**	114.18	Poor water	119.11	Poor water
56	**Puduchattram**	112.95	Poor water	119.91	Poor water
57	**Ariyagoshti**	112.42	Poor water	119.19	Poor water
58	**Karakkaduchavadi**	92.11	Good water	101.33	Poor water
59	**Panagkadu**	94.88	Good water	104.37	Poor water
60	**Navappettai**	111.04	Poor water	116.34	Poor water
61	**Keel Chavadi**	134.51	Poor water	142.91	Poor water
62	**Vadakku Pichchvaram**	139.63	Poor water	148.41	Poor water
63	**Thiruvasaladi**	147.01	Poor water	154.09	Poor water
64	**Therkku Pichavaram**	140.22	Poor water	145.38	Poor water
65	**T S Pettai**	144.89	Poor water	154.18	Poor water
66	**Pichavaram extension RF**	125.47	Poor water	85.08	Poor water
67	**Kille**	100.83	Poor water	108.2	Poor water
68	**Sangolikuppam**	98.03	Good water	109.26	Poor water
69	**Mudasal Odai**	85.17	Good water	92.31	Good water
70	**Port Novo Parangipettai**	112.99	Poor water	119.32	Poor water
71	**Karikkuppam**	116.78	Poor water	123.07	Poor water
72	**V.Panchangkuppam**	83.78	Good water	90.76	Good water
73	**Andikuli**	117.31	Poor water	125.34	Poor water
74	**Vandipalayam**	113.87	Poor water	122.66	Poor water
75	**Puthiravalli**	135.57	Poor water	145.89	Poor water
76	**Tiruchopuram**	142.18	Poor water	146.21	Poor water
77	**Alappakkam RS**	139.64	Poor water	146.41	Poor water
78	**Chinakattusagai**	148.52	Poor water	153.57	Poor water
79	**Maruthadu**	139.85	Poor water	148.74	Poor water
80	**Kudikkadu**	97.19	Good water	104.23	Poor water
81	**Ayipettai**	90.98	Good water	97.71	Good water
82	**Cudalore Old Town**	105.28	Poor water	113.73	Poor water
83	**Manaveli**	95.28	Good water	102.97	Poor water
84	**Pudu Palayam**	106.82	Poor water	105.15	Poor water
85	**Manjakuppam**	128.09	Poor water	138.93	Poor water
86	**Talanguda**	135.23	Poor water	142.81	Poor water
87	**Devanampattinam**	132.57	Poor water	140.78	Poor water
88	**Sonakuppam**	135.67	Poor water	143.34	Poor water
89	**Rajapettai**	102.61	Poor water	108.68	Poor water
90	**Nochikkadu**	106.76	Poor water	113.11	Poor water
91	**Chithiraipettai**	101.99	Poor water	108.78	Poor water
92	**Tammanam Pettai**	113.18	Poor water	121.91	Poor water
93	**Periyakuppam**	115.24	Poor water	116.95	Poor water
94	**Ayyampettai**	173.05	Poor water	182.08	Poor water

95	**Rediyar Pettai**	146.66	Poor water	155.05	Poor water
96	**Samiyar Pettai**	101.44	Poor water	106.98	Poor water
97	**Pudukuppam**	78.06	Good water	88.82	Good water
98	**Chinnur**	84.47	Good water	96.38	Good water
99	**MGR Thittu Old**	97.87	Good water	104.51	Poor water
100	**Mulukkuttarai**	144.91	Poor water	144.91	Poor water

Seawater mixing index (SMI)

SMI values greater than one indicating the influence of seawater mixing with fresh groundwater. Seawater Mixing Index (SMI) values greater than one (SMI > 1) indicating the influence of seawater mixing with fresh groundwater. **Table 4** represent the Seawater mixing index (SMI) in pre-monsoon and post-monsoon of selected area of Cuddalore district. The calculation of SMI for groundwater total of 100 samples were analyzed for SMI. Among the 100 samples, 95 % of the samples fall under SMI<1 category and 5 % of the samples fall under SMI>1 water quality respectively in pre-monsoon while 91 % of the samples fall under SMI<1 category and 9% of the samples fell under SMI>1 water quality respectively in post-monsoon season of selected area of Cuddalore district.

Table 4: Seawater mixing index (n=100)

S. No	Sample Location (Cuddalore District)	Pre-monsoon		Post-monsoon	
		SMI	Type of water	SMI	Type of water
1	**Kalaiyur**	1.037	SMI > 1	1.108	SMI > 1
2	**Irandayiramvilagam**	1.006	SMI > 1	1.096	SMI > 1
3	**Singarathoppu**	0.801	SMI < 1	0.847	SMI < 1
4	**Varakalpattu**	0.578	SMI < 1	0.644	SMI < 1
5	**Otteri**	0.949	SMI < 1	1.022	SMI > 1
6	**Andipalaiyam**	0.568	SMI < 1	0.583	SMI < 1
7	**Samattikuppam**	0.726	SMI < 1	0.741	SMI < 1
8	**Sandapettai**	0.458	SMI < 1	0.511	SMI < 1
9	**Ramanathakuppam**	0.706	SMI < 1	0.741	SMI < 1
10	**Vandaiyampallam**	0.586	SMI < 1	0.623	SMI < 1
11	**Theerthanagiri**	0.781	SMI < 1	0.809	SMI < 1
12	**Kallaiyan Kuppam**	0.774	SMI < 1	0.791	SMI < 1
13	**Poovalai**	1.088	SMI > 1	1.099	SMI > 1
14	**Sendrakillai**	0.723	SMI < 1	0.734	SMI < 1
15	**Arulmozhidevan**	0.851	SMI < 1	0.855	SMI < 1
16	**Manjakkuli**	0.674	SMI < 1	0.811	SMI < 1
17	**Mandapam**	0.834	SMI < 1	0.874	SMI < 1
18	**Kovilampoondi**	0.806	SMI < 1	0.835	SMI < 1
19	**Chidambaranathan Pettai**	0.714	SMI < 1	0.775	SMI < 1
20	**Vasapputhur**	0.752	SMI < 1	0.759	SMI < 1
21	**Alakkudi**	0.731	SMI < 1	0.741	SMI < 1
22	**Kanakkarapattu**	0.638	SMI < 1	0.692	SMI < 1
23	**Pinnathur**	0.665	SMI < 1	0.688	SMI < 1
24	**killai Railway station**	0.822	SMI < 1	0.869	SMI < 1
25	**Mutlur**	0.751	SMI < 1	0.841	SMI < 1
26	**Anayankuppam**	0.994	SMI < 1	1.046	SMI > 1
27	**Chinna Kummattu**	0.573	SMI < 1	0.637	SMI < 1
28	**Athivaraganallur**	0.771	SMI < 1	0.811	SMI < 1
29	**Manikkollai**	0.794	SMI < 1	0.816	SMI < 1

30	**Sirupalaiyur**	0.583	SMI < 1	0.646	SMI < 1
31	**Adinarayapuram**	0.551	SMI < 1	0.591	SMI < 1
32	**Thachampalaiyam**	0.772	SMI < 1	0.783	SMI < 1
33	**Arasa Kuppam**	0.735	SMI < 1	0.773	SMI < 1
34	**Vanniyar Palayam**	0.365	SMI < 1	0.437	SMI < 1
35	**Pudukuppam**	0.596	SMI < 1	0.648	SMI < 1
36	**Othiyadikuppam**	0.648	SMI < 1	0.702	SMI < 1
37	**M. pudur**	0.722	SMI < 1	0.762	SMI < 1
38	**Tiruvanthipuram**	0.782	SMI < 1	0.804	SMI < 1
39	**Kumarapuram**	0.586	SMI < 1	0.634	SMI < 1
40	**Kondur**	0.606	SMI < 1	0.644	SMI < 1
41	**Perumal Nagar**	0.706	SMI < 1	0.727	SMI < 1
42	**Tiruppapuliyur**	0.694	SMI < 1	0.698	SMI < 1
43	**Karaikkadu**	0.768	SMI < 1	0.781	SMI < 1
44	**Ramapuram**	0.467	SMI < 1	0.615	SMI < 1
45	**Sandrorpalaym**	0.803	SMI < 1	0.821	SMI < 1
46	**Kannarappettai**	0.672	SMI < 1	0.722	SMI < 1
47	**Tevadiyarchattram**	0.757	SMI < 1	0.923	SMI < 1
48	**Sedappalaiyam**	0.588	SMI < 1	0.671	SMI < 1
49	**Konthandarampuram**	0.502	SMI < 1	0.576	SMI < 1
50	**Anuvampattu**	0.701	SMI < 1	0.718	SMI < 1
51	**Palli Neer Odai**	0.586	SMI < 1	0.636	SMI < 1
52	**Allapakkam**	0.682	SMI < 1	0.713	SMI < 1
53	**Thazhanchavadi**	0.801	SMI < 1	0.855	SMI < 1
54	**Andarmullipallam**	0.539	SMI < 1	0.564	SMI < 1
55	**Periyappattu**	0.734	SMI < 1	0.731	SMI < 1
56	**Puduchattram**	0.672	SMI < 1	0.707	SMI < 1
57	**Ariyagoshti**	0.727	SMI < 1	0.735	SMI < 1
58	**Karakkaduchavadi**	0.574	SMI < 1	0.614	SMI < 1
59	**Panagkadu**	0.551	SMI < 1	0.601	SMI < 1
60	**Navappettai**	0.544	SMI < 1	0.566	SMI < 1
61	**Keel Chavadi**	0.659	SMI < 1	0.668	SMI < 1
62	**Vadakku Pichchvaram**	0.682	SMI < 1	0.711	SMI < 1
63	**Thiruvasaladi**	0.617	SMI < 1	0.645	SMI < 1
64	**Therkku Pichavaram**	0.695	SMI < 1	0.745	SMI < 1
65	**T S Pettai**	0.682	SMI < 1	0.728	SMI < 1
66	**Pichavaram extension RF**	0.948	SMI < 1	1.007	SMI > 1
67	**Kille**	1.023	SMI > 1	1.058	SMI > 1
68	**Sangolikuppam**	0.935	SMI < 1	0.978	SMI < 1
69	**Mudasal Odai**	0.783	SMI < 1	0.838	SMI < 1
70	**Port Novo Parangipettai**	0.868	SMI < 1	0.934	SMI < 1
71	**Karikkuppam**	0.575	SMI < 1	0.625	SMI < 1
72	**V.Panchangkuppam**	0.521	SMI < 1	0.591	SMI < 1
73	**Andikuli**	0.836	SMI < 1	0.941	SMI < 1

74	**Vandipalayam**	0.726	SMI < 1	0.804	SMI < 1
75	**Puthiravalli**	1.103	SMI > 1	1.148	SMI > 1
76	**Tiruchopuram**	0.641	SMI < 1	0.711	SMI < 1
77	**Alappakkam RS**	0.941	SMI < 1	0.957	SMI < 1
78	**Chinakattusagai**	0.678	SMI < 1	0.711	SMI < 1
79	**Maruthadu**	0.681	SMI < 1	0.765	SMI < 1
80	**Kudikkadu**	0.462	SMI < 1	0.531	SMI < 1
81	**Ayipettai**	0.549	SMI < 1	0.631	SMI < 1
82	**Cudalore Old Town**	0.463	SMI < 1	0.524	SMI < 1
83	**Manaveli**	0.617	SMI < 1	0.714	SMI < 1
84	**Pudu Palayam**	0.751	SMI < 1	0.792	SMI < 1
85	**Manjakuppam**	0.877	SMI < 1	1.002	SMI > 1
86	**Talanguda**	0.847	SMI < 1	0.921	SMI < 1
87	**Devanampattinam**	0.623	SMI < 1	0.703	SMI < 1
88	**Sonakuppam**	0.591	SMI < 1	0.674	SMI < 1
89	**Rajapettai**	0.861	SMI < 1	0.912	SMI < 1
90	**Nochikkadu**	0.645	SMI < 1	0.704	SMI < 1
91	**Chithiraipettai**	0.674	SMI < 1	0.733	SMI < 1
92	**Tammanam Pettai**	0.731	SMI < 1	0.783	SMI < 1
93	**Periyakuppam**	0.644	SMI < 1	0.723	SMI < 1
94	**Ayyampettai**	0.841	SMI < 1	0.852	SMI < 1
95	**Rediyar Pettai**	0.604	SMI < 1	0.651	SMI < 1
96	**Samiyar Pettai**	0.796	SMI < 1	0.864	SMI < 1
97	**Pudukuppam**	0.415	SMI < 1	0.537	SMI < 1
98	**Chinnur**	0.604	SMI < 1	0.636	SMI < 1
99	**MGR Thittu Old**	0.842	SMI < 1	0.861	SMI < 1
100	**Mulukkuttarai**	0.942	SMI < 1	0.969	SMI < 1

CONCLUSIONS

The study area is always under stress due to increasing population and more demand for water resources. To improve the quality of water, the Government and non-government organization should provide the moral support to design the rain water harvesting structures and artificial recharge methods for young generation especially budding civil engineers.

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