Anomalous Concentration of Uranium in Groundwater in Parts of Salem District, Central Tamil Nadu, India

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Research Article

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Abstract

Anomalous concentration of Uranium in groundwater has been identified around Virakkal, Veerapanpalayam, Pakkanadu, Erithottam, Kammampatti, Kumarappalyam, Idappadiand Moolakkadu areas in parts of Salem district, Tamil Nadu. In this study, an area of 970 sq. km from Mettur in the north to Kumarapalayam in the south parallel to the Koratti shear zone has been examined for uranium content in groundwater. Systematic sampling of groundwater (n=78) from bore well, open well and hand pump have been collected. The samples were analysed for uranium concentration using LED Fluorimeter. Analysis resulted higher concentration of uranium along the southern extension of Koratti Shear Zone where the emplacement of younger granites, syenite and carbonatites has been reported. These lithounits might have played a vital role in the contribution of uranium to the groundwater. Based on the result, two areas have been identified such as North Block and South Block for detailed investigation.58 systematic samples from North block and 52 samples from South block have been collected and analysed. Uranium values assayed in these areas are many times higher than the prescribed limit of World Health organisation and Atomic Energy Regulatory Board of 30ppb and 60ppb respectively. In northern block, among 58 samples 18 samples were assayed higher than 30ppb in which the samples from Veerappanpalayam assayed upto 545.81 ppb. Apart from Veerappanpalayam, many areas such as Mosakumarapalayam (273.90), Arasiramani (250.49ppb), Vellarivalli (131.32ppb), Kodarapalayam (106.52ppb), Savuthanur (174.79ppb), Veerapanpalayam-2 (373.43ppb) and Kotamppalayam (100ppb) were assayed more than 100ppb. Similarly, in the southern block, 52 samples were assayed in which 15 samples were higher than the prescribed limit in which Kuppampatti analyzed 402.29ppb, Virakkal and Thannikuttampatti assayed more than 100ppb. Among the total samples (n=188), 28% of samples were falling under non-potable category. The Present study has spatially brought to light significant areas where groundwater enriched by uranium concentration. It is also provided indirect evidences for uranium exploration in the study area.

Keywords: Uranium, Groundwater, Salem, LED Fluorimeter

Introduction

Uranium is a naturally occurring radioactive element, which is present throughout the mother earth. It is found in low concentration within all rock, soil, and water. This is the heaviest element to be found naturally in significant quantities on earth. Based on United Nations Scientific Committee, the Effects of Atomic Radiation the normal concentration of uranium in soil is 11.7 mg/kg to 300 µg/kg. Granite and younger intrusive rocks in general show higher concentrations of uranium, especially, Granitic rocks rich in uranium are sometime called hot granite where the uranium concentration normally exceeds 15ppm and it may as great as 120ppm sometimes. Some important uranium ores found include Pitchblende, Uraninite, Brannerite, Carnotite, Autunite, Torbenite etc.

In general, uranium in water that controls our daily exposure to this radioactive element which is particularly where the drinking water obtained directly from groundwater. In view of health impacts, it is directly associated with exposure to higher level of naturally occurring uranium in drinking water. Uranium concentration in groundwater is a result of the dissolution of uranium bearing minerals that have been in contact with groundwater for long periods of time. Higher concentrations

of natural uranium in well water are more likely to be found in drilled wells that obtain their water from the cracks and fractures of bedrock, rather than dug wells or surface water supplies. The uranium concentration in groundwater various with respect to the source rock and its intrinsic uranium content. Uranium exist in 4 valence such as U^{3+}, U^{4+}, U^{5+} and U^{6+}, in natural material, it is generally present in either U^{4+} (Uranus) or U^{6+}(uranyl) form.

The World Health Organization (WHO) recommends that uranium in drinking waters should not exceed 30ppb and Atomic Energy Regulatory Board recommends (AERB) should not above 60ppb. Concentration levels are set to represent that does not result in any significant risk to health over a lifetime by drinking the water. The WHO value for uranium concentration in drinking water is based on a "Tolerable Daily Intake" (TDI) based on bodyweight. The TDI is an estimate of the amount that can be consumed daily over a lifetime without appreciable health risk. This is a TDI of 36mcg for an average adult weighing 60kg.

The exploration for atomic minerals in the study area was started during 1948 by the Madras party of Rare Mineral Survey Unit (RMSU). Radioactivity due to thorium was reported in general with few uraniferous anomalies associated with granite and pegmatite in western margins of Suryamalai batholiths at the contact of hornblende biotite gneiss in Kullampatti (1955-56), Kodamedu and Serandampalayam (1981-82) areas in Salem districts of Tamilnadu. Besides, several U-Th-REE-Nb-Ta anomalies were reported in the carbonatites and quartz-barite vein associated with the alkaline complex of Sevattur, Pakkanadu and Mulakkadu (1972-73) . Uranium has also been reported in the Sevattur carbonatite resulted 0.202% – 0.240% (n=4 Nos) and in the U-rich pyrochlore mineral [1].

Uranium exploration is not different from other exploration ores; however uranium, thorium and potassium emit gamma rays which make it possible to identify the radioactive element under certain conditions. Hence, radiometric surveys are usually the first considered uranium exploration programme using gamma ray spectrometer. However, there are many cases in which this instrument does not advance the uranium exploration programme like where the uranium deposit is obscured non-radioactive rock, soil, water or vegetation. Under such conditions, other methods of exploring for uranium must be considered. Among the many options available to the explorationist is remote sensing[2].

According to Talaat M. Ramadan, et al, the processed Landsat ETM+ data facilitate to identify uraniferous alteration zones hosted in the granitic rocks. He has used band ratio 5/7, 4/5, 3/1 in RGB, density slicing and supervised classification techniques to locate the uraniferous zone[3]. The study recorded the presence of uranium mineralization in alteration zones associating with the granitic rocks occurring along ENE–WSW trending shear zones.

Ramadan et al also used remote sensing with geological and AGRS data set to locate the uraniferous zone[4]. The study recorded a number of uranium anomalies along NNE-SSW trending fault zones within the granitic rocks. These occurrences are associated with alkali monzogranites, pegmatitic and manganese veins, trachytic dykes.

Based on the scanning of previous works pertaining to Uranium and Rare Earth Elements around Mecheri, Pakkanadu and South of Idappadi, it was decided that the area in and around these villages need to be explored thoroughly for Uranium distribution in groundwater using LED Fluorimeter and also to prepare spatial model for uranium concentration in the study area using Remote Sensing and GIS technique. (Figure-1).

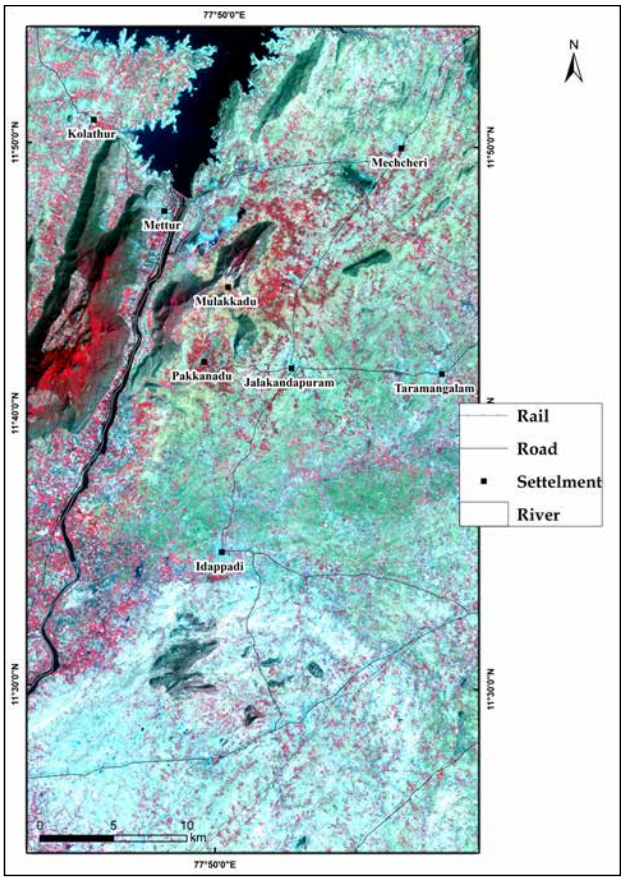

Figure 1: Base Map of the Study Area

Lithology

The study area comprises Archaean to Early Proterozoic rocks represented by high grade granulites, gneisses, alkali complexes and younger intrusive of granite, sayenite and pegmatite. Majority of the study area is covered by the fissile hornblende biotite gneiss followed by the Suryamalai batholiths (SMB) granitoids and syenites. The northern part of the study area exhibits small portion of charnockite and epidote hornblende biotite gneiss. Bands of meta-limestone and calc-granulites were also noticed in the southern part of the study area near Sankaridurg. The age of the fissile hornblende biotite gneiss is equivalent to the southern granulite terrain which ranges between 2400 and 2100 Ma and the age of the younger intrusive such as Sankaridurg granite, carbonantites and syenites are 750 – 550 Ma[5,6,7]. These younger plutons

are aligned in the NE-SW direction which is parallel to the trend of major faults and shear zone observed in the study area. Various alteration processes found in the study area (Figure-2).

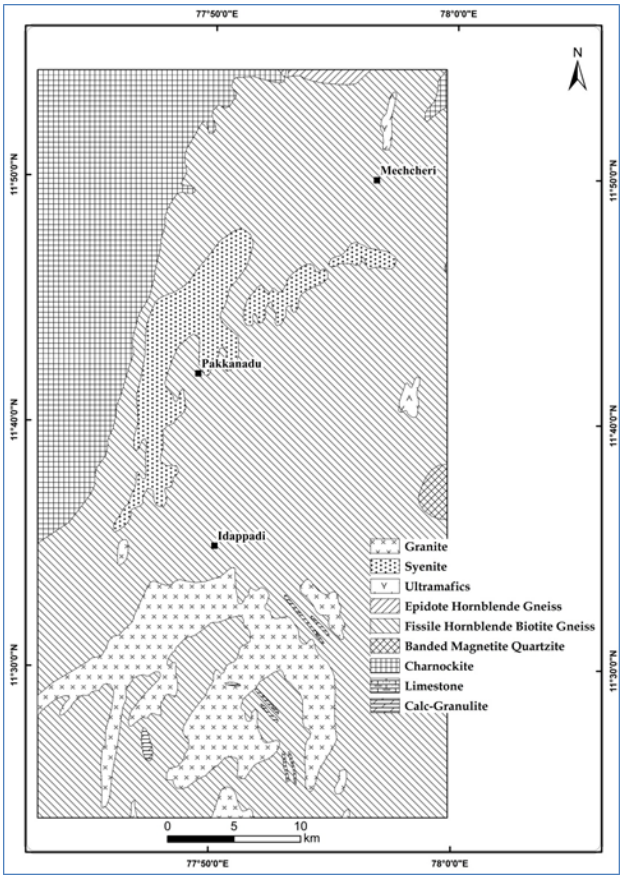

Figure2: Lithology Map of the Study Area

Methodology and Instrument Used

Methodology adopted for this study explained based on the following steps given;

Step 1: Preparation of grid (4kmx4km and 2kmx2km) pattern for the study area to collect systematic groundwater samples.

Step 2: Collection of groundwater samples from borewell, open well, and hand pump. Before collection of water samples pre-processing of water bottles have been carried out. Washed the bottles and caps with a dilute solution of detergent and tap water were kept overnight. Again rinsed thoroughly with tap water and then with aqueous 10% nitric acid solution. Before collecting the groundwater samples hand pump or motor has run for few minutes and then samples were collected in the pre-processed bottles after rinsing twice with the water to be collected.

Step 3: Samples were filtered using whatman grade 541 filter paper and acidified using HNO3 to maintain the pH level below 4 to prevent the uranium precipitation in walls of the container.

Step 4: Drying of sample using hot plate to remove the acid and preparation of sample for analysis.

Step 5: Preparation 10% fluren (Buffer) to the sample for florescent enhancement. Buffer Solution (FLUREN) has been prepared using Sodium Pyrophosphate powder of 5gms. It is added 100ml. of double distilled water and shakes well to dissolve the Sodium Pyrophosphate powder. Further, added Ortho-phosphoric acid drop by drop while monitoring the pH of solution until a pH of 7 is reached. This is the desired buffer solution also called FLUREN. Adding buffer solution to a uranium sample increases the fluorescence yield by orders of magnitude.

Step 6: Preparation of blanks, uranium standards for 2ppb, 4ppb, 6ppb and 20ppb. Finally,

Step 7: Analysis of sample using LED Fluorimeter. Water sample of 6ml quantity with 10% of the buffer solution is used to find its uranium content. It is filled in to the clean and dry quartz cuvette made up of ultrapure fused silica has taken to the LED Fluorimeter. The instrument was calibrated with the standard uranium solution of known standards.

Step 8: Calculation of uranium concentration in groundwater with respect to standard values (Figure-3).

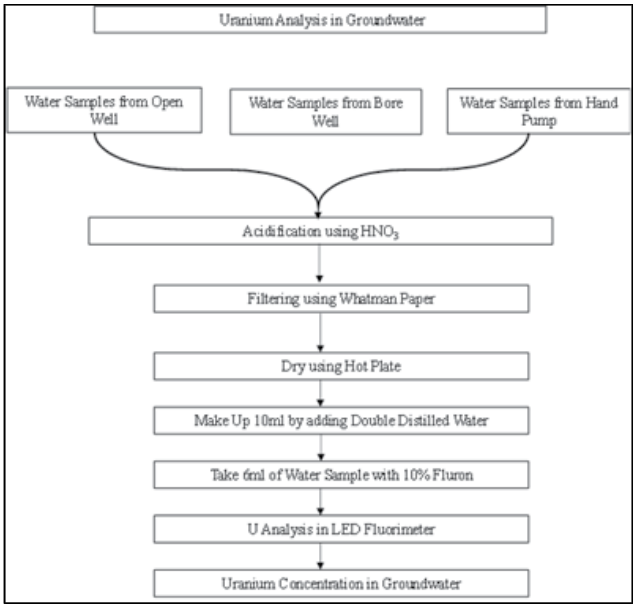

Figure 3: Flowchart for Methodology

Result and Discussion

Systematic sampling of groundwater (n=78; 4km x 4km) has been collected over an area of 970 sq km from bore well, open well and hand pump for the analysis of uranium concentration using LED Fluorimeter (Figure-4). The analyses resulted uranium concentration between 0.01ppb and 385.40ppb (Plot-1). Resulted values were used to prepare uranium image of the study area which shows the higher concentrations around Kumaramangalam, Idappadi, Pakkanadu and Mettur (Figure-5). Samples from Virakkal (385.4ppb), Erithottam (351.44ppb) and Kurukkupalayam (249.39ppb) assayed very high concentration of uranium indicates the proximity of possible uranium ore. The groundwater sample may not give accurate position about the uranium ore as it is easily move with water but it can guide the explorationist to narrow down the target area. The average uranium value calculated for the study area shows 33.76ppb which is above the WHO standard for drinking water. Among 78 samples 20 samples have been assayed more than 30ppb which is about 25 percentage of the samples analysed. (Table-1).

S. Id	U in PPB	Locations
1	6.60	Thottilpatti
2	5.07	Gonur
3	21.38	Pottaneri
4	2.96	M.Kalipatti
5	1.46	Amaram
6	2.68	Thettiiripatti
7	3.07	Kali Kaandanur
8	3.46	Kaikattivellar
9	0.01	Kammampatti
10	3.21	Sollayanur
11	3.02	Thoppaiyar
12	5.49	Mallikundham
13	1.77	Uppupallam
14	1.94	Koonadiyur
15	**65.27**	Thottakadu
16	0.23	Thottilpatti
17	1.82	North of Saanayur
18	1.05	Poriyur
19	11.10	Vaachanpalli
20	19.64	Poolampatti
21	6.18	Pillikurichi
22	2.14	Yellakuttur
23	1.97	Pulampatti
24	0.40	Koavilpalayam
25	40.07	South of Pakkanadu
26	13.65	Adaiyur
27	2.12	Kuppampatti
28	42.02	Nangavalli
29	**385.40**	Virakkal
30	8.95	Semmannankaattuvalivu
31	**86.45**	Annanagar
32	19.89	Moolakaadu
33	2.65	Yannaipallam
34	2.53	Vellaraivelli
35	1.14	Okkillipatti
36	3.30	Kooneripatti
37	1.62	Mettankadhu
38	24.91	Kalvadangam
39	**351.44**	Erithottam
40	**76.62**	Katheri
41	8.57	Samathuvapuram
42	**78.03**	Kumarapalayam
43	5.25	Kumarapalayam
44	7.46	Kaavadiyankadu
45	28.46	Ranganoor
46	16.66	Paatharai
47	9.20	Nettavellampalayam
48	3.21	Padaivedu
49	8.12	Kundachikaddu
50	**94.91**	Chinna Goundanoor
51	2.08	Sunnambukuttai
52	7.31	Periyasoragi
53	0.03	Paiyur
54	48.75	Selavadai
55	30.44	Kattampatti
56	23.64	Panikanur
57	13.49	Pudupalayam
58	31.39	Dadapuram
59	4.98	Kattuvalaivu
60	2.48	Thoranapatti
61	**96.71**	Puthukathukattur
62	42.67	Rettipatti
63	49.82	Mosakurmarapalayam
64	28.19	Koolipannai
65	24.72	Kupakadu
66	26.36	Pandiyamedu
67	**75.10**	North of Mothaiyanur
68	**104.08**	Alathur
69	9.01	Kallampalam
70	**190.89**	Pachapuliyur
71	**249.39**	Kurukupalayam
72	53.81	Chetimankurichi
73	1.99	Koolaiyoor
74	1.99	Parakallur
75	0.86	Selagalthittu
76	2.35	Palakaranoor
77	28.16	Aavaniyoor
78	3.34	Idappadi

Bold indicates the value above WHO standard such as 60 ppb
Table 1: Uranium Assay of Groundwater samples from Study Area in 4kmx4km Grid

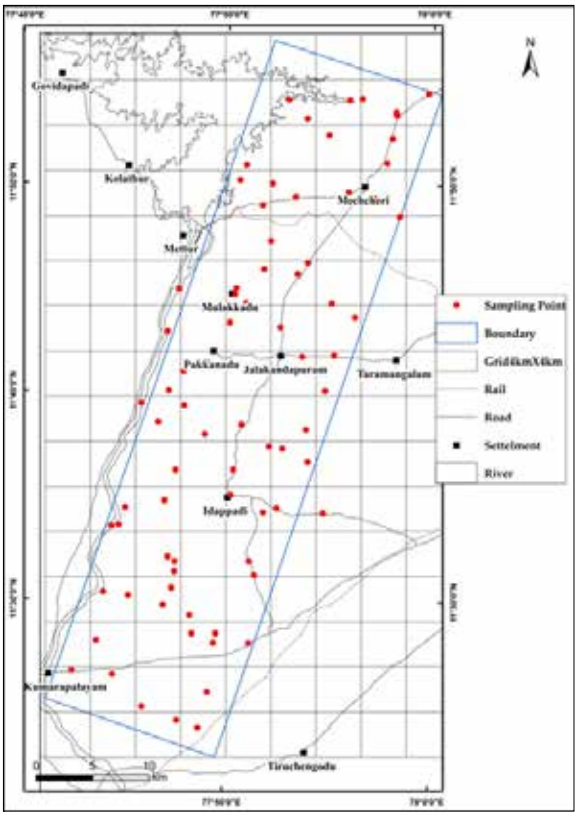

Figure 4: Groundwater Sampling Location

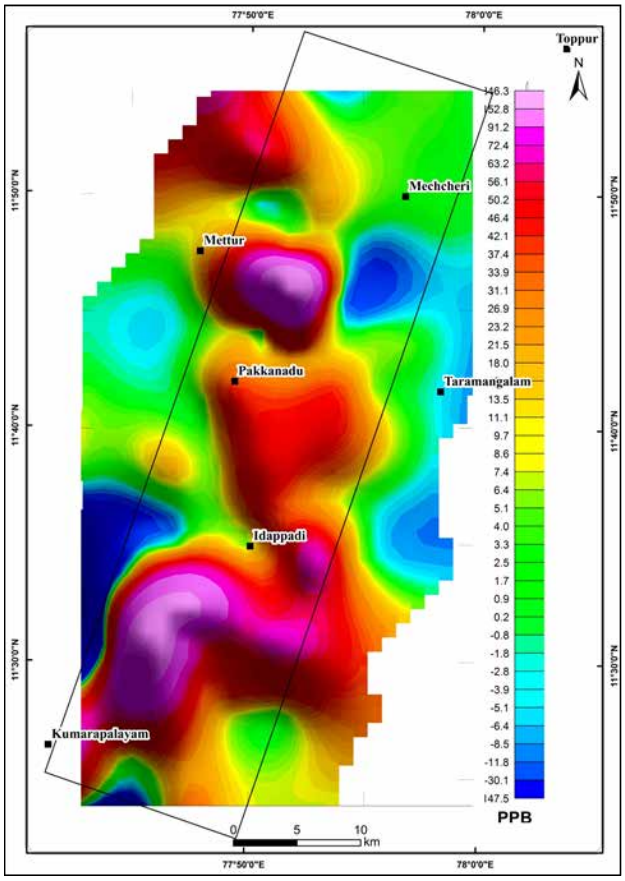

Figure 5: Uranium Concentration in Groundwater

Uranium values were further classified in two categories such as potable and non-potable water under the GIS environment using WHO and AERB standards (Figure-6 and Figure-7). As per the Atomic Energy Regulatory Board norms, the area such as south east of Mettur, Pakkanadu, Idappadi, Kumaramangalam have fallen under the non-potable category. Uranium image based on WHO standard shows that the area around Kumarapalayam, Idappadi, south east of Idappadi (Sangaridurg), Pakkanadu and around south east of Mettur comes under the class of non-potable.

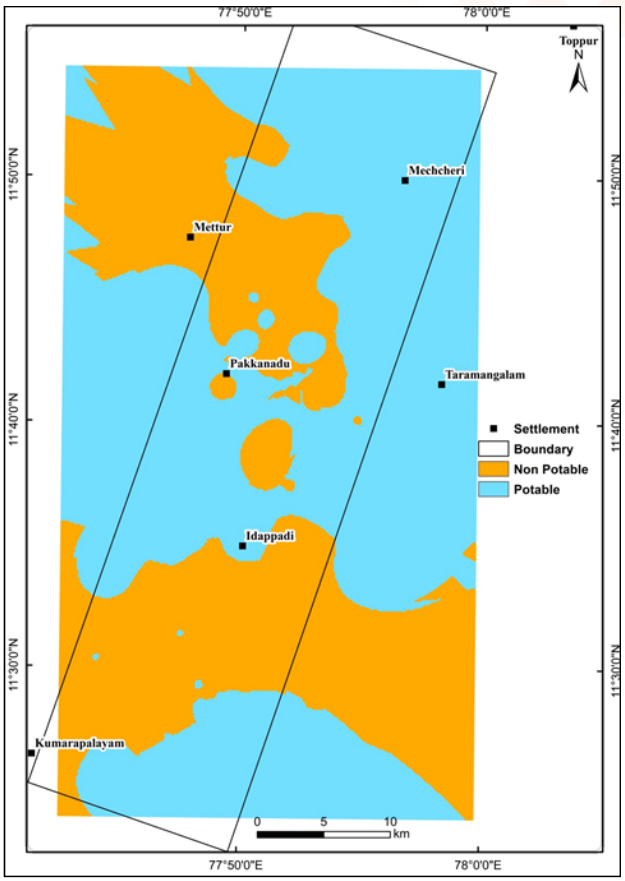

Figure 6: Water Quality Map of Uranium as per AERB Norm

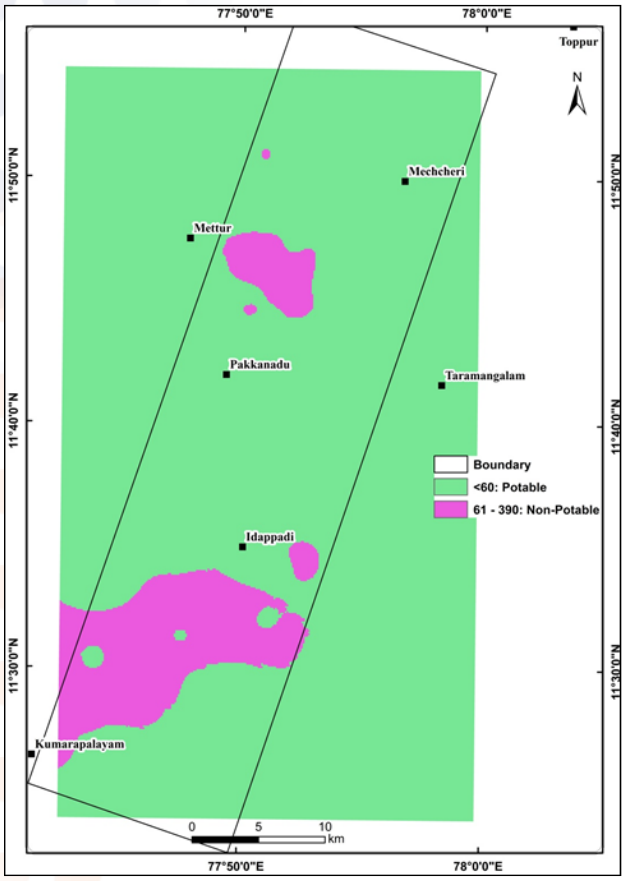

Figure 7: Water Quality Map of Uranium as per WHO Norm

Figure 8: North and South Block

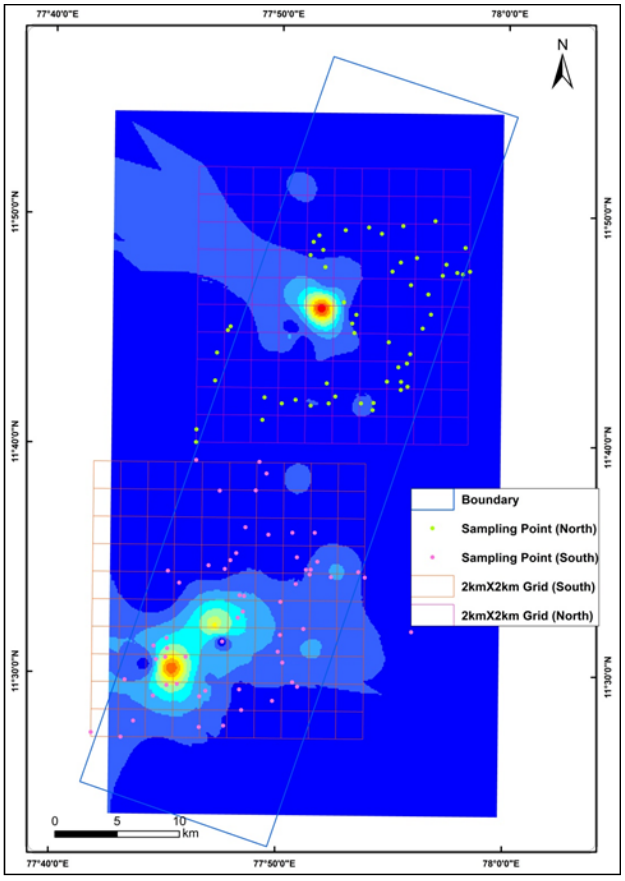

Figure 9: Sampling Grid pattern of 2kmx2km

Based on the result obtained from the groundwater samples (n=78), two areas were selected for detailed study to narrow down the target area. North Block (385ppb) and South block (351 ppb) have been identified based on their uranium concentration distribution (Figure-8) for further study. These areas were sampled using 2km x 2km grid size (Figure-9) however the regional samples were collected using 4km x 4km grid size. Groundwater samples of 58 numbers in north block and 52 samples in south block were collected and analysed. Northern and southern block samples show 31 and 28 percentage of samples respectively falling under the non- potable drinking water category as per AERB norm. In northern part, among 58 samples 18 samples were assayed higher than 30ppb in which the samples from Veerappanpalayam assayed upto 545.81 ppb. Apart from Veerappanpalayam many areas such as Mosakumarapalayam (273.90), Arasiramani (250.49ppb), Vellarivalli (131.32ppb), Kodarapalayam (106.52ppb), Savuthanur (174.79ppb), Veerapanpalayam-2 (373.43ppb) and Kotamppalayam (100ppb) were assayed higher concentration (Figure-10), (Table2). Similarly, in the southern part 52 samples were assayed in which 15 samples were higher than 30ppb. The area near Kuppampatti (Sevasathai) analyzed 402.29ppb Virakkal and Thannikuttampatti assayed more than 100ppb (Fig-11), (Table-3)

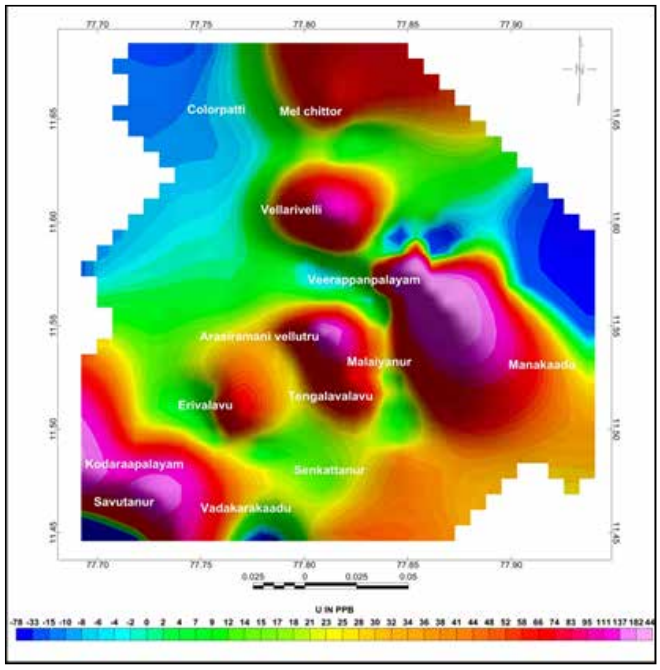

Figure 10: Uranium Concentration in Groundwater North Block

S.No	U in ppb	Location
1	2.47	Maylampatti
2	545.81	Virappanpalayam
3	**61.26**	Malaiyanur
4	39.16	Kaliyanur
5	13.80	Vannakadu
6	26.24	Senkattanur
7	1.06	Aalathur
8	**95.96**	Erivalavu
9	1.68	Thevur
10	3.45	Kanniyapatti
11	35.28	Pullagoundapatti
12	1.36	Chinna panayakkanpam
13	2.85	Boomaniyur
14	0.52	Okkilappatti
15	6.65	Mettupalayam
16	3.52	Kunjampalayam
17	3.24	Vellagoundanoor
18	6.25	Kuppanur
19	0.51	Colorpatti
20	**61.55**	Mel chittor
21	10.48	Chittor
22	2.94	Yellankuttur Katuvalasu
23	**131.32**	Vellarivelli
24	2.96	Kurukuppalayam
25	1.75	Arasiramani
26	5.61	Olappalayam
27	44.85	Olappalayam
28	**250.49**	Arasiramanivellutru
29	**62.73**	Arasiramanivellutru
30	23.97	Ellapalayam
31	**106.52**	Kodaraapalayam
32	**174.79**	Savutanur
33	10.34	Katheri
34	**373.43**	Veeraappam palayam
35	13.05	Palanyankurichi palayam
36	27.03	Thvur
37	2.88	Thvur
38	3.62	Vaikundampalayam
39	18.90	Pallakapalayam
40	28.54	Nallampalayam
41	6.89	Virachcipalayam/Roha
42	22.95	Vadakarakaadu
43	12.47	Pandiyameedu
44	16.49	Mothaiyanoor
45	11.83	Kidaiyur
46	70.37	Tengalavalavu
47	5.68	Koambai
48	10.38	Natthakaadu
49	8.19	Aavaniyur
50	**100.00**	Kottampalayam
51	11.32	Kurumbapatti
52	**273.90**	Mosakumara palayam
53	57.15	Rakkiyampatty
54	11.03	Konganapuram
55	24.59	Manakaadu
56	**69.32**	Puttamani
57	3.08	Kappamadakaadu
58	10.36	Virappampalayam

Bold indicates the value above WHO standard such as 60 ppb

Table 2: Uranium Assay of Groundwater samples from North Block in 2kmx2km Grid

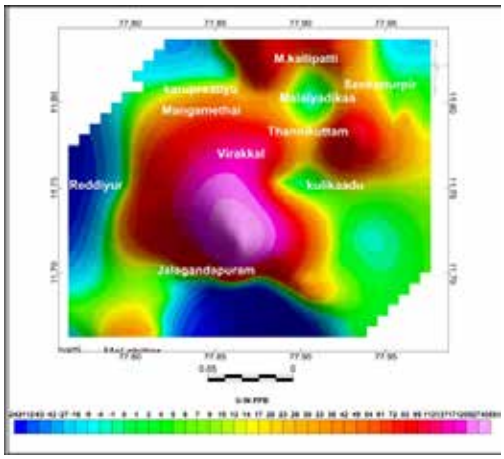

Figure 11: Uranium Concentration in Groundwater South Block

S.No	U in ppb	Location
1	49.56	M.kallipatti
2	1.19	Kolkanoor
3	2.20	Paanapuram
4	2.60	Gonur
5	11.21	Panaapuram
6	4.96	Senkatturpiruvu
7	1.93	Koolaiyur
8	30.88	Pottaneri
9	**99.48**	Kandanoor
10	14.85	Senkattur
11	38.17	Sathapaadi
12	40.18	Nangavalli
13	43.30	Mangamethai
14	18.89	Karuprettiyur
15	7.43	South of Nangavalli
16	4.25	N of sathaapadi
17	2.82	Boomirettipatti
18	2.59	Reddiyur
19	21.94	Selavadai
20	50.41	Kattampatti
21	25.86	Kosavankudivalaivu
22	7.06	Vadakattrikaadu
23	-0.27	Iyerkaadu
24	51.39	Thoramangalam
25	3.69	Poraiyur
26	2.19	Kuppanoor
27	6.11	Karatupatti
28	12.82	Satyanagar
29	3.75	Kaaligoundanoor
30	23.69	Vanavaasi
31	0.25	Pakkanadu
32	42.88	Jalakandapuram
33	1.34	N of poraiyur
34	5.81	Kundathimeadu
35	36.04	Karuperiddiyur
36	8.45	Adaiyur
37	29.04	Ariyampattipudur
38	**130.42**	Virakkal
39	2.39	Rajanoor
40	7.34	Periyagoundanoor
41	4.09	S of Reddiyur
42	**402.29**	Kuppampatti
43	3.59	Pachanoor
44	8.64	Periyasoragai
45	14.70	Kulikaadu
46	15.43	Pudhur
47	40.052	Malaiyadikaadu
48	30.84	Naadarcolony
49	**83.59**	Muthaampatti
50	5.32	Kuttampatti
51	11.67	Pottaneri
52	**118.49**	Thannikuttampatti

Bold indicates the value above WHO standard such as 60 ppb

Table 3: Uranium Assay of Groundwater samples from South Block in 2kmx2km Grid

Conclusion

Uranium concentration in 78 systematic groundwater samples from bore well, open well and hand pump were analysed using LED Fluorimeter. Minimum and maximum values are recorded in the study area are 0.01ppb and 385.40 ppb. Uranium map was prepared from the resulted values shows that maximum concentration of uranium near the contact zones of metasediments and intrusive granite, syenite and carbonatite. Uranium concentration maps were generated as per the AERB and WHO norm, the value of uranium higher then 60ppb and 30ppb are not suitable for drinking respectively. The present study carried out so far, suggest that the groundwater around Veerappanpalayam, Savtanur, Erivalavu, Virakkal, Mosakumarapalayam, Idappadi, Pakkanadu, Mecheri and Mettur east are not suitable for drinking purpose as per AERB standard. Occurrences of higher concentration of uranium element in groundwater may lead to cancer, kidney disease and lungs failure in these zone. These anomalous areas may lead to the proximity of uranium ore and act as an indirect indicator to locate where it comes from which may further helpful to plan the detailed survey for uranium exploration. Further, it assumes significance in suggesting that there may be other uranium enriched zone in groundwater where similar settings located along the northern extension of the study area [7-14].

Acknowledgement

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