Journal of Earth Science & Climatic Change

Research Article Open Access

Impact of Seawater Intrusion on Groundwater in Kanchipuram District, Tamil Nadu Coastal Area

Soujanya Jonnalagadda*, Gokulan Ravindiran, Lokesh Reddy, Venkat Revanth, Sharj and Mahesh Babu

Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, India

Abstract

Saltwater intrusion is a global issue that affects the coastal areas worldwide. Due to this intrusion it will affects the growth of crops, soil fertility and human health. Current study estimates parameters such as Water Quality Index(WQI), Human Health Risk Assessment(HHRA), Seawater Mixing Index(SMI) and Irrigation efficiency(IE) in order to examine the ground water quality of Kanchipuram district, Tamil Nadu coastal area. A total of 60 sampling stations were taken to examine ground water quality. For the ground water analysis the physicochemical parameters were taken into the account. Q-GIS have been used in mapping the sampling locations and affected areas. For WQI out of 60 stations, it was observed that around 30% of groundwater is above good quality and around 42% is very poor and not suitable for consumption. The WQI states that groundwater in Kanchipuram district was moderately polluted. SMI was also calculated, it was observed that out of 60 stations SMI values of 23 stations were above 1 i.e, in 38% of stations SMI value was observed to be high. Also calculated HHRA, it was observed in 13 % of stations fluoride content is greater than 1 in children. The analysis shows that children's average fluoride content is higher than adults. Irrigation Indices concludes that 65% of sampling stations having SAR values greater than 10 mEq/L and 58 stations having Na% less than 80 percent.

Keywords: WQI, HHRA; Seawater Mixing Index; Saltwater intrusion

Introduction

Water is one of the vital natural resources in our daily life. Water is used for various purposes like domestic, industrial and agriculture. Humans mainly depends on the groundwater to fulfill their basic needs [1]. Due to increase in population and industrialization the usage of groundwater is increasing day by day. The water bodies were under danger situation due to rapid increase in population and also urbanisation, this automatically leads to use of chemicals in irrigation in order to get more yield which eventually causes contamination of water by surface runoff. In coastal areas, the excess usage of groundwater leads to difference in sea level which results in intrusion of seawater on groundwater, so there is a risk of contamination of groundwater [2]. The migration of saltwater into freshwater aquifers as a result of human or natural activity is known as seawater intrusion. The seawater intrusion decreases the storage capacity of groundwater and also in some cases it leads to abandonment of wells. Areas which are adjacent to coastal waters are having more risk of seawater intrusion [3]. It is a serious issue that affects coastal aquifers globally. Reductions in groundwater levels or elevations in seawater levels can result in seawater intrusion. A cone of depression is created in the aquifer when freshwater is pumped out quickly, lowering its height. In a conical ascent, the sea level increases 40 feet for every foot of freshwater depression. Saltwater intrusion into freshwater bodies affects the soil condition, vegetation, and water quality it seems as a global problem. Higher concentration of chlorides in water is unfit for drinking and industrial activities, higher concentrations of sodium ions in water can lead to high blood pressure in humans [4]. To assess the groundwater quality various parameters were determined. The most effective way to evaluate the quality of ground water is WQI. We computed the Seawater Mixing Index (SMI) to figure out how ground water is affected by seawater intrusion. Due to consumption of this polluted groundwater and also through agricultural activities like usage of excessive fertilizers and unsanitary conditions human health is at risk. To examine the fluoride content in both adults and children Human Health Risk Assessment (HHRA) was calculated. Intruded groundwater can have a negative impact on irrigation indices. To know the effect on irrigation we had also calculated the Irrigation Indices (II) [5]. The present study was undertaken in Kanchipuram district(12.8185° N, 79.6947° E) located at northern east coast of Tamil Nadu. Kanchipuram district covers a total area of 1448 Sq.Kms, where 87.2km is the coastal length. It has a normal rainfall of 1200-1300mm. The river basins of the Palar, Araniyar & Kosasthalaiyar, and Thondiar, are utilized for irrigation and drinking purposes. This study's primary goal is to determine the groundwater quality in different blocks of Kanchipuram district and also mapping the results using Q-GIS.

Materials and Methods

Study area: Figure 1 illustrates The Kancheepuram district's study area is near Chennai city and located on Tamil Nadu's northern east coast. The district has a total area of 1448 Sq.Kms. It lies between 11° 00' to 12° 00' latitudes and 77° 28' to 78° 50' longitudes. The maximum and minimum temperatures of Kanchipuram district are during summer 38.5 °C (101.3 °F) , 29.1 °C (84.4 °F) and during winter 27.7 °C (81.9 °F), 19.0 °C (66.2 °F). The maximum rainfall of 9.8 inches occurs in October and the least amount of rainfall occurs in February with average of 0.4 inches. The average humidity conditions range from 73 to 90%.The research was conducted using 60 groundwater samples that were collected all over the Kanchipuram district. The samples were tested by Central Groundwater Board of India (CGWB) (Table 1).

***Corresponding author:** Soujanya Jonnalagadda, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, India, E-mail: soujanya_j@vnrvjiet.in

Received: 02-Feb-2024, Manuscript No: jescc-24-128783; **Editor assigned:** 05-Feb-2024, Pre-QC No: jescc-24-128783 (PQ); **Reviewed:** 19-Feb-2024, QC No: jescc-24-128783; **Revised:** 24-Feb-2024, Manuscript No: jescc-24-128783 (R); **Published:** 29-Feb-2024, DOI: 10.4172/2157-7617.1000771

Citation: Soujanya J, Gokulan R, Lokesh R, Venkat R, Sharj, et al. (2024) Impact of Seawater Intrusion on Groundwater in Kanchipuram District, Tamil Nadu Coastal Area. J Earth Sci Clim Change, 15: 771.

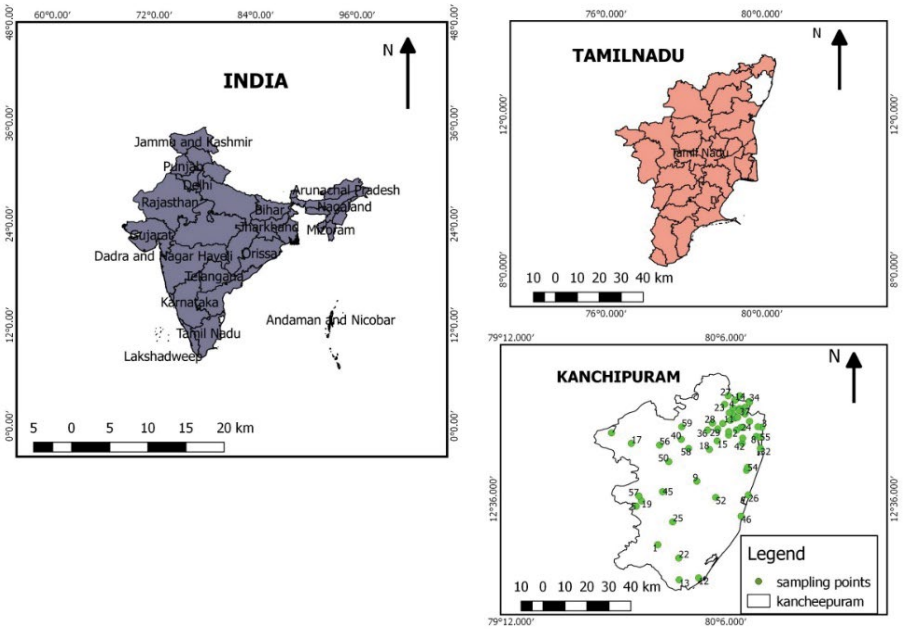

Figure 1: Location of sampling stations of Kanchipuram district, Tamil Nadu, India.

Table 1: Latitude and Longitude details of sampling locations.

S. No	Sampling location	Latitude	Longitude
1	Acharapakkam	12.4064	79.8133
2	Agaram	12.8898	80.143
3	Akkarai	12.902	80.2494
4	Anakaputhur	12.9827	80.1286
5	Arasanimangalam	12.5689	79.7233
6	Athur	12.4064	79.8133
7	Baluchettychatram	10.4633	77.79
8	Chemmancheri	12.8633	80.2261
9	Chenglepet	12.6744	79.9769
10	Chitlapakkam	12.9403	80.1378
11	Chrompet	12.95	80.1338
12	Chunambedu	12.2669	79.9844
13	Chunamedu	12.2586	79.9028
14	Girugambakkam	13.0153	80.1366
15	Guduvancheri	12.8439	80.0622
16	Hastinapuram	12.9431	80.1476
17	Kancheepuram	12.8336	79.7025
18	Kattankalathur	12.8083	80.0297
19	Kattur-Pz	12.5708	80.9749
20	Kilkattalai	12.9574	80.1785
21	Kolapakkam	12.8687	80.1101
22	Kolathanallur	12.3506	79.9014
23	Kundrathur	12.998	80.0936
24	Madambakkam	12.9008	80.1615
25	Madurantagam	12.5028	79.8761
26	Mahabalipuram	12.6158	80.1925
27	Mangadu	13.0342	80.1085
28	Manimangalam	12.919	80.0424
29	Mannivakkam	12.8922	80.8019
30	Meenambakkam	12.9855	80.1784
31	Mudichur	12.8943	80.0645
32	Muthukadu	12.8125	80.2433
33	Nagalkani	12.9576	80.1261
34	Nandambakkam	13.0106	80.196
35	Nedunkundram	12.8833	80.1106
36	Paddapai (Pz)	12.8898	80.022
37	Pallavaram	12.9814	80.156
38	Pallavaram pz	12.9725	80.1543
39	Pallikaranai (Pz)	12.9263	80.1979
40	Panruti Kandigai	12.8506	79.9119
41	Perungulathur	12.9173	80.0856
42	Ponmar	12.8338	80.1667
43	Ponmar (Pz)	12.8556	80.1693
44	Porur	13.0338	80.1569
45	Rettamangalam	12.63	79.8336
46	Sadras	12.5269	80.1622
47	Shollinganallore	12.9037	80.233
48	St.Thomas Mount	13.0071	80.1976
49	Tambaram	12.931	80.1166
50	Thirumukkudal	12.7564	79.8592
51	Thiruporur (Pz)	12.72	80.1852
52	Tirukalukundram	12.6061	80.056
53	Tiruneermalai	12.9628	80.1132
54	Tiruporur	12.7318	80.1891
55	Uthandi	12.86	80.2417
56	Uthikadu	12.8267	79.8211
57	Uthiramerur	12.6117	79.7344
58	Vadakkupattu	12.8117	79.9425
59	Vadekkal (Palnallur)	12.9036	79.9139
60	Vengaivasal	12.9004	80.1711

Water Quality Index (WQI): WQI provides the overall quality of the water for any intended purpose by expressing the water's quality as an index number. For calculation of WQI physicochemical parameters of water are taken into consideration [6,7]. Based on WQI the water quality is classified as Excellent (0-25), Good (26-50) , Poor (51-75) , Very Poor (76-100) and Unfit (>100).

$$WQI = \frac{\sum q_i w_i}{\sum w_i} \quad (1)$$

Table 2: HHRA Standards for the calculation of HI of fluoride.

Description	IR (L/day)	EF (day/year)	ED (year)	BW (kg)	AT (day)	SA (cm^2)	ET (h/day)
Adults	2	350	40	70	14,000	18,000	0.58
Children's	0.78	350	4	15	1,400	6,600	1

$$q_i = 100 \times \frac{(v - v_o)}{(s_n - s_o)} \quad (2)$$

$$W_i = \frac{K}{s_n} \quad (3)$$

$$K = \frac{1}{\sum \frac{1}{s_n}} \quad (4)$$

Where,

q_i – is the quality rating of each water quality parameter;

W_i – is the unit weight of each water quality parameter;

v – is the actual concentration of each water quality parameter;

v_o – is the constant value of each parameter (for pH it is 7 and for remaining all it is zero);

K – is the proportionality constant;

s_n – is the standard permissible value of each water quality parameter.

Seawater Mixing Index (SMI): The SMI is proposed by Park and Aral and it is used to estimate the relative index of saltwater mixing with fresh water.

The concentration of Na+, Mg+, Cl^-, SO_4^{2-} are used to calculate the sea water mixing index. It had been calculated using the following equation.

$$SMI = a \times \frac{C_{Na}}{T_{Na}} + b \times \frac{C_{Mg}}{T_{Mg}} + c \times \frac{C_{Cl}}{T_{Cl}} + d \times \frac{C_{SO_4}}{T_{SO_4}} \quad (5)$$

Where, Constants a, b, c and d denotes a relative proportion of Na+, Mg+, Cl^-, SO_4^{2-} respectively, there values are (a = 0.31,b = 0.04, c = 0.57, d = 0.08), T is the regional threshold values and C is the calculated Concentration of groundwater samples. The threshold value is obtained by drawing the graph between the sampling stations vs cumulative probability.

Human Health Risk Assessment (HHRA): Nitrate and fluoride are the two most pervasive contaminants found in groundwater that can be harmful to human health (Table 2). Worldwide reports of nitrate contamination in shallow groundwater, particularly in agricultural areas, are on the rise [8-10].

$$\mathrm{ADD_{ing}} = \frac{C_W \times IR \times EF \times ED}{BW \times AT} \quad (6)$$

$$ADD_{der} = \frac{C_W \times SA \times K_P \times ET \times EF \times ED \times 10^{-3}}{BW \times AT} \quad (7)$$

$$HQ_{ing} = \frac{ADD_{ing}}{RfD} \quad (8)$$

$$HQ_{der} = \frac{ADD_{der}}{RfD} \quad (9)$$

$$HI = HQ_{ing} + HQ_{der} \quad (10)$$

Where

C_W – is the actual concentration of water quality parameter in the water (mg/L);

IR – is the ingestion rate (L/day);

EF – is the exposure frequency (day/year);

ED – is the exposure duration in years;

BW – is the average body weight (kg);

AT – is the average time (days);

ET – is the exposure time (h/day);

SA – is the average surface area of the skin exposed to water in cm^2;

K_p – is the coefficient of water for dermal activity (0.001 for Na^{2+}, F^-, NO_3^- and Cl^-).

ADD_{ing} – is the average daily exposure dose through ingestion (ing);

ADD_{der} – is the average daily exposure dose through dermal (der);

RfD – is the reference dose of water quality parameters in mg/kg/day (F^- is 0.06 and NO_3^- is 1.6);

HQ_{ing} – is the Hazard Quotient of ingestion ;

HQ_{der} – is the Hazard Quotient of dermal;

HI – is the Hazard Index.

Irrigation Indices (II): In order to know the irrigation indices the following were calculated Sodium Adsorption Ratio(SAR), percentage of Na, Magnesium Adsorption Ratio(MAR), Permeability Index(PI) and Kelly's Ratio(KR) [11-14].

$$SAR = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}} \quad (11)$$

$$\%Na = \frac{Na+K}{Na+k+Ca+Mg} \times 100 \quad (12)$$

$$MAR = \frac{Mg}{Mg+Ca} \times 100 \quad (13)$$

$$KR = \frac{Na^+}{Ca^{2+}+Mg^{2+}} \quad (14)$$

$$PI = \frac{Na+\sqrt{HCO_3}}{Ca+Mg+Na} \times 100 \quad (15)$$

Results and Discussion

The presence of higher amounts of cations and anions results in seawater intrusion. As we can clearly observe that most of the sampling locations are having higher concentrations of anions and cations.

The above physico-chemical parameter shows that TDS values vary from 266 mg/L to 5213 mg/L. As per BIS standards 10 samples are less than 500 mg/L.

The pH values vary from 6.9 to 7.9. All the 60 samples are below the

Table 3: Physical and chemical characteristics of water samples from the Kanchipuram district (pH is the only unit not in mg/L).

Sample	pH	TDS	F	Cl	SO4	TH	Na	K	Ca	Mg	NO3
1	7.81	663	1.04	142	3	390	37	1	84	44	1
2	7.4	634	0.49	192	8	350	59	2	76	39	2
3	7.48	554	0.12	121	46	310	54	17	52	44	57
4	6.9	1004	1.4	206	5	400	145	45	78	36	157
5	7.1	748	0.52	145	60	380	64	1	100	32	70
6	7.2	924	1.15	248	50	450	99	1	64	70	40
7	7	1307	0.29	347	70	450	160	5	92	53	30
8	7.45	497	0.37	114	108	190	69	40	20	30	34
9	7.9	482	0.94	191	3	190	89	8	56	12	32
10	7.42	323	0.17	60	16	165	35	1	23	23	50
11	7.09	1145	0.91	312	29	530	169	4	76	83	7
12	7	880	0.41	305	50	460	72	0	120	39	45
13	7.11	315	0.4	28	2	160	36	0	32	19	21
14	7	1102	1.13	277	70	450	163	11	112	41	1
15	7.15	884	0.69	220	10	420	90	26	110	24	99
16	7.2	768	0.55	178	35	400	89	3	76	51	9
17	7.8	2555	1.76	596	8	140	722	23	32	15	72
18	7.7	535	0.59	113	6	310	37	3	56	41	38
19	7.7	391	0.81	85	42	270	20	6	60	29	6
20	7.4	1050	0.55	305	78	460	153	4	120	39	39
21	7.38	1186	0.64	312	73	480	199	2	116	46	98
22	7.64	625	0.9	163	6	250	104	2	44	34	19
23	7.2	865	1.21	241	44	350	127	3	112	17	27
24	7.38	1274	0.78	369	44	490	214	3	104	56	26
25	7.38	837	0.36	156	5	390	78	5	136	12	38
26	7.55	288	0.59	57	54	190	17	6	24	32	3
27	7.1	1178	0.8	298	66	460	184	14	128	34	85
28	7.54	1365	0.97	277	40	330	169	268	92	24	146
29	7	660	0.38	160	56	370	37	2	76	44	35
30	7.47	672	0.63	156	64	340	87	1	80	34	27
31	7.4	1112	0.37	291	52	430	182	21	140	19	65
32	6.96	1417	0.32	540	186	380	304	15	60	56	6
33	7.12	1097	0.42	348	7	350	226	3	68	44	1
34	7.3	593	0.93	146	35	230	93	15	64	17	16
35	7.1	790	0.63	160	90	370	82	0	72	46	35
36	7.33	1229	0.48	391	48	690	126	4	132	88	49
37	7.27	1359	0.89	391	106	510	217	2	132	44	40
38	7.56	757	0.82	213	47	420	72	1	108	36	16
39	7.25	1138	0.25	369	49	580	133	3	176	34	22
40	7.3	376	0.5	82	30	70	72	0	12	10	10
41	7.32	1749	1.11	518	71	440	402	4	80	58	53
42	7.52	591	0.2	170	35	340	52	5	64	44	2
43	7.5	686	0.54	163	31	350	81	3	58	46	62
44	7.1	881	1.21	213	21	370	123	2	88	36	2
45	7.1	546	0.99	57	30	230	54	0	76	10	25
46	7.82	863	0.7	178	122	460	90	21	128	34	73
47	7.51	2022	1.12	696	328	340	467	102	68	41	112
48	7	1242	1.32	320	78	540	184	1	144	44	59
49	7.26	629	0.54	149	25	310	83	4	72	32	58
50	7.2	416	0.33	71	35	160	72	4	28	22	37
51	7.59	947	0.84	220	144	360	158	7	56	54	5
52	7.7	298	0.51	85	34	180	23	8	24	29	8
53	7.15	583	0.12	156	9	270	65	31	68	24	13
54	7.86	1065	1.25	213	160	280	255	9	24	54	48
55	7.47	266	0.53	64	59	140	25	8	20	22	13
56	7	1697	1.7	440	98	780	65	89	240	44	110
57	7.12	5213	1.04	2382	9	2780	457	0	576	326	68
58	7.1	624	0.36	106	25	310	40	1	72	32	41
59	7.1	2002	0.77	638	155	440	398	29	64	68	25
60	7.29	1742	0.52	504	88	780	239	20	164	90	21

desired limit (pH: 6.5-8.5).

Total hardness values vary from 70 mg/L to 2780 mg/L. The desired limit is 300mg/L. 16 samples are in desired limit as per standards (Table 3).

As per BIS standards the desired limit for fluoride is 1.5mg/L and nitrate is 45 mg/L. For fluoride sample 17 and 56 are not within the limits.

Water Quality Index (WQI): In general the water quality depends upon the values of iron, manganese and arsenic. Increase in these values indicates decrease in its quality. Water quality index values ranges from 21 to 233. Out of 60 samples, 13 samples have exceeded the desired limit of drinking water as per BSI standards (Figure 2).

For WQI if the value is greater than 100 it is unfit for consumption, out of 60 stations 13 stations recorded are unfit for consumption,12 stations are very poor and 17 stations are poor. we observed that manimangalam (station 28) has a highest value of 233 which is greater than 100, Uthikadu has 193, Shollinganallore has 157 and many more. These are unfit for drinking because that area covered by many dyeing factories. Whereas places like Chitlapakkam have WQI value of 21 comes under excellent category. This area has no risk of mixing water from sea. From Fig.2 it is clear that the Kanchipuram district, Tamil Nadu was moderately polluted (Figure 3).

Seawater Mixing Index (SMI): The threshold values obtained from the graph (Actual frequency vs Concentration) are Na =93mg/L, Mg=44mg/L, Cl =440mg/L, SO_4 =50mg/L. From results SMI values varies from 0.18 to 4.92.

Generally, SMI value >1 signifies that the seawater is mixing with the groundwater. Out of total, 38% of the sampling stations namely Uthiramerur(4.92), Kancheepuram(3.21), Muthukadu(2.06) has SMI values above 1 are affected by seawater intrusion . Majorly seawater intrusion in that area causes due to climatic conditions, hydraulic gradient, rate of groundwater extraction and sea level rise. The people of Kanchipuram district uses more groundwater during summer this results in the decrease of groundwater table and due to this seawater intrusion takes place (Figure 4 and Figure 5).

Human Health Risk Assessment (HHRA) for fluoride: From above HHRA we conclude that fluoride content in children is greater

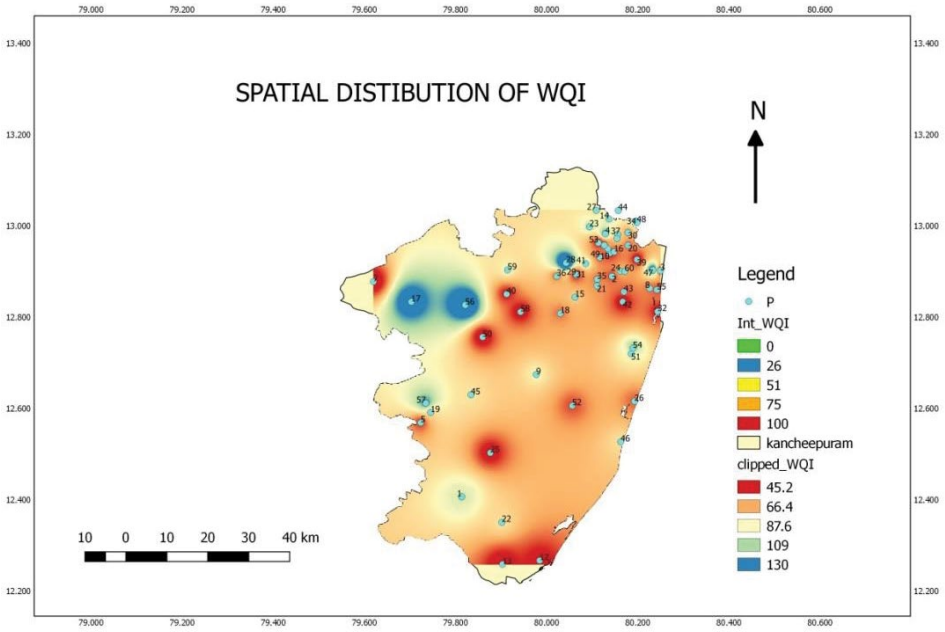

Figure 2: Geographical distribution map of Water Quality Index (WQI) of Kanchipuram district.

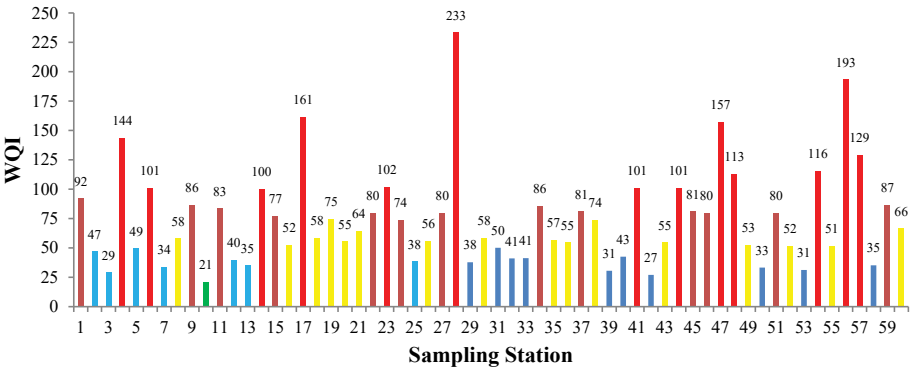

Figure 3: WQI values of different sampling stations of Kanchipuram District.

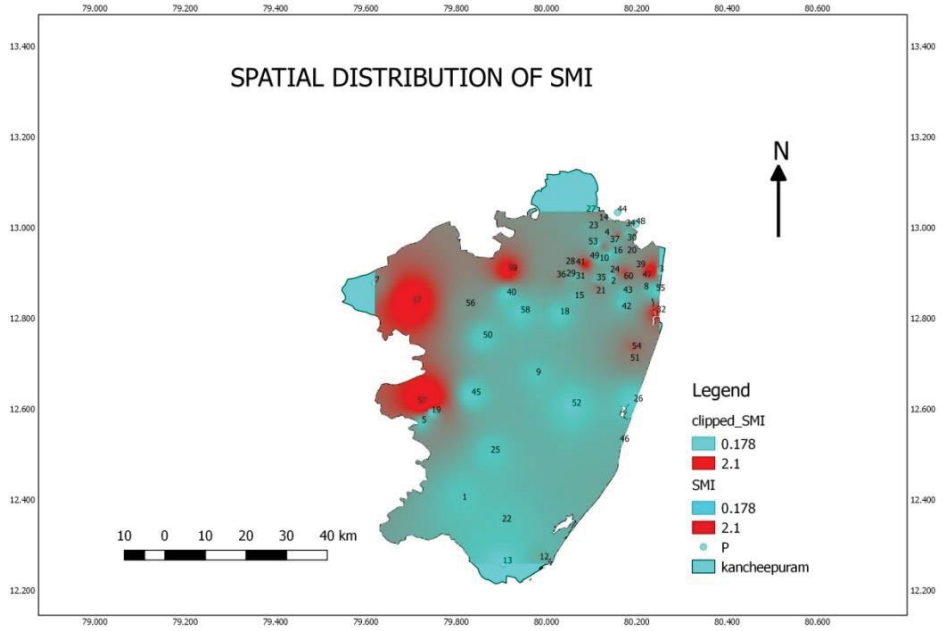

Figure 4: Geographical distribution map of Seawater Mixing (SMI) of Kanchipuram district.

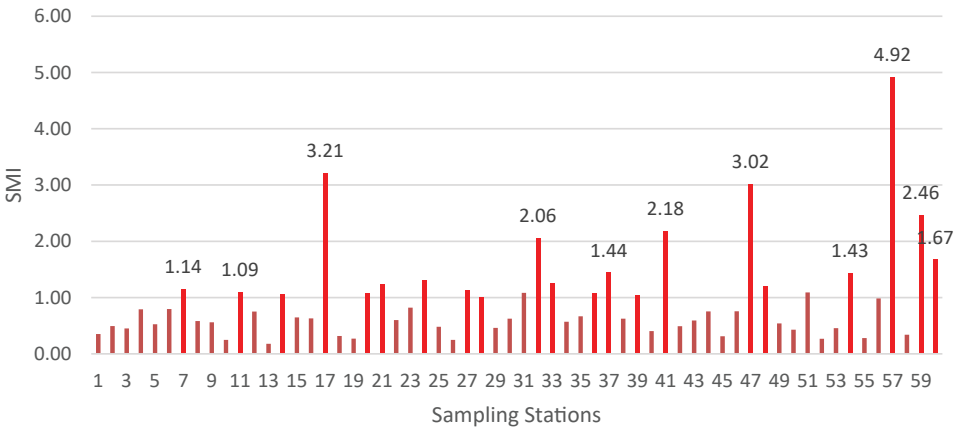

Figure 5: SMI values of different sampling stations of Kanchipuram District.

than adults. For adults the HI concentrations is less than 1 in all sampling stations, as fluoride content is not having much impact on adults. For adults the HI concentrations of Fluoride varied from 0.06 to 0.81 has an Average=0.37 and Children varied from 0.104 to 1.538 has an Average=0.69. Kancheepuram (station 17) area has high fluoride content in children (1.54). The main reason behind this is by consumption of these groundwater fluoride content is having much impact on children than compared to adults. 8 stations having HI value greater than 1 in children (Figure 6, Figure 7 and Figure 8). The samples analysed from the research area has high fluoride content in children ranging from 0.1 to 1.53. From results it shows that most of the samples having high fluoride content in children than the permissible limits. Due to the excessive fluoride content present in groundwater can cause dental problems, bone damage, joint-related problems, and change of colour of teeth (Table 4).

Irrigation Indices (II)

Sodium Adsorption Ratio (SAR): SAR values of Kanchipuram district varies from 2.99 to 148.94. In general, the SAR value should be less than 10mEq/L. Out of 60 samples, only 20 samples are below the desired limit. These sampling stations has no effect on irrigation whereas remaining 40 stations are unfit for irrigation (Figure 9 and Figure 10).

Kelly's Ratio (KR): Kelly's ratio depends on sodium , magnesium and calcium concentrations. 24 stations are having value greater than 1 which indicates excessive sodium present in the water. So, these stations are unsuited for irrigation (Figure 11 and Figure 12).

Magnesium Adsorption Ratio (MAR): Higher concentration of magnesium present in the groundwater effects the quality of soil and lowers the crop yield. The desired value for MAR is less than 50 (Figure 13 and Figure 14).

Percentage of Na: Ground water is categorized according to its percentage of Na, which ranges from excellent (<20%) to good (20–40%), acceptable (40–60%), dubious (60–80%), and inappropriate (> 80%). (Khodapanah et al. 2009) (Figure 15 and Figure 16).

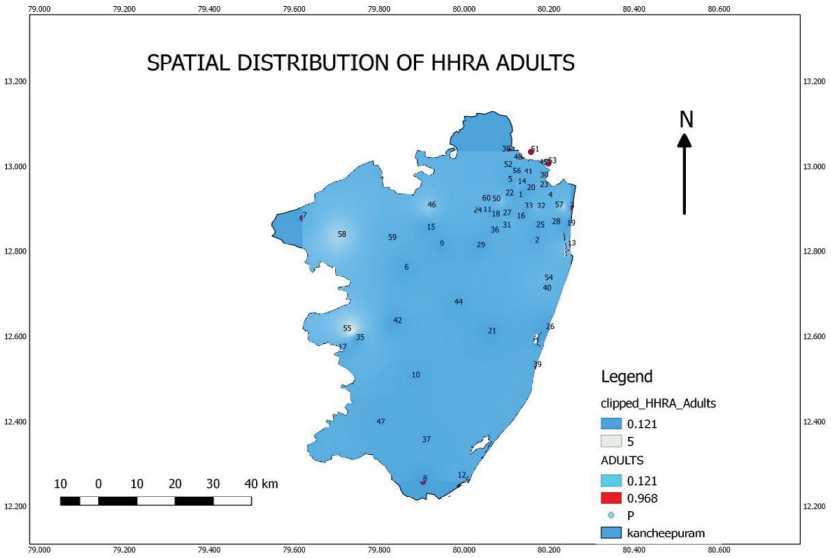

Figure 6: Geographical distribution map of Human Health Risk Assessment (HHRA) for adults of Kanchipuram district.

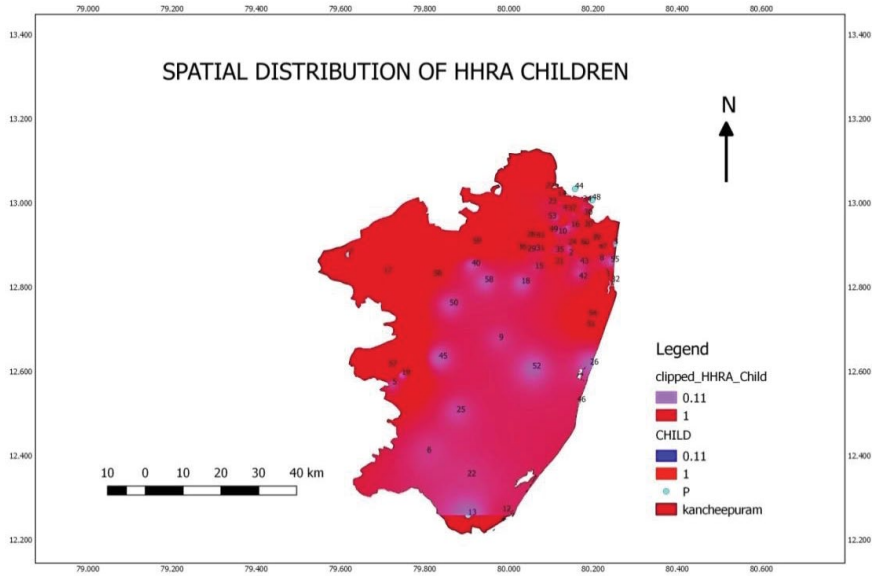

Figure 7: Geographical distribution map of Human Health Risk Assessment (HHRA) for children of Kanchipuram district.

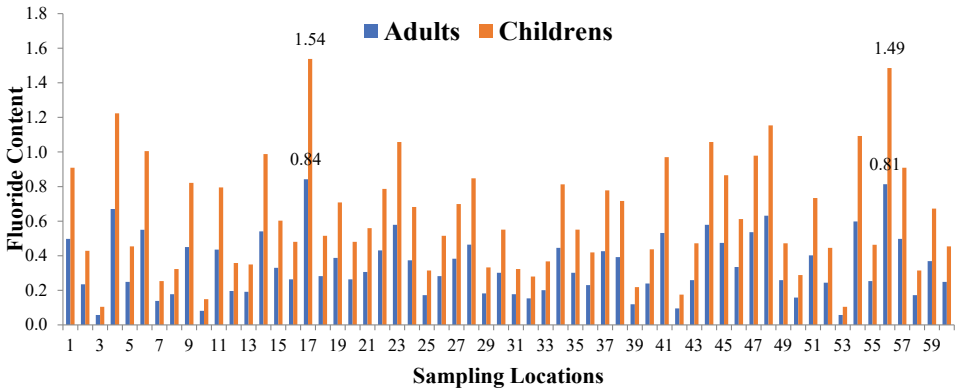

Figure 8: Human Health Risk Assessment (HHRA) of Kanchipuram district.

Table 4: Different parameters of HHRA for sampling stations.

Station	Fluoride (Adult's)					Fluoride (Children)				
	ADD_{ing}	ADD_{der}	HQ_{ing}	HQ_{der}	HI	ADD_{ing}	ADD_{der}	HQ_{ing}	HQ_{der}	HI
1	0.02971	0.00016	0.50	0.0026	0.4978	0.90133	0.00763	0.90	0.0076	0.90896
2	0.01400	0.00007	0.23	0.0012	0.2346	0.42467	0.00359	0.42	0.0036	0.42826
3	0.00343	0.00002	0.06	0.0003	0.0574	0.10400	0.00088	0.10	0.0009	0.10488
4	0.04000	0.00021	0.67	0.0035	0.6701	1.21333	0.01027	1.21	0.0103	1.22360
5	0.01486	0.00008	0.25	0.0013	0.2489	0.45067	0.00381	0.45	0.0038	0.45448
6	0.03286	0.00017	0.55	0.0029	0.5505	0.99667	0.00843	1.00	0.0084	1.00510
7	0.00829	0.00004	0.14	0.0007	0.1388	0.25133	0.00213	0.25	0.0021	0.25346
8	0.01057	0.00006	0.18	0.0009	0.1771	0.32067	0.00271	0.32	0.0027	0.32338
9	0.02686	0.00014	0.45	0.0023	0.4500	0.81467	0.00689	0.81	0.0069	0.82156
10	0.00486	0.00003	0.08	0.0004	0.0814	0.14733	0.00125	0.15	0.0012	0.14858
11	0.02600	0.00014	0.43	0.0023	0.4356	0.78867	0.00667	0.79	0.0067	0.79534
12	0.01171	0.00006	0.20	0.0010	0.1963	0.35533	0.00301	0.36	0.0030	0.35834
13	0.01143	0.00006	0.19	0.0010	0.1915	0.34667	0.00293	0.35	0.0029	0.34960
14	0.03229	0.00017	0.54	0.0028	0.5409	0.97933	0.00829	0.98	0.0083	0.98762
15	0.01971	0.00010	0.33	0.0017	0.3303	0.59800	0.00506	0.60	0.0051	0.60306
16	0.01571	0.00008	0.26	0.0014	0.2633	0.47667	0.00403	0.48	0.0040	0.48070
17	0.05029	0.00026	0.84	0.0044	0.8425	1.52533	0.01291	1.53	0.0129	1.53824
18	0.01686	0.00009	0.28	0.0015	0.2824	0.51133	0.00433	0.51	0.0043	0.51566
19	0.02314	0.00012	0.39	0.0020	0.3877	0.70200	0.00594	0.70	0.0059	0.70794
20	0.01571	0.00008	0.26	0.0014	0.2633	0.47667	0.00403	0.48	0.0040	0.48070
21	0.01829	0.00010	0.30	0.0016	0.3064	0.55467	0.00469	0.55	0.0047	0.55936
22	0.02571	0.00013	0.43	0.0022	0.4308	0.78000	0.00660	0.78	0.0066	0.78660
23	0.03457	0.00018	0.58	0.0030	0.5792	1.04867	0.00887	1.05	0.0089	1.05754
24	0.02229	0.00012	0.37	0.0019	0.3734	0.67600	0.00572	0.68	0.0057	0.68172
25	0.01029	0.00005	0.17	0.0009	0.1723	0.31200	0.00264	0.31	0.0026	0.31464
26	0.01686	0.00009	0.28	0.0015	0.2824	0.51133	0.00433	0.51	0.0043	0.51566
27	0.02286	0.00012	0.38	0.0020	0.3829	0.69333	0.00587	0.69	0.0059	0.69920
28	0.02771	0.00014	0.46	0.0024	0.4643	0.84067	0.00711	0.84	0.0071	0.84778
29	0.01086	0.00006	0.18	0.0009	0.1819	0.32933	0.00279	0.33	0.0028	0.33212
30	0.01800	0.00009	0.30	0.0016	0.3016	0.54600	0.00462	0.55	0.0046	0.55062
31	0.01057	0.00006	0.18	0.0009	0.1771	0.32067	0.00271	0.32	0.0027	0.32338
32	0.00914	0.00005	0.15	0.0008	0.1532	0.27733	0.00235	0.28	0.0023	0.27968
33	0.01200	0.00006	0.20	0.0010	0.2010	0.36400	0.00308	0.36	0.0031	0.36708
34	0.02657	0.00014	0.44	0.0023	0.4452	0.80600	0.00682	0.81	0.0068	0.81282
35	0.01800	0.00009	0.30	0.0016	0.3016	0.54600	0.00462	0.55	0.0046	0.55062
36	0.01371	0.00007	0.23	0.0012	0.2298	0.41600	0.00352	0.42	0.0035	0.41952
37	0.02543	0.00013	0.42	0.0022	0.4260	0.77133	0.00653	0.77	0.0065	0.77786
38	0.02343	0.00012	0.39	0.0020	0.3925	0.71067	0.00601	0.71	0.0060	0.71668
39	0.00714	0.00004	0.12	0.0006	0.1197	0.21667	0.00183	0.22	0.0018	0.21850
40	0.01429	0.00007	0.24	0.0012	0.2393	0.43333	0.00367	0.43	0.0037	0.43700
41	0.03171	0.00017	0.53	0.0028	0.5313	0.96200	0.00814	0.96	0.0081	0.97014
42	0.00571	0.00003	0.10	0.0005	0.0957	0.17333	0.00147	0.17	0.0015	0.17480
43	0.01543	0.00008	0.26	0.0013	0.2585	0.46800	0.00396	0.47	0.0040	0.47196
44	0.03457	0.00018	0.58	0.0030	0.5792	1.04867	0.00887	1.05	0.0089	1.05754
45	0.02829	0.00015	0.47	0.0025	0.4739	0.85800	0.00726	0.86	0.0073	0.86526
46	0.02000	0.00010	0.33	0.0017	0.3351	0.60667	0.00513	0.61	0.0051	0.61180
47	0.03200	0.00017	0.53	0.0028	0.5361	0.97067	0.00821	0.97	0.0082	0.97888
48	0.03771	0.00020	0.63	0.0033	0.6319	1.14400	0.00968	1.14	0.0097	1.15368
49	0.01543	0.00008	0.26	0.0013	0.2585	0.46800	0.00396	0.47	0.0040	0.47196
50	0.00943	0.00005	0.16	0.0008	0.1580	0.28600	0.00242	0.29	0.0024	0.28842
51	0.02400	0.00013	0.40	0.0021	0.4021	0.72800	0.00616	0.73	0.0062	0.73416
52	0.01457	0.00008	0.24	0.0013	0.2441	0.44200	0.00374	0.44	0.0037	0.44574
53	0.00343	0.00002	0.06	0.0003	0.0574	0.10400	0.00088	0.10	0.0009	0.10488
54	0.03571	0.00019	0.60	0.0031	0.5983	1.08333	0.00917	1.08	0.0092	1.09250
55	0.01514	0.00008	0.25	0.0013	0.2537	0.45933	0.00389	0.46	0.0039	0.46322
56	0.04857	0.00025	0.81	0.0042	0.8137	1.47333	0.01247	1.47	0.0125	1.48580
57	0.02971	0.00016	0.50	0.0026	0.4978	0.90133	0.00763	0.90	0.0076	0.90896
58	0.01029	0.00005	0.17	0.0009	0.1723	0.31200	0.00264	0.31	0.0026	0.31464
59	0.02200	0.00011	0.37	0.0019	0.3686	0.66733	0.00565	0.67	0.0056	0.67298
60	0.01486	0.00008	0.25	0.0013	0.2489	0.45067	0.00381	0.45	0.0038	0.45448

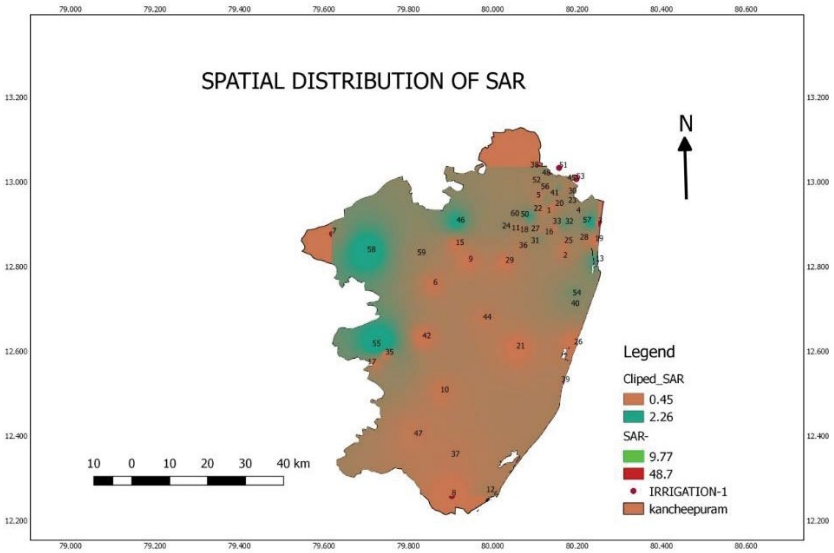

Figure 9: Geographical distribution map of Kanchipuram district for Irrigation Indices (II) based on sodium adsorption ratio (SAR).

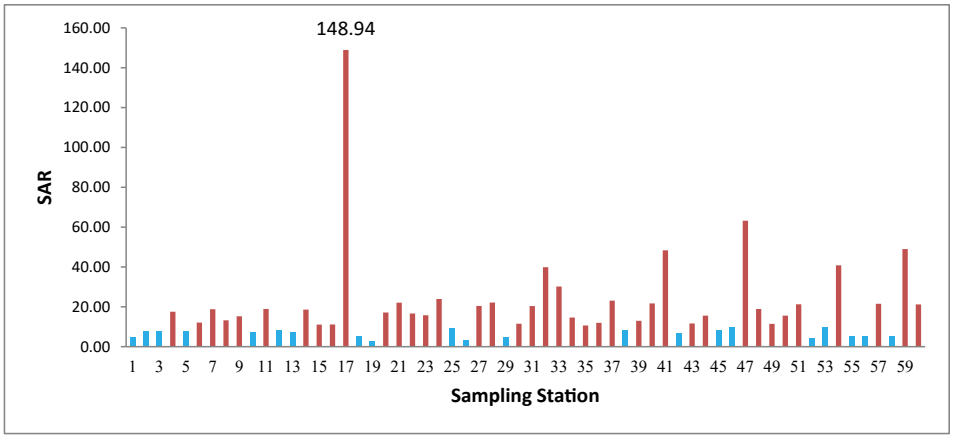

Figure 10: Irrigation Indices (II) of Kanchipuram district based on sodium adsorption ratio (SAR).

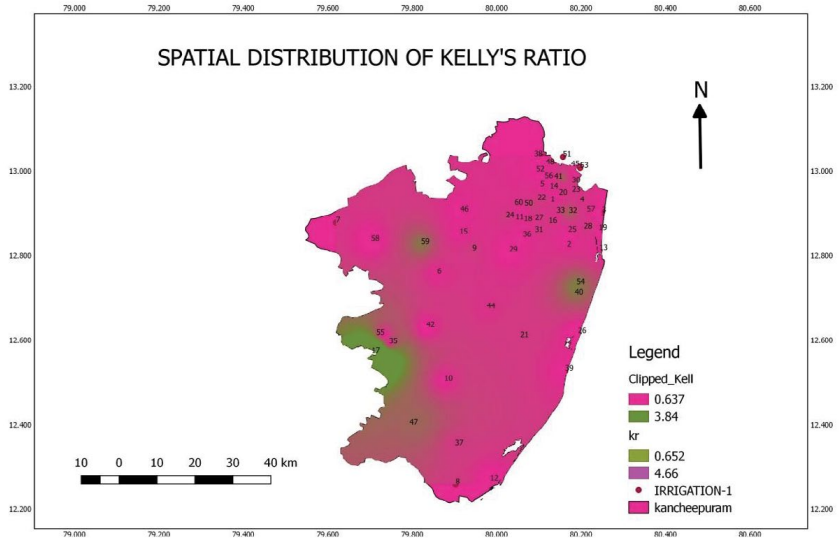

Figure 11: Geographical distribution map of Kanchipuram district for Irrigation Indices (II) based on kelly's ratio (KR).

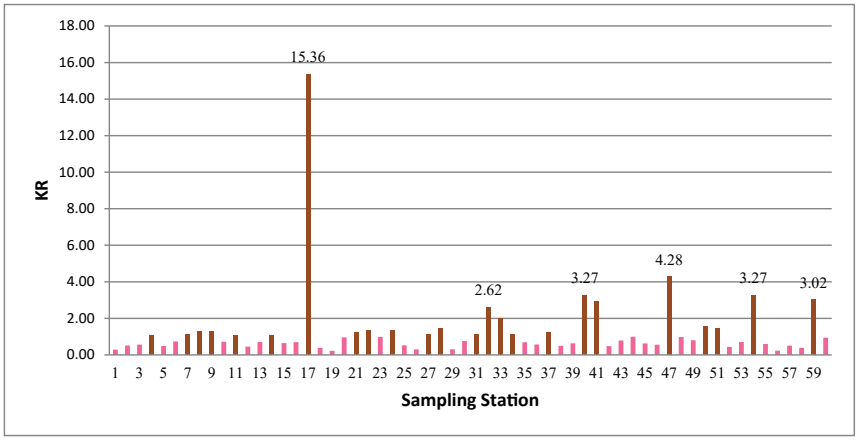

Figure 12: Irrigation Indices(II) of Kanchipuram district based on Kelly's ratio (KR).

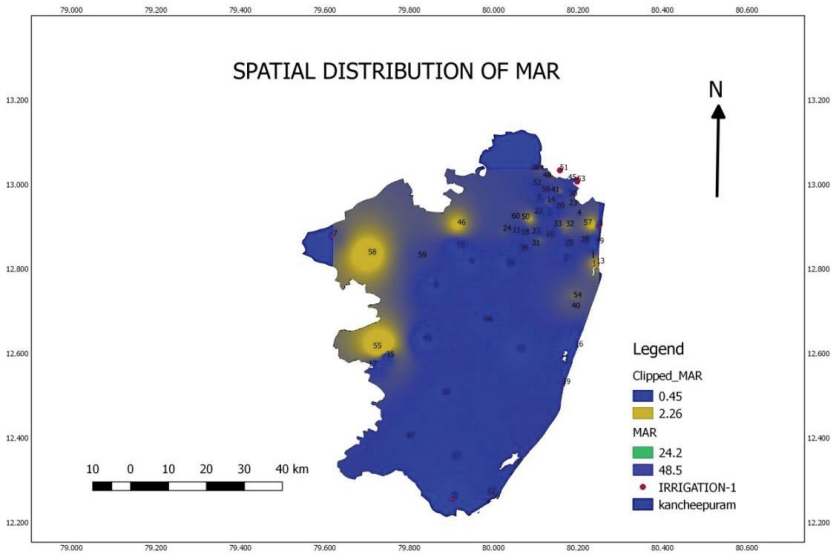

Figure 13: Geographical distribution map of Kanchipuram district for Irrigation Indices(II) based on magnesium adsorption ratio (MAR).

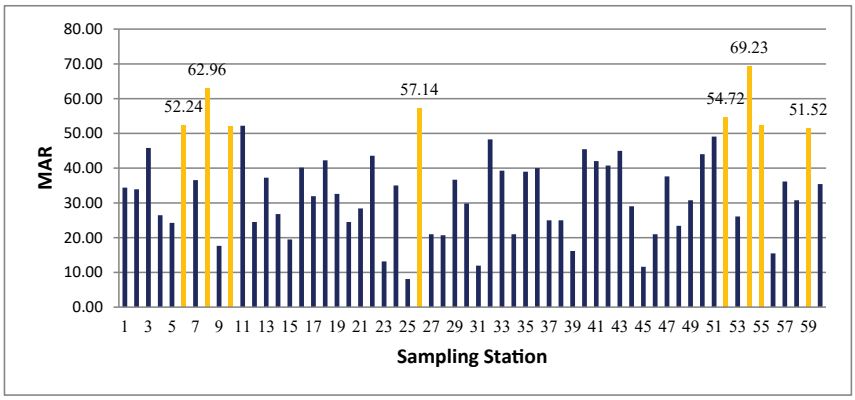

Figure 14: Irrigation Indices (II) of Kanchipuram district based on magnesium adsorption ratio (MAR).

Permeability Index (PI): From results PI values varies from 30.13 to 98.22. The average value of PI was reported as 54.91.As per desired limits PI value less than 25 unsuited for irrigation.

For the irrigation indices we conclude that out of 60 stations, SAR values of 21 stations is less than 10meq/L, so in those areas the water is fit for irrigation, the crops doesn't give much yield. Due to the saltwater

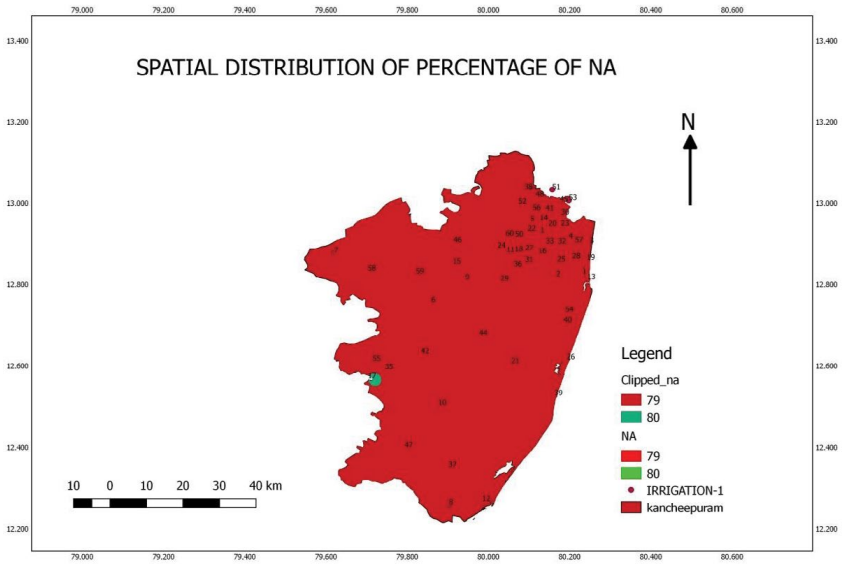

Figure 15: Geographical distribution map of Kanchipuram district for Irrigation Indices (II) based on percentage of Na.

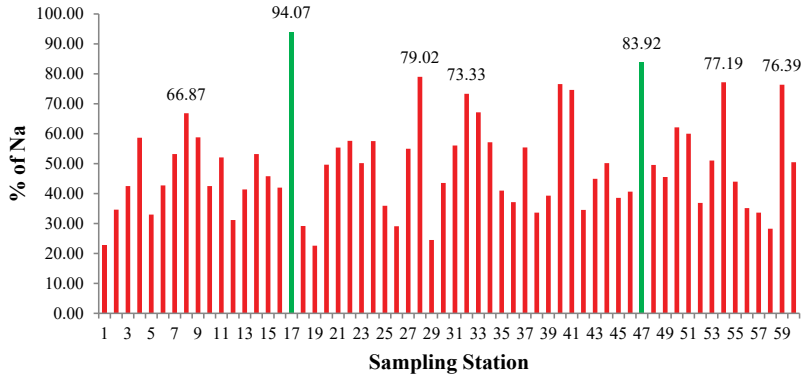

Figure 16: Irrigation Indices (II) of Kanchipuram district based on percentage of Na.

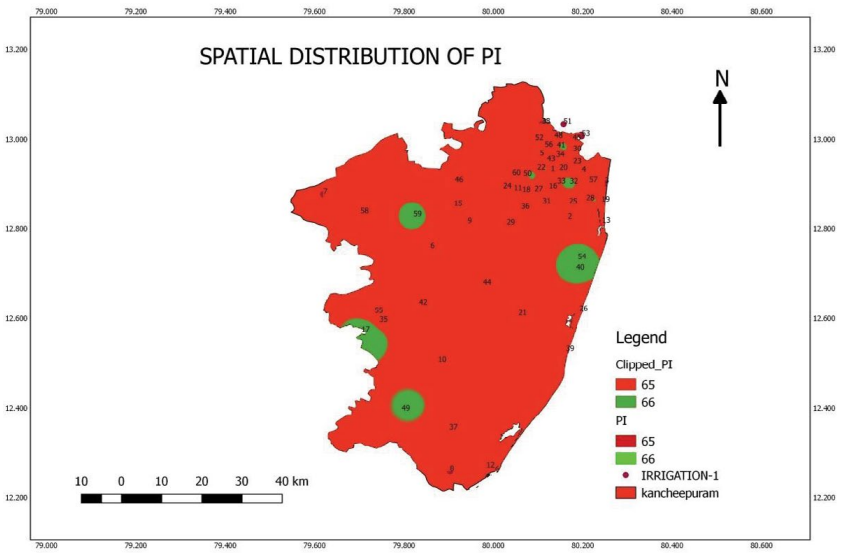

Figure 17: Geographical distribution map of Kanchipuram district for Irrigation Indices (II) based on permeability index (PI).

Table 5: Different parameters for Irrigation Indices (II) for sampling stations.

S. No	Sampling Location	SAR	KR	NA	MAR	PI
1	Acharapakkam	4.63	0.29	22.89	34.38	34.30
2	Agaram	7.78	0.51	34.66	33.91	42.89
3	Akkarai	7.79	0.56	42.51	45.83	46.67
4	Anakaputhur	17.58	1.07	58.66	26.47	59.06
5	Arasanimangalam	7.88	0.48	32.99	24.24	41.48
6	Athur	12.09	0.74	42.74	52.24	50.20
7	Baluchettychatram	18.79	1.10	53.23	36.55	58.47
8	Chemmancheri	13.28	1.28	66.87	62.96	63.90
9	Chenglepet	15.26	1.31	58.79	17.65	63.18
10	Chitlapakkam	7.20	0.72	42.53	52.00	55.32
11	Chrompet	18.95	1.06	52.11	52.20	58.51
12	Chunambedu	8.08	0.45	31.17	24.53	36.63
13	Chunamedu	7.13	0.71	41.38	37.25	58.66
14	Girugambakkam	18.64	1.07	53.21	26.80	58.30
15	Guduvancheri	11.12	0.64	45.82	19.46	45.95
16	Hastinapuram	11.17	0.70	42.01	40.16	50.28
17	Kancheepuram	148.94	15.36	94.07	31.91	98.22
18	Kattankalathur	5.31	0.38	29.20	42.27	39.12
19	Kattur-Pz	3.00	0.22	22.61	32.58	30.13
20	Kilkattalai	17.16	0.96	49.68	24.53	54.91
21	Kolapakkam	22.11	1.23	55.37	28.40	60.64
22	Kolathanallur	16.65	1.33	57.61	43.59	66.14
23	Kundrathur	15.81	0.98	50.19	13.18	56.50
24	Madambakkam	23.93	1.34	57.56	35.00	62.86
25	Madurantagam	9.07	0.53	35.93	8.11	43.25
26	Mahabalipuram	3.21	0.30	29.11	57.14	38.79
27	Mangadu	20.44	1.14	55.00	20.99	58.75
28	Manimangalam	22.19	1.46	79.02	20.69	68.09
29	Mannivakkam	4.78	0.31	24.53	36.67	32.60
30	Meenambakkam	11.52	0.76	43.56	29.82	51.53
31	Mudichur	20.41	1.14	56.08	11.95	59.26
32	Muthukadu	39.92	2.62	73.33	48.28	74.95
33	Nagalkani	30.20	2.02	67.16	39.29	73.02
34	Nandambakkam	14.61	1.15	57.14	20.99	62.75
35	Nedunkundram	10.68	0.69	41.00	38.98	49.73
36	Paddapai (Pz)	12.01	0.57	37.14	40.00	42.17
37	Pallavaram	23.13	1.23	55.44	25.00	60.29
38	Pallavaram pz	8.49	0.50	33.64	25.00	41.26
39	Pallikaranai (Pz)	12.98	0.63	39.31	16.19	44.40
40	Panruti Kandigai	21.71	3.27	76.60	45.45	87.75
41	Perungulathur	48.40	2.91	74.63	42.03	79.06
42	Ponmar	7.08	0.48	34.55	40.74	41.77
43	Ponmar (Pz)	11.65	0.79	44.95	44.95	52.21
44	Porur	15.62	0.99	50.20	29.03	58.10
45	Rettamangalam	8.23	0.63	38.57	11.63	51.05
46	Sadras	10.00	0.56	40.66	20.99	42.91
47	Shollinganallore	63.26	4.28	83.92	37.61	83.42
48	St.Thomas Mount	18.98	0.98	49.60	23.40	55.40
49	Tambaram	11.51	0.80	45.55	30.77	53.04
50	Thirumukkudal	15.60	1.56	62.12	44.00	71.68
51	Thiruporur (Pz)	21.30	1.44	60.00	49.09	65.92
52	Tirukalukundram	4.47	0.43	36.90	54.72	43.29
53	Tiruneermalai	9.58	0.71	51.06	26.09	51.71
54	Tiruporur	40.83	3.27	77.19	69.23	82.69
55	Uthandi	5.46	0.60	44.00	52.38	50.07
56	Uthikadu	5.45	0.23	35.16	15.49	24.28
57	Uthiramerur	21.52	0.51	33.63	36.14	35.62
58	Vadakkupattu	5.55	0.38	28.28	30.77	39.42
59	Vadekkal (Palnallur)	48.99	3.02	76.39	51.52	78.70
60	Vengaivasal	21.21	0.94	50.49	35.43	53.46

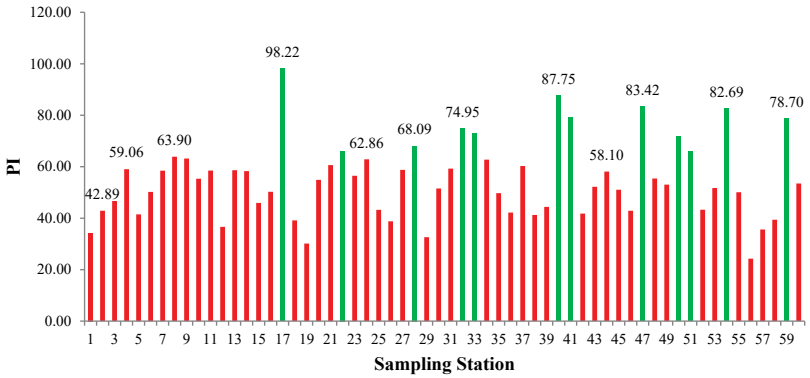

Figure 18: Irrigation Indices (II) of Kanchipuram district based on PI.

intrusion these ions will mix up with the ground water (Figure 17 and Figure 18). This water will carry through the irrigation fields. The water with high SAR content is supply to soil for years, The calcium and magnesium ions in the soil may be replaced by the sodium in the water. The soil's fertility will decline as a result of this.. For the percentage of Na, 98% of stations is less than 80 percent, this water will impact on irrigation crops (Table 5).

Conclusion

From the investigation, the following result was concluded.

WQI values concluded, out of 60 stations it was observed that around 30% of groundwater is above good quality (WQI: 0-50), around 42% is very poor and unfit for drinking purpose (WQI: 76 - >100) and 28% of the sampling stations are poor (WQI: 51-75) respectively.

The SMI values concluded that, out of 60 stations it was observed that 23 stations which means 38% of the sampling stations are affected by seawater intrusion greater than 1.

There are 7 sampling stations which are affected by both WQI and SMI. Due to SMI these 7 areas will have impact on WQI.

HHRA study concludes for Children, 13% of the sampling station is having a health impact due to fluoride. The analysis shows that children's average fluoride content is higher than adults.

Irrigation efficiency concludes that 65% of sampling stations, SAR values greater than 10 mEq/L and 2 stations having percentage of Na greater than 80% therefore the water is unfit for irrigation. Nearly 40% of sampling stations having KR value less than 1, which means those areas are suitable for irrigation purpose and Almost 12 sampling stations having PI value greater than 65% therefore water is suitable for irrigation purpose. 9 stations having MAR value greater than 50, so those stations are not recommended for irrigation purposes.

References

1. Tchobanoglous G, Peavy HS, Rowe DR (1985) Environmental Engineering. New York: McGraw- Hill Book Company, New York. 696.
2. Shiklomanov IA (2000) Appraisal and assessment of world water resources. Water international 25: 11-32
3. Means III EG, Brueck T, Manning A, Dixon L (2002) The coming crisis: Water institutions and infrastructure. American Water Works Association 94: 34.
4. Siener R, Jahnen A, Hesse A (2004) Influence of a mineral water rich in calcium, magnesium and bicarbonate on urine composition and the risk of calcium oxalate crystallization. European journal of clinical nutrition. 58: 270-276.
5. Rosenzweig C, Casassa G, Karoly DJ, Imeson A, Liu C, et al. (2007) Assessment of observed changes and responses in natural and managed systems. 79-131.
6. Dalla Valle M, Codato E, Marcomini A (2007) Climate change influence on POPs distribution and fate: A case study. Chemosphere 67: 1287-1295.
7. Karavoltsos S, Sakellari A, Mihopoulos N, Dassenakis M, Scoullos MJ (2008) Evaluation of the quality of drinking water in regions of Greece. Desalination 224: 317-329.
8. Whitehead PG, Wilby RL, Battarbee RW, Kernan M, Wade AJ (2009) A review of the potential impacts of climate change on surface water quality. Hydrological sciences journal 54: 101-123.
9. Sinclair RG, Jones EL, Gerba CP (2009) Viruses in recreational water□borne disease outbreaks: A review. Journal of applied microbiology 107: 1769-1780.
10. Funari E, Manganelli M, Sinisi L (2012) Impact of climate change on waterborne diseases. Annali dell'Istituto superiore di sanita 48: 473-487.