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RESEARCH ARTICLE

HYDROGEOCHEMICAL STUDIES OF GROUNDWATER IN EDAPPADI TALUK, SALEM DISTRICT, TAMIL NADU, INDIA

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A R T I C L E I N F O

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A B S T R A C T

GIS is emerged uses of Hydro geological studies. GIS technology is used in this study. Hydro geochemical characteristics of groundwater with respect to WHO standard for drinking purposes in Edappadi Taluk, Salem District have been studied. The study area of about 240.33 sq. km is with mainly occupied by Charnockite and Hornblende-Biotite-Gneisses. Edappadi Taluk area is associated with active agricultural region. 50 groundwater samples were collected from open and bore wells which are being extensively used for drinking and irrigation purposes in the investigation period. During pre-monsoon 2011 and analysed for pH, Electrical conductance, total dissolved solids, calcium, magnesium, sodium, potassium, chloride, fluoride, nitrate, iron etc., Analysed Geochemical data were evaluated and compared with WHO water quality standards. Chemical concentration values are taken into GIS platform to prepare the spatial distribution maps. Finally to find out the ground water quality zones for drinking purposes.

INTRODUCTION

Groundwater is one of the replenishable natural resource available in Earth. The most important source of ground water for drinking and irrigation in the world, hence both its quantity and quality gains importance. Freeze and Cherry (1979) and Davis and DeWiest (1966) studied the water quality and reported that high values of TDS is unsuitable for drinking and irrigation purposes. Quality of ground water is the function of its physical, chemical, biological and geological parameters (Bhargava and Killender, 1988), which depends upon the soluble products of weathering and decomposition and the related changes that occur with respect to time and space (Raghunath, 1987). Understanding the factors responsible for influencing the groundwater hydrochemistry is very essential for protection and sound management of the groundwater resources in a region. Conductivity is an important criterion in determining the suitability of water and waste water for irrigation (Shrivastava and Patil, 2002) and is essential to assess water pollution and useful in controlling water treatment processes. The water quality studies with respect to EC, TDS, Ca, Mg, NO_3, Cl and SO_4 of Courtallam regions show that during monsoon, the concentration are minimum and in pre-monsoon are maximum with spatial variations during the study period (Drusilla et al. 2005). The high electrical conductivity (EC) values detected the sub-surface water quality to the existence of weathering of rocks and minerals (Di Sipio *et al.,* 2006). The chemical composition of groundwater depends upon the soluble products of rock weathering and decomposition and changes with respect to time and space in addition to the external polluting agents (Mariappan *et al.,* 2000). The groundwater chemistry of the hard rock area is dominated by Ca and Mg (Nachiappan *et al.,* 2004). High TDS in groundwater may be due to ground water pollution when waste waters are discharged into pits, ponds and lagoons enabling the waste to migrate down to the water table (Rani *et al.,* 2003). The value of alkalinity in water provides an idea of natural salts present in water. WHO (1983) prescribed the desirable limit of pH range between 6.5 and 8.5, as safe range for drinking.

STUDY AREA

Edappadi (also spelt as Idappadi or Edapadi) is a city and a municipality in Salem_district in the state of Tamil_Nadu, India. Idappadi is located at $77^0 45' 56''$ and $77^0 57' 25''$ and latitude of $11^0 31' 25''$ to $11^0 43' 27''$ (Fig. 1.1). It has an average elevation of 288 m (945 ft). It is situated at the basin of the hill called 'Soorieya malai' (Mountain of Sun). The epic says, the Panja Pandavas were resided at the top of the hill during the first year of their 14 years forest living. Still this mountain doesn't have any plants due to its rocky and unusual properties. The research done by Periyar University Geologist shows it consists of rare radioactive minerals. Edappadi has a variable terrain. Sankagiri - Edappadi route via Veerappam Palayem and Sunnambukkuttai is rocky. It is really beautiful view of this town, while seen from 'Konamoori'(A Bridge with dangerous Turns in Kavadikaraoor) busstop via. Sankagiri - Edappadi route. River Cauvery is 6km away from Edappadi.

Edappadi was once known for its thriving powerloom industry. The economy is diversified. The main modes of income are agriculture, Lorry transport, granite, textile power loom, entertainment and foundry. It is third largest town in Salem Dt. next to Attur and Mettur. The rocks around the Edappadi are expected to have more number of rare minerals. The name is derived from a group of family name 'Edayar'

(means the people who survived with Cow, Buffalo and house animals. Now it is an ideal place for peaceful life and harmony synchronize with nature living. The water was supplied by Cauvery river and 'Periya-yeri' (Big-lake) near Edappadi. It is surrounded by many lakes like, Periyayeri, ChettiYeri, Punka-yeri, Rettipatti-Yeri, Kavadikaranoor-Yeri(Aachampalli Yeri). It is an Ideal spot for Cinema shootings (Rich in Forest, Riverside, Rocky landscape, Village peoples with reality). The total study area covers 240.33 km^2. The total area has 24 revenue villages.

METHODOLOGY

In order to assess the groundwater chemistry, a total of 50 groundwater samples were collected from open and bore wells which are being extensively used for drinking and irrigational purpose in the investigation area during pre monsoon 2011. The groundwater samples were collected in a well cleaned 1000 ml polyethylene bottles. pH and electrical conductance were measured within a few hours of collection by using Elico pH meter and conductivity meter.

Ca and Mg were determined titrimetrically using standard EDTA, and chloride was determined by silver nitrate titration. Na and K by Elico flame photometer (APHA, 1996). The samples were analyzed for physico-chemical parameters (pH, EC), major and minor cations (Ca, Mg, Na, K, Fe) and major and minor anions (CO_3, HCO_3, SO_4, Cl, F, NO_2, NO_3) as per standard procedures. For the drinking water purposes, World Health Organization (WHO) standard limit and its correlated for suitability of groundwater. Their attributes are added and analyzed in ArcGIS software. Spatial analysis tools were used for the preparation of interpolation map. The maps were interpolated by using inverse distance methods for the spatial distribution map preparation.

RESULTS AND DISCUSSION

Drinking Purposes of Groundwater

The hydro-chemical analysis data of groundwater samples for the pre-monsoon season are presented in Table 1. The pre-monsoon pH value of the groundwater during pre-monsoon ranged from 6.86 to 7.98 with the average value of 7.22 indicating that from acidic to basic nature. As per the (WHO, 1996) standards, all the samples fall within the recommended limit (6.5 to 8.5) for human consumption. The TDS value varies from 670 to 6209 mg/l, (average 1922.68) during the pre-monsoon season. Water is not considered to be desirable for drinking when the quantity of dissolved minerals exceeds 1,000 mg/l (milligrams per liter).

Water with a few thousand mg/l of dissolved minerals is classified as slightly saline. Eighty four percentage of the samples fall under brackish water type with respect to Freeze and Cherry classification. Calcium is the second dominating ion in the groundwater of the study area. During pre-monsoon calcium concentration in the groundwater of the study area ranged from 60 to 852 mg/l, with an average value of 183.64 mg/l. 39 (78%) of samples fell within the acceptable and allowable limit, only 22% of samples fell above the WHO limit. It is because, the rate of decomposition of feldspar group of minerals (Hem, 1985). The desirable limit of calcium in drinking water is 75 mg/l. If the presence of calcium is more in drinking water, it will cause formation of renal calculi (Kidney stones). The desirable limit of magnesium in drinking water is 150 mg/l (WHO, 1983).

Magnesium is the third dominating ion in the groundwater. During pre-monsoon magnesium concentration in the groundwater ranged from 17 to 156 mg/l, with an average value of 59.5. Sodium concentration is good if it is less than 250 mg/l (WHO, 1996) concentration. Sodium is found to be the most abundant ion in the groundwater during pre-monsoon season. Sodium concentration in the groundwater from 104 to 896 mg/l, with an average value of 301.12 mg/l. Among the cations, potassium occupies the last position in the order of abundance in the groundwater;

Potassium concentration is good if it is less than 10 mg/l for drinking water (WHO, 1996). Potassium concentration ranged from 6 to 86 mg/l and 11 to 40.06 mg/l in pre-monsoon season. Potassium content in water more than few tens of mg/l is indicative of pollution (Table 1). The maximum admissible level of potassium in drinking water is 10 mg/l. Iron (Fe) concentration is good if it is less than 0.3 mg/l (WHO, 1996) concentration.

Iron is found to be the most abundant ion in the groundwater during pre-monsoon season iron concentration in the groundwater ranged from 0 to 3.2 mg/l, with an average value of 0.756 mg/l. (Table 1). Chloride concentration ranged from 60 to 1760 mg/l and 36 to 1800 mg/l during pre monsoon seasons. The high chloride concentration was noticed in only few locations. It is due to replacement of hydroxide to chloride in the gneissic rocks (Kuroda and Sandell, 1953). Based on the WHO standards, few samples fell under not acceptable and allowable zone (Table 1).

Sulphur readily undergoes oxidation-reduction reactions and transformations in the near-surface environment. The processes of transformation of Sulpher from one state to the other transport in solution, biogenic assimilation, and re-precipitation all form part of an on-going sulphur cycle in near-surface environment (Granat et al., 1976).

Sulphate ion when combined with calcium or magnesium in water induces permanent hardness to the water. The sulphate concentration in the groundwater during pre-monsoon season ranged from 25 to 520 mg/l, with an average value of 122.6 mg/l (Table 1). The desirable limit of nitrate in drinking water is 45 mg/l (WHO, 1983). The limiting values for nitrate are given in Table 1. During pre-monsoon nitrate concentration in the groundwater of the study area ranged from 12 to 182 mg/l, with an average value of 61.64 mg/l.

The maximum level of fluoride which the human body may tolerate is 1.5 mg/l. This is based on the fluoride content in water. The maximum limit prescribed by BIS (Bureau of Indian Standards) for fluoride in drinking water is 1.5 mg/l. In pre monsoon, the minimum concentration values of Fluoride were observed as 0.4 mg/l at Kanniyampatty and maximum concentration values were observed as 3.5 mg/l in Aalachampalayam. The number of sample fall in the above said zone is given in the Table 1.

Table 1 Chemic al Composition of Groundwater (Ionic concentrations are expressed in mg/L and EC in μScm^{-1})

Station	Ca	Mg	Na	K	Fe	HCO_3	CO_3	SO_4	Cl	F	NO_3	pH	EC*	TDS
Pakkanadu	159.92	35.02	178.02	16.81	0.28	635.83	23.40	85.01	191.84	0.57	40.32	6.87	1751	1226
Reddiyur	171.94	39.03	230	32.84	0.56	570.54	36.30	99.90	324.10	1.14	51.84	6.86	2320	1624
Kanniyampatty	81.96	17.02	103.96	10.95	0.00	465.58	7.20	24.98	59.93	0.38	12.16	7.31	957	670
Kovilpalayam	165.93	48.03	204.01	26.98	0.00	593.11	33.00	89.82	296.09	0.57	46.08	7.15	2190	1533
Puliyampatty	102.00	38.06	192.05	25.02	0.28	538.81	22.80	49.95	213.82	0.76	32	7.27	1826	1278
Oruvapatty	159.92	32.95	181.93	23.07	0.00	602.27	25.50	64.84	231.91	0.38	35.84	6.98	1887	1321
Melkadu	112.02	53.99	296.01	35.19	0.28	394.19	47.40	99.90	452.12	1.14	56.32	6.95	2470	1129
Mel Chittur	175.95	38.06	284.05	30.89	0.56	658.41	39.00	120.08	336.16	2.47	56.32	7.07	2510	1757
Irupali	128.06	56.06	192.05	25.02	0.56	542.47	30.30	109.99	246.09	2.28	48	7.28	2070	1449
Chettimankuruchi	395.99	146.04	477.94	52.00	1.40	680.98	116.70	159.94	1180.11	2.85	126.08	7.01	4840	3388
Thirumalur	251.90	102.02	396.06	43.01	0.84	391.14	89.70	199.80	875.86	1.33	62.08	7.45	3890	2723
Sadaichipalayam	216.03	44.99	384.1	39.10	0.56	439.95	68.10	180.11	628.00	1.14	76.16	7.24	3290	2303
Samudram	136.07	52.04	423.89	35.97	2.51	619.35	55.50	109.99	524.10	2.47	67.84	7.28	2950	2065
Pillukurichi	171.94	39.03	264.04	37.93	0.00	573.59	40.50	89.82	369.85	1.14	72.32	7.06	2440	1708
Morasampatty	108.02	52.04	359.95	44.97	1.68	591.28	45.90	99.90	419.85	3.23	78.08	7.11	2620	1904
Vedikaranpalayam	257.91	56.06	652.05	96.19	0.84	-28.68	132.90	240.15	1340.03	1.14	96	7.18	4780	3346
Kanaiyampatty	91.98	35.99	126.04	14.86	0.00	399.68	18.60	49.95	165.95	0.38	32	6.95	1394	976
Manikkampalayam	108.02	45.96	255.99	30.89	0.28	336.22	42.60	80.21	409.92	1.33	56.32	7.28	2240	1568
Vembaneri	110.02	48.03	241.96	32.84	0.56	477.18	35.40	99.90	319.85	0.95	42.24	7.18	2200	1540
Kanniyampatty	208.02	85.97	215.97	32.06	0.84	771.90	41.10	139.77	359.92	0.76	35.84	7.14	2660	1862
Bachaliyur	368.94	77.95	623.99	121.99	1.68	410.66	132.00	280.01	1280.11	2.85	124.16	7.01	5750	4025
Valaikinatur	112.02	58.00	241.96	26.98	0.00	690.14	27.90	89.82	236.16	0.95	48	7.26	2050	1435
Vellanaickenpalayam	226.05	98.01	408.02	52.00	0.56	495.48	82.80	120.08	830.12	2.28	97.92	7.05	3890	2723
Kottapalayam	138.08	76.00	385.94	41.84	0.84	463.14	63.90	130.16	609.91	0.95	85.76	7.18	3360	2352
Darapuram	118.04	56.06	319.93	32.06	1.68	1090.43	20.10	109.99	109.93	3.23	60.16	7.21	2414	1689
Koranampatty	195.99	92.05	325.91	41.84	1.12	406.39	70.80	139.77	680.12	1.14	81.92	7.01	3300	2310
Sadaiyampalayam	126.05	58.00	186.07	25.02	0.56	523.55	30.60	109.99	256.02	0.57	42.24	7.68	2040	1428
Pallipatty	161.92	32.95	195.96	21.11	0.00	574.81	28.50	99.90	240.06	1.33	35.84	7.31	2020	1414
Vellarivelli	185.97	77.95	684.02	80.16	2.23	398.46	111.90	159.94	1140.04	2.66	96	7.06	4720	3304
Avaniperur	397.99	92.05	793.96	69.99	3.07	1104.46	124.80	209.89	1230.11	2.85	136.32	7.11	5890	4123
Vendanur	116.03	48.03	273.93	28.93	0.56	378.93	44.10	99.90	412.05	0.95	62.08	7.28	2310	1617
Sanarpatty	112.02	44.99	204.01	226.00	0.00	683.42	34.80	80.21	324.10	1.14	46.08	7.35	1970	1379
Devanur	161.92	75.03	192.05	25.02	0.28	582.74	37.50	89.82	336.16	0.76	67.84	7.46	2210	1547
Katchupalli	95.99	41.95	117.99	14.86	0.56	466.80	16.80	49.95	140.07	0.38	35.84	7.98	1370	959
Vadugapatty	91.98	35.99	140.07	16.03	0.00	410.66	20.10	64.84	168.08	1.14	32	7.72	1400	980
Aalachampalayam	836.07	142.03	851.92	84.07	2.79	1454.72	187.80	479.82	1759.88	3.42	156.16	7.16	8570	5999
Virappampalayam	151.90	39.03	215.97	25.81	0.56	283.13	44.40	89.82	424.10	0.95	56.32	7.65	2460	1722
Reddipatty	851.90	156.01	896.08	91.89	2.79	2573.82	148.80	520.16	1259.89	3.04	181.76	7.18	8870	6209
Rakkiyampatty	200.00	85.97	376.05	55.91	1.12	535.76	71.10	139.77	680.12	2.47	96	7.32	3390	2373
Konganapuram	218.04	103.97	376.05	35.97	0.56	429.58	81.00	199.80	759.91	2.09	72.32	7.21	3530	2471
Mottampatty	114.03	39.03	126.04	10.95	0.00	477.79	18.60	49.95	159.92	2.85	32	7.57	1370	959
Annamalaipalayam	108.02	39.03	232.07	26.98	0.56	581.52	27.00	70.12	243.96	1.14	35.84	7.28	1820	1274
Kavadikaranur	116.03	41.95	239.89	30.11	0.84	614.47	28.50	80.21	252.12	0.57	42.24	7.15	1940	1358
Madathur	112.02	45.96	192.05	25.81	2.23	514.40	27.30	74.93	246.09	1.14	35.84	7.12	1866	1306
Erumaipatty	91.98	36.97	155.94	16.81	0.00	405.78	22.50	70.12	191.84	0.38	35.84	7.16	1435	1005

Malayanur	127.05	62.02	117.99	16.03	0.00	541.25	22.20	70.12	181.91	1.14	46.08	7.13	1695	1187
Korankuttayur	59.92	31.98	123.97	14.86	0.56	356.36	15.30	49.95	128.01	0.76	24.32	7.21	1050	735
Ammankattur	118.04	48.03	132.02	21.11	0.00	553.45	19.20	60.04	163.83	0.57	32	7.07	1555	1088
Vattukaduthottam	91.98	36.97	147.89	16.81	0.56	407.61	21.30	80.21	171.98	0.95	35.84	7.19	1400	980
Vellakalpatty	61.92	35.02	117.99	17.99	0.00	336.22	16.50	64.84	131.91	0.38	26.24	7.18	1162	813

Table 2 Chemical Quality – GIS Spatial Distribution Results

Class	Area in sq. km										
	Ca – Results	Mg – Results	Na – Results	K – Results	F e– Results	Cl – Results	F – Results	NO3 – Results	pH – Results	EC – Results	TDS – Results
Acceptable	1.64	3.87	83.72	0.006	46.81	203.76	140.47	53.50	240.33	9.46	7.30
Allowable	179.12	81.43	-	-	-	-	-	-	-	230.86	-
Not Potable	59.56	155.02	156.60	240.32	193.51	36.56	99.85	186.82	-	-	233.02
Very Bad	-	-	-	-	-	-	-	-	-	-	-

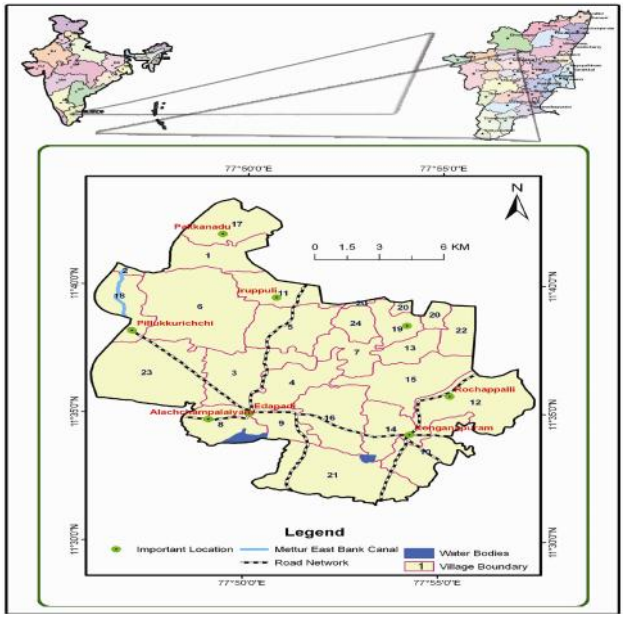

Fig. 1 Key Map of the study Area – Edappadi Taluk, Salem District

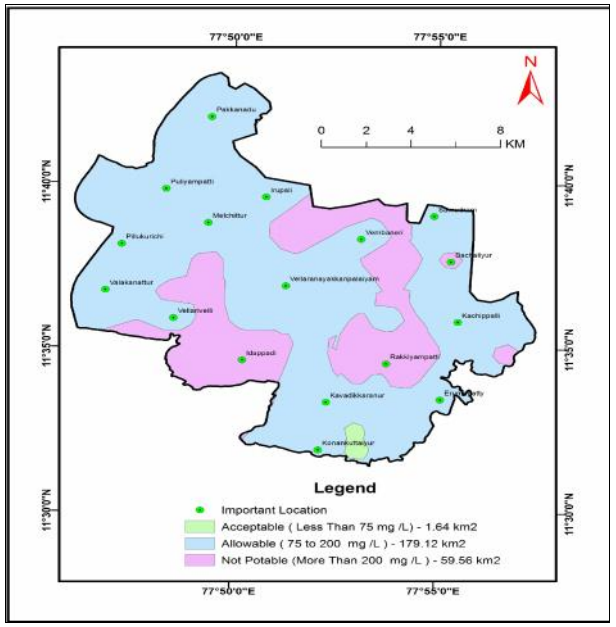

Fig.2 Calcium Quality – Spatial Distribution Map

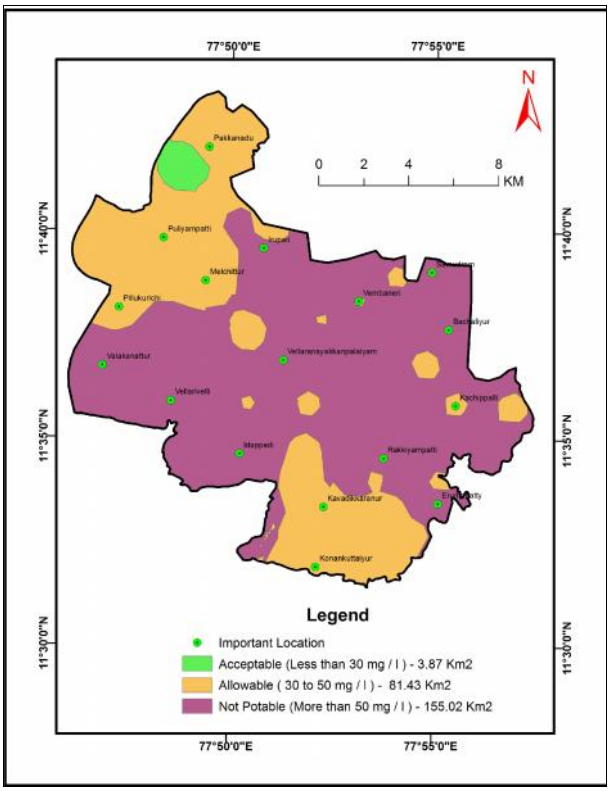

Fig.3 Magnesium Quality – Spatial Distribution Map

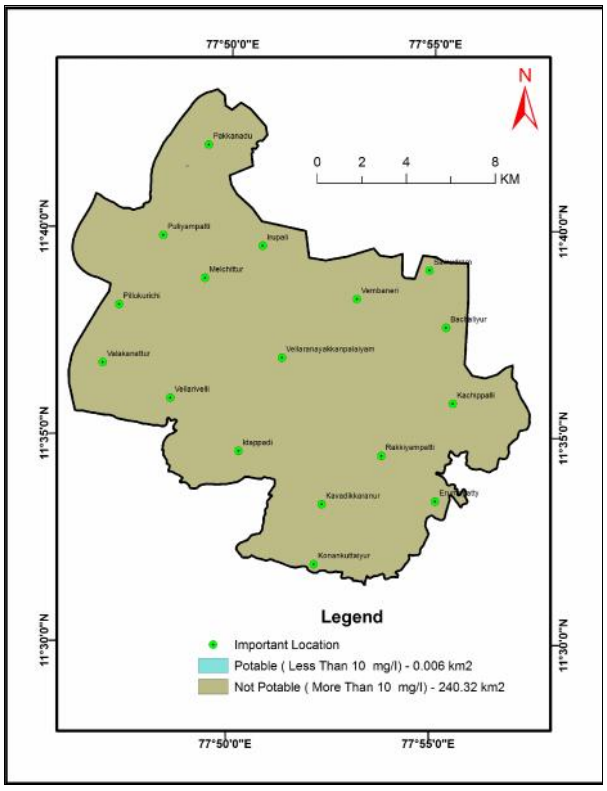

Fig.5 Potassium Quality – Spatial Distribution Map

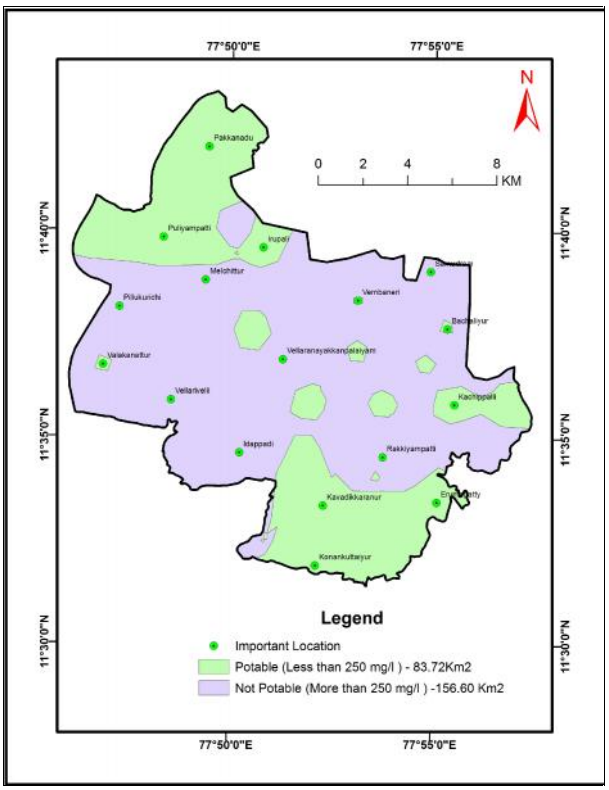

Fig.4 Sodium Quality – Spatial Distribution Map

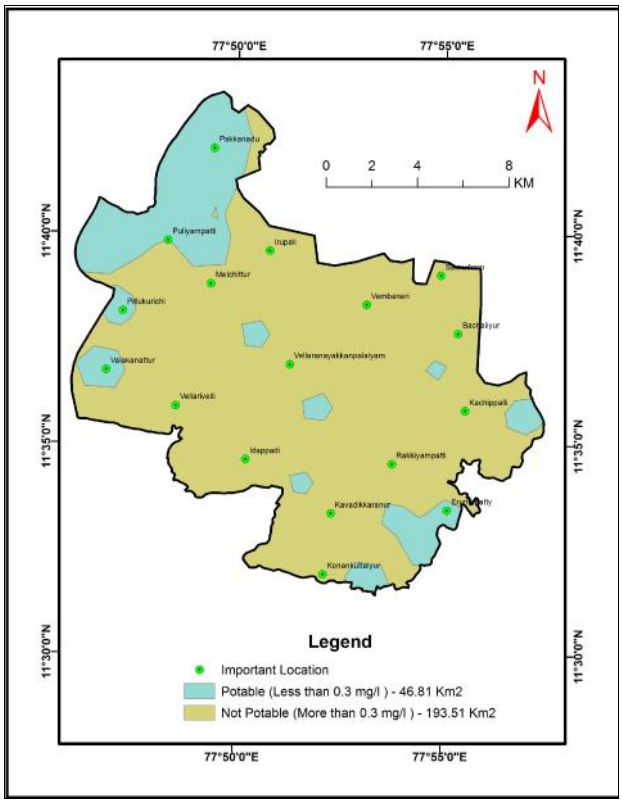

Fig.6 Iron Quality – Spatial Distribution Map

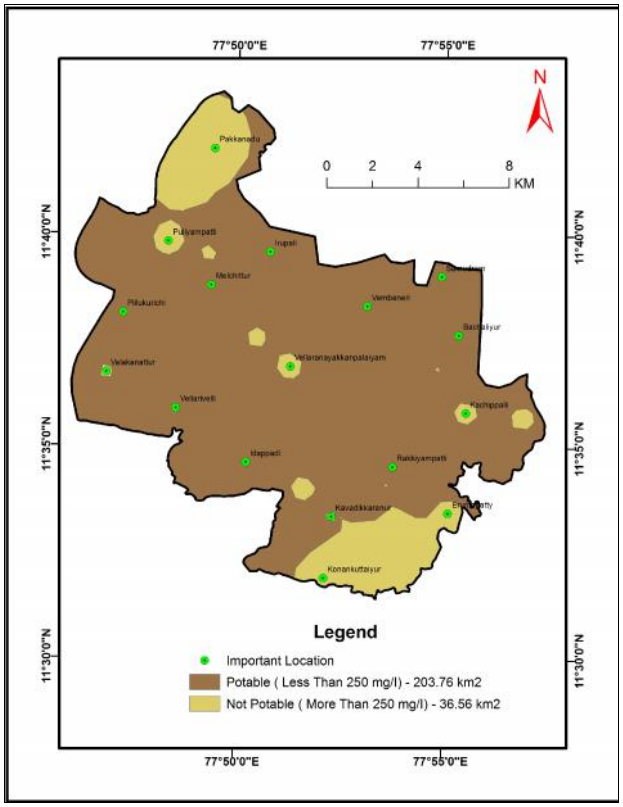

Fig.7 Chloride Quality – Spatial Distribution Map

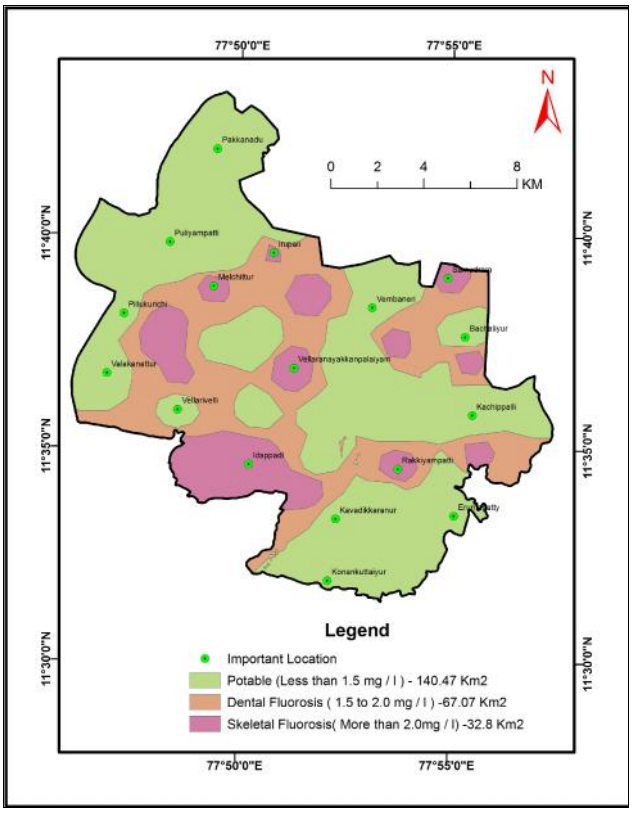

Fig.9 Fluoride Quality – Spatial Distribution Map

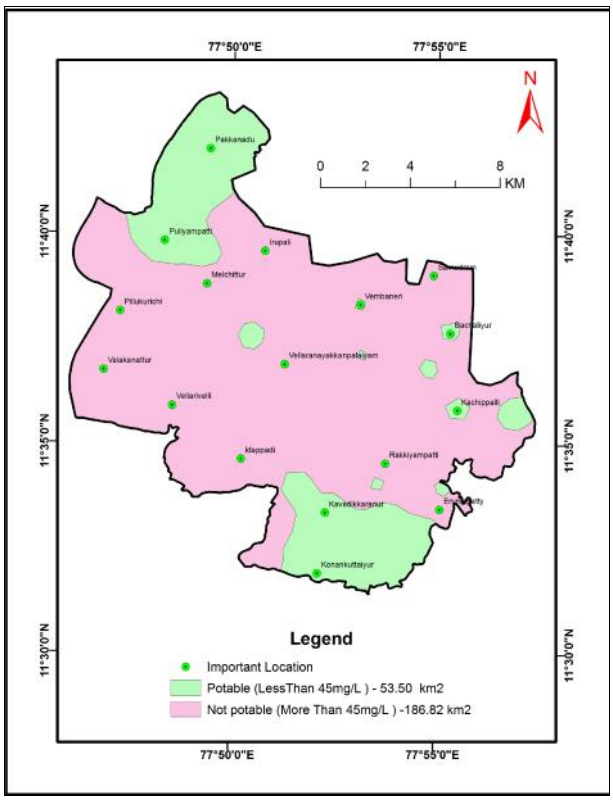

Fig.8 Nitrate Quality – Spatial Distribution Map

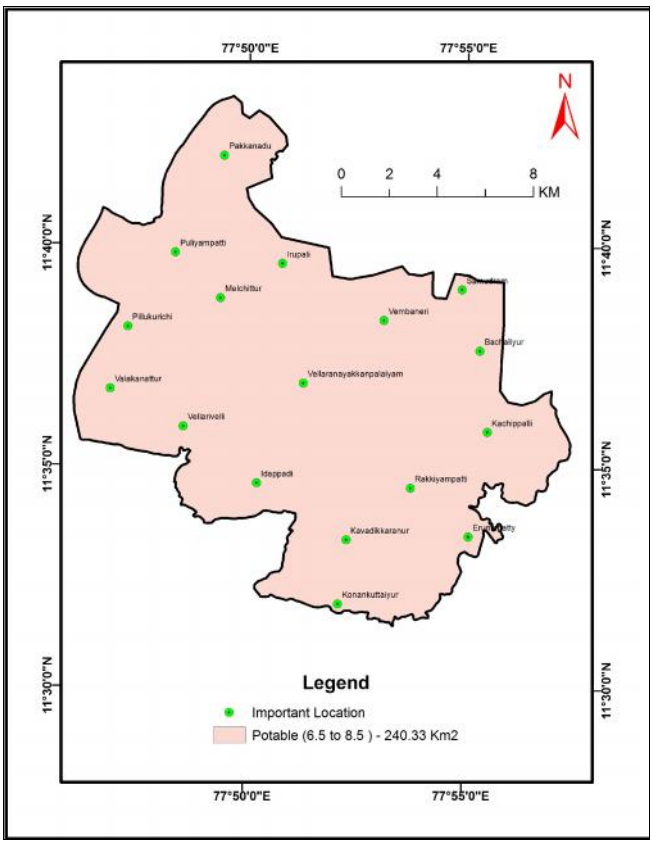

Fig.10 pH Quality – Spatial Distribution Map

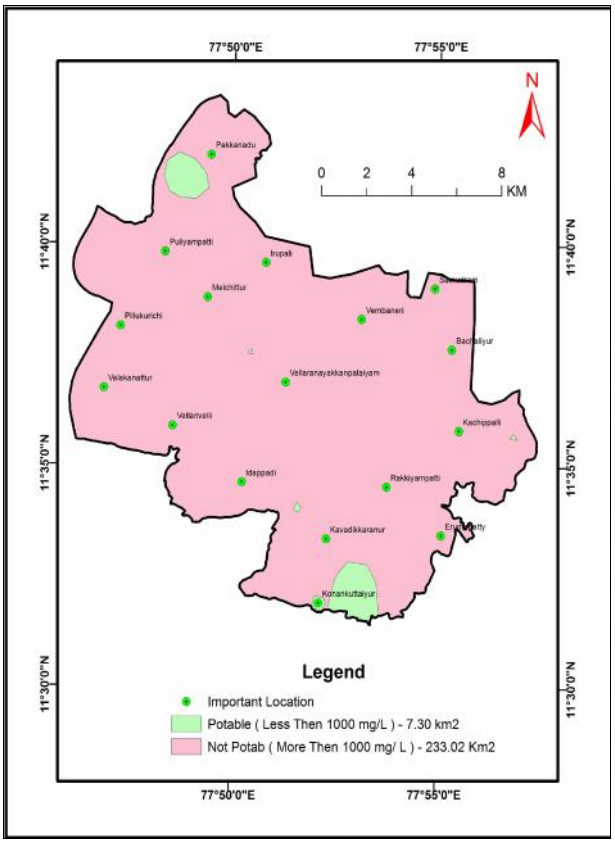

Fig.11TDS Quality – Spatial Distribution Map

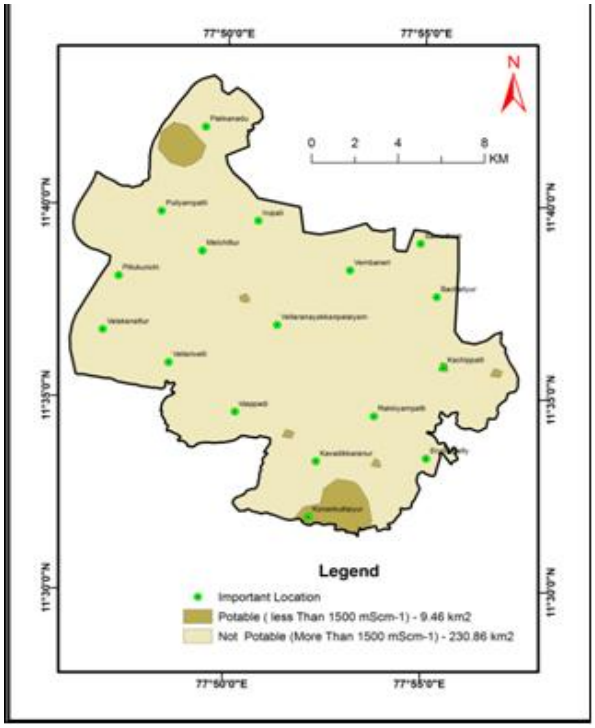

Fig.12 EC Quality – Spatial Distribution Map

Using the WHO standards (1996), the quality of drinking water was categorized. The erratic behaviors of groundwater geochemical elements were spatially given through GIS study. It shows that in the study area, pH, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate, Iron, Nitrate, Fluoride and Total Dissolved Solids (TDS) were observed in potable and not potable limit. To find out the spatial distribution of these elements in the study area, GIS was employed. The geochemical locations were digitized and the corresponding values of its attributes were given as an input. Using this data, the interpolation raster maps were generated. Subsequently, these maps were classified with respect to WHO limiting values and converted into vector maps.

These maps were clipped with the boundary to arrive within the boundary of the study area. The results of calcium for pre-monsoon season map (Fig 2) is given below. The results of magnesium for pre-monsoon season spatial distribution map is given below Fig 3. The pre-monsoon season sodium spatial distribution result is given in the Fig 4 and the result is given in Table 2. The result of potassium for pre-monsoon season (Table 2) and spatial distribution map is given in Fig 5. Results of Iron (Fe) for pre-monsoon season maps (Figs. 6) is given below. Results of Chloride for pre-monsoon season map (Figs. 7) is given below. The results of Nitrate for pre-monsoon season is given in Table 2 and spatial distribution map is given in Fig 8. Results of fluoride for pre-monsoon season samples are given in Table 2 and the spatial distribution map is given in Fig 9. Results of the pH for pre-monsoon season samples are given in Table 2 and the spatial distribution map is given in Fig 10. Results of the TDS for pre-monsoon season spatial distribution map is given in Fig 11.

CONCLUSIONS

The groundwater quality parameters in the study area with reference to the WHO 1996 standards, were used to prepare the spatial distribution map. The pre-monsoon pH values are indicating an acidic to basic nature. In pre-monsoon, TDS concentration indicate that 80% of the groundwater belongs to the brackish water (1,000 to 10,000 ppm) type and 20% of the groundwater falls in fresh water (<1,000 ppm) type. Most of the samples fell within the acceptable and allowable limit, only few samples fell above the WHO limit in calcium and magnesium. Na and K elements concentration was more in post-monsoon. In pre monsoon, the minimum concentration values of Fluoride were observed as 0.4 mg/l and maximum concentration values were observed as 3.5 mg/l. The groundwater quality parameters in the study area with reference to the WHO (1996 standards) limits were used to prepare the spatial distribution map. All the elements spatial distribution maps shows that most of the study area falls under potable category with respect to WHO 1996. The high concentration of all elements in area because due to the geology like Syenite, Granite, Hornblende-biotite-gneiss rocks. The study area occupies mostly Charnockite and hornblende biotite gneiss as country rock which highly rich minerals such as gabbro, anorthosite and pyroxenite etc.

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