

Study of Uranium concentration in groundwater in Nagapattinam District of Tamil Nadu, India

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ABSTRACT

The attentiveness of uranium has been assessed from the Nagapattinam district of Tamilnadu, India. The water samples were collected from the various locations by hand pumps and tube wells and analysed by using LED Fluorimeter LF 2a Uranium analyser. The Uranium is directly measured by based on the fluorescence of uranyl complex formed by Fluren as buffer reagent (Tosheva, 2003). The concentration of Uranium in water samples varies from 0.04±0.01 to 13.4792±0.1 µg/L. Concentration of Uranium and associated water quality parameters such as pH, TDS, Turbidity, Electrical Conductivity, Fluoride, Chloride, Mg, Ca and Total hardness, Sulphate, Phosphate, Nitrate and Alkalinity were studied as the associated parameters are interfering substances in Uranium concentration. The values are varied with the different locations of samples.

KEY WORDS: LED Fluorimeter, Uranium, Radio activity, Fluorescence.

1. INTRODUCTION

Uranium (U), a intense metal, can be worn as an rich source of concerted power. It occurs mostly in rocks (2-4 ppm). The high density of uranium means that it also finds applications in the keels of yachts and as counterweights for aircraft manage surfaces, as well as for emission shielding. Uranium has a melting point of 1132°C.

The concentrations of uranium are analyzed by various methods such as Photometry, Liquid scintillation method (LSC), Fission track technique, spectrometry and Fluorimetry. The last one is chosen for its extra ordinary sensitivity, high specificity, Low cost and simplicity compared to other techniques. Fluorimetric method is ordinarily 1000 fold more sensitive than absorbance measurements. Fluorimetry technique has two narrow band light sources such as LED and LASER. The LED Fluorimetry is better efficiency than LASER.

Study area and Sampling: In the present study, the sample collected from the different locations of Nagapattinam district of Tamilnadu, India. Nagapattinam district is spread over eight Taluks and eleven panchayat unions covers the area around 2715.83 sq.km. The district lies on the shores of the Bay of Bengal between northern latitude 10°25' and 11°40' and eastern longitude 76°49' and 80°01'. Lignite, Illeminite sands, kankar and tuffaceous lime are mineral resources in this district (Kumaraperumal, 2007). The geological structure of the region is formed of black and alluvial soil. Nagapattinam district covers the eighty samples of each 5×6 km of grid map. The samples are collected and preserved and stored by using polyethylene bottles.

2. METHODS AND MATERIALS

Uranium concentration in water: Various methods are used for the assessment of uranium in water sample. In the current examination of uranium is analyzed by fluorescence technique. In this technique LED fluorometer generates the wavelength of light essential to excite the analytic of interest, it selectively transmits the wavelength of light emitted and it measures the intensity of the emitted light from the water sample. LED Fluorimeter LF-2a can measure the concentration range of 0.5-1000µg/L with an accuracy of ±5% and the reading time is about 1 seconds. In this technique the standard solution (ICP-MS-66N-0.01X-1) is being calibrated and then the concentration of the uranium is being analyzed.

Concentration of uranium = $CF \times (\text{fluorescence from sample} - \text{fluorescence from water})$

Physico- Chemical analysis of water: pH, TDS, Conductivity, ORP and DO measurements are carried out in the water sample with the respective electrode by using digital Hach HQ 430d Flexi multiparameter. The total, calcium and magnesium hardness are measured by EDTA method. The concentration of chloride is determined by Mohre's methods by adding silver nitrate to give silver chloride precipitate. The alkalinity is determined by titration with HCl and indicator solution. The content of Sulphate, Phosphate and Nitrate ions are determined by using UV-Visible spectrophotometer (Hach DR6000). It events the amount of light passing through water sample (I), and compares it to the intensity of light before it passes through the sample (I₀). The ratio I/I₀ is called transmittance. Generally UV-Visible spectrometer obeys the Beer-Lambert law. It also events reflectance when light reflected from sample (I) and compared from reference material (I₀).

3. RESULTS AND DISCUSSION

The results of Uranium concentration along with Ca, Mg and Total Hardness, pH, TDS, Chloride, Fluoride, Sulphate, Phosphate and Nitrate are reported in three regions such as Sirkazhi, Nagapattinam and Vedaranyam in

tables.1, 2 and 3. In Sirkazhi region the concentration of uranium is found to vary from 0.1564 in the village Vadurangan to 5.2374 on Neppathur village. In Nagapattinam region the uranium content changed from 0.0427 in Idaiyathangudi village to 8.2776 in Alangudicheri. Vedaranyam region the concentration of uranium differs from 0.0442 in the village Andarkadu to 13.4792 in the village Mudaliyappan kandiur. Maximum concentration of uranium is found in the village Mudaliyappan kandiur. However in Nagapattinam district uranium content lies in between 0.0427 and 13.4792.

The pH level was found to vary from 6.83 in village Madappuram to 8.24 in katripulam village while the TDS level was found to vary from 130.1mg/L in Thillaiyadi village to 8060 mg/L in Mudaliyappan kandiur village. Chloride the common substance of water is found to vary from 40 mg/L in water collected from the village Thillaiyadi to 5298 mg/L from Mudaliyappan kandiur. The evaluation of Flouride concentration in the water sample varies from 0.1mg/L to 2 mg/L in the villages Kachchnagaram and Kaththripulam respectively. Whereas the calcium and magnesium hardness are found to lies in between 12 to 400 mg/L for villages Thillaiyadi and Pudupalli and 58 to 2605 mg/L for the villages Thillayadi and Mudaliyappan kandiur respectively. In this result some samples are shows as calcium deficiency. The concentration of Sulphate lie in the ranges 1.21 to 289.57 mg/L in the sample collected from Pazhayapalayam and Kaththripulam respectively. The evaluation of Phosphate and Nitrate lies in the range between 0-4.2 mg/L in the villages Andipandal, Kadaikkadu and 32.8 to 481.2mg/L fromValluvur and Vanagiri respectively.

Nitrate content in water samples are varies from 32.8 in Valluvur village to 481.22 in Vanagiri. 88% of the sample exceeds the safe limit of 50 mg/L recommended by WHO (2012). The excess of nitrate may cause blue baby syndrome. Sulphate concentration in water is initiated to vary from 3.2 mg/L in Mahili to 289.7mg/L in Kaththripulam. The concentration of phosphate shows between 0.01 to 4.68mg/L. In many samples the concentration of phosphate and sulphate are originated to higher than acceptable limit of 0.05 and 250 stated by WHO (2012). The concentration of Chloride found to vary from 40 mg/L in Thillaiyadi to 5298 in the village Mudaliyappan kandiur, whereas the Fluoride Concentration lies in between 0.1 in Kachchanagaram and 2.0 in Kaththripulam. Ayakkarambalam I setti and Kaththripulam have higher value of fluoride.

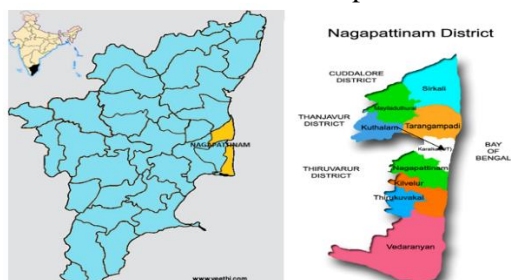


Figure.1. Location map for Nagapattinam District

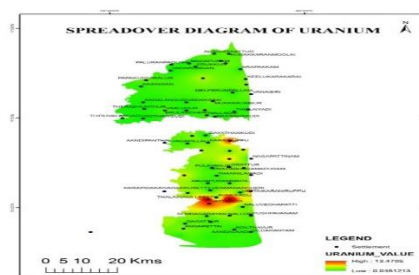


Figure.2. Uranium distribution in Nagapattinam District

Table.1. The concentration of Uranium, TDS, pH, Chloride, Fluoride, Ca and Mg Hardness and other parameter in the water sample from Sirkazhi region of Nagapattinam District, Tamilnadu, India.

| Locations | Source of water | U (µg/L) | pH | TDS mg/L | EC µS/cm | Salinity (ppt) | F (mg/L) |
|---------------------|-----------------|----------|------|----------|----------|----------------|----------|
| Vadarungan | Borewell | 0.1564 | 7.5 | 252 | 520 | 2.5 | 0.9 |
| Paluran padugai | Borewell | 0.3863 | 6.95 | 321 | 658 | 3.2 | 0.5 |
| Madapuram | Borewell | 0.2485 | 6.83 | 389 | 794 | 3.9 | 0.6 |
| Alakkudi | Hand pump | 0.7265 | 7.19 | 628 | 1266 | 6.3 | 0.3 |
| Kattur | Hand pump | 1.2903 | 6.96 | 1274 | 2510 | 12.9 | 0.7 |
| Kodakkaramoolai | Borewell | 0.9676 | 7.24 | 678 | 1364 | 6.8 | 0.4 |
| Pazhayapalayam | Borewell | 0.8928 | 7.71 | 535 | 1084 | 5.4 | 0.4 |
| Panakkarakottam | Borewell | 2.6565 | 7.02 | 1641 | 3190 | 16.7 | 0.7 |
| Toduvaipattanacheri | Borewell | 0.4195 | 7.78 | 346 | 770 | 3.4 | 1 |
| Arapakkam | Borewell | 0.4590 | 7.14 | 526 | 1067 | 5.3 | 1 |
| Sattanatha puram | Borewell | 2.7306 | 7.72 | 1326 | 2600 | 13.4 | 0.5 |
| Neppathur | Hand pump | 5.2374 | 7.15 | 1666 | 3240 | 16.9 | 0.9 |
| Kilmugarakarai | Hand pump | 1.6473 | 7.52 | 798 | 1597 | 8.0 | 0.8 |
| Kadaikkadu | Hand pump | 2.0183 | 7.05 | 2110 | 4060 | 21.4 | 0.9 |
| Vanagiri | Borewell | 1.3530 | 7.11 | 2170 | 4170 | 22.1 | 0.6 |
| Melperumpallam | Hand pump | 0.4562 | 7.2 | 909 | 1810 | 9.2 | 0.9 |
| Kasingan | Borewell | 0.4184 | 7.17 | 401 | 819 | 4.0 | 0.8 |

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|-----------------|-----------|--------|------|-------|------|------|-----|
| Pappakkudi | Borewell | 0.5608 | 7.35 | 477 | 970 | 4.8 | 0.4 |
| Viralur | Borewell | 1.6052 | 6.97 | 1357 | 2660 | 13.7 | 0.7 |
| Erukkur | Hand pump | 0.4255 | 6.98 | 282 | 580 | 2.8 | 0.8 |
| Thiruvallangadu | Hand pump | 0.3178 | 6.91 | 362 | 741 | 3.6 | 0.4 |
| Kadalankudi | Hand pump | 0.3198 | 7.08 | 485 | 985 | 4.8 | 0.9 |
| Teralundur | Hand pump | 0.3434 | 7.29 | 295 | 607 | 2.9 | 0.8 |
| Kottangudi | Hand pump | 0.2036 | 7.43 | 137.5 | 287 | 1.4 | 1 |
| Valluvur | Hand pump | 0.8072 | 7.42 | 393 | 803 | 3.9 | 0.5 |

| Locations | Source of water | Cl (mg/L) | NO ₃ ⁻ (mg/L) | SO ₄ ²⁻ (mg/L) | PO ₄ ³⁻ (mg/L) | Ca (mg/L) | Mg (mg/L) |
|---------------------|-----------------|-----------|-------------------------------------|--------------------------------------|--------------------------------------|-----------|-----------|
| Vadarungan | Borewell | 55 | 82.93 | 47.63 | 0.75 | 40 | 160 |
| Paluran padugai | Borewell | 75 | 91.4 | 49.02 | 0.01 | 52 | 208 |
| Madapuram | Borewell | 95 | 66.41 | 111.83 | 0.01 | 52 | 178 |
| Alakkudi | Hand pump | 165 | 94.42 | 105.22 | 0.21 | 40 | 180 |
| Kattur | Hand pump | 710 | 206.62 | 114.64 | 2.29 | 68 | 452 |
| Kodakkaramoolai | Borewell | 235 | 215.41 | 130.41 | 3.83 | 48 | 222 |
| Pazhayapalayam | Borewell | 235 | 122.3 | ND | 2.26 | 52 | 238 |
| Panakkarakottam | Borewell | 725 | 204.75 | 164.39 | 3.09 | 96 | 454 |
| Toduvaipattanacheri | Borewell | 105 | 95.63 | 136.62 | 0.17 | 24 | 96 |
| Arapakkam | Borewell | 155 | 202.02 | 153.79 | 0.48 | 48 | 202 |
| Sattanatha puram | Borewell | 510 | 42.54 | 190.16 | 0.01 | 44 | 226 |
| Neppattur | Hand pump | 660 | 86.83 | 181.01 | ND | 76 | 444 |
| Kilmugarakarai | Hand pump | 245 | 184.83 | 146.9 | 4.59 | 32 | 218 |
| Kadaikkadu | Hand pump | 950 | 329.97 | 229.06 | 4.68 | 40 | 340 |
| Vanagiri | Borewell | 1230 | 481.22 | 186.11 | 0.2 | 124 | 626 |
| Melperumpallam | Hand pump | 310 | 198.41 | 49.76 | 0.44 | 44 | 216 |
| Kasingan. | Borewell | 80 | 79.09 | 4.08 | 0.03 | 52 | 208 |
| Pappakkudi | Borewell | 135 | 69.85 | 93.84 | ND | 76 | 164 |
| Viralur | Borewell | 412 | 110.09 | 227.9 | 0.05 | 114 | 476 |
| Erukkur | Hand pump | 70 | 71.05 | 68.04 | 0.13 | 36 | 154 |
| Thiruvallangadu | Hand pump | 100 | 78.25 | 73.57 | 0.2 | 56 | 174 |
| Kadalankudi | Hand pump | 150 | 61.97 | 71.42 | 0.45 | 340 | 64 |
| Teralundur | Hand pump | 60 | 153.34 | 26.15 | 0.02 | 48 | 152 |
| Kottangudi | Hand pump | 60 | 83.13 | 8.54 | ND | 20 | 110 |
| Valluvur | Hand pump | 70 | 32.8 | 4.77 | ND | 80 | 260 |

SIR-Sirkazhi, MDI- Mayiladururai, KDM- Kuththalam, WGD- Ground Water Drinking, WGN-Ground Water Not Drinking, ND-Not Detectable

Table.2. The concentration of Uranium, TDS, pH, Chloride, Fluoride, Ca and Mg Hardness and other parameter in the water sample from Nagapattinam District, Tamilnadu, India

| Location | Source of water | U (µg/L) | pH | TDS (mg/L) | EC (µS/cm) | Salinity (ppt) | F (mg/L) |
|-----------------|-----------------|----------|------|------------|------------|----------------|----------|
| Kottarakudi | Hand pump | 2.7249 | 7.12 | 934 | 1857 | 9.4 | 1 |
| Karaiyiruppu | Hand pump | 1.3473 | 7.34 | 452 | 920 | 4.5 | 0.9 |
| Idaiyatthankudi | Hand pump | 0.0427 | 7.43 | 294 | 604 | 2.9 | 0.9 |
| Neykunnam | Hand pump | 1.9838 | 7.08 | 724 | 1453 | 7.3 | 0.8 |
| Alangudicheri | Hand pump | 8.2776 | 7.27 | 920 | 1831 | 9.3 | 0.6 |
| Nagoor | Hand pump | 3.6136 | 7.18 | 2270 | 4360 | 23.1 | 0.7 |
| Budangudi | Hand pump | 1.9114 | 7.49 | 955 | 1897 | 9.6 | 0.6 |
| Sangamangalam | Hand pump | 5.4179 | 7.8 | 922 | 1835 | 9.3 | 0.8 |
| Nagapattinam | Hand pump | 0.224 | 7.94 | 1042 | 2064 | 10.5 | 0.9 |
| Orattur | Hand pump | 0.7348 | 7.24 | 461 | 939 | 4.6 | 0.5 |
| Mahili | Hand pump | 0.97465 | 7.58 | 166.2 | 346 | 1.6 | 0.5 |

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|--------------------|-----------|---------|------|-------|------|------|-----|
| Pudupalli | Hand pump | 6.5295 | 7.19 | 4360 | 8090 | 44.8 | 1 |
| Velankanni | Hand pump | 2.237 | 7.37 | 1155 | 2280 | 11.7 | 0.7 |
| Vadaku poyyur | Hand pump | 2.3643 | 7.11 | 1427 | 2790 | 14.5 | 0.5 |
| Irukkai | Hand pump | 3.3993 | 7.16 | 2700 | 5140 | 27.6 | 0.6 |
| Kovil kannappur | Hand pump | 3.6393 | 7.62 | 583 | 1178 | 5.8 | 0.5 |
| Prathaparama puram | Hand pump | 1.5036 | 7.52 | 819 | 1637 | 8.2 | 1 |
| Pulavanur | Hand pump | 0.1815 | 7.16 | 337 | 692 | 3.4 | 0.8 |
| Vettaikaraniruppu | Hand pump | 0.2279 | 7.63 | 393 | 803 | 3.9 | 0.8 |
| Karapidagai | Hand pump | 0.4188 | 7.49 | 455 | 926 | 4.5 | 0.4 |
| Thannilapadi | Hand pump | 0.5132 | 7.29 | 361 | 740 | 53.5 | 1 |
| Arasanakkudi | Hand pump | 0.1758 | 7.11 | 452 | 920 | 4.5 | 0.9 |
| Eralacheri | Hand pump | 0.2376 | 7.69 | 203.5 | 422 | 2.0 | 0.7 |
| Pichchakkattalai | Hand pump | 0.2376 | 7.06 | 645 | 1298 | 6.5 | 0.7 |
| Kutti andiyur | Hand pump | 0.3386 | 7.37 | 348 | 713 | 3.5 | 0.6 |
| Vadakarai | Hand pump | 0.3443 | 7.3 | 209 | 434 | 2.1 | 0.8 |
| Thillaiyadi | Hand pump | 0.4534 | 7.19 | 130.1 | 272 | 1.3 | 0.3 |
| Nalladai | Hand pump | 0.6767 | 7.09 | 468 | 952 | 4.7 | 0.9 |
| Kumaramangalam | Hand pump | 1.3125 | 7.18 | 615 | 1241 | 6.2 | 0.3 |
| Mukkarumbur | Hand pump | 1.4286 | 7.74 | 464 | 943 | 4.6 | 0.8 |
| Veppancheri | Hand pump | 1.8078 | 7.01 | 1458 | 2850 | 14.8 | 0.9 |
| Vadapillali | Hand pump | 0.57583 | 7.53 | 217 | 449 | 2.1 | 0.5 |

| Location | Source of water | Cl (mg/L) | NO ₃ ⁻ (mg/L) | SO ₄ ²⁻ (mg/L) | PO ₄ ³⁻ (mg/L) | Ca (mg/L) | Mg (mg/L) |
|--------------------|-----------------|-----------|-------------------------------------|--------------------------------------|--------------------------------------|-----------|-----------|
| Kottarakudi | Hand pump | 320 | 98.68 | 148.75 | 0.02 | 116 | 314 |
| Karaiyiruppu | Hand pump | 110 | 55.17 | 74.24 | ND | 48 | 222 |
| Idaiyatthankudi | Hand pump | 80 | 93.51 | 33.24 | 0.73 | 24 | 96 |
| Neykunnam | Hand pump | 250 | 62.59 | 116.09 | 0.08 | 64 | 266 |
| Alangudicheri | Hand pump | 300 | 171.77 | 176.45 | 0.15 | 100 | 500 |
| Nagoor | Hand pump | 490 | 122.46 | 135.1 | 2.38 | 108 | 462 |
| Budangudi | Hand pump | 260 | 85.22 | 245.39 | 0.13 | 100 | 330 |
| Sangamangalam | Hand pump | 120 | 62.62 | 122.69 | 0.08 | 72 | 308 |
| Nagappatinam | Hand pump | 510 | 45.83 | 59 | 0.01 | 44 | 166 |
| Orattur | Hand pump | 120 | 119.7 | 25.83 | 0.48 | 92 | 298 |
| Mahili | Hand pump | 80 | 266.06 | ND | 1.67 | 32 | 68 |
| Pudupalli | Hand pump | 2369 | 181.98 | 227.56 | 0.41 | 400 | 1340 |
| Velankanni | Hand pump | 175 | 67.2 | 205.24 | 1.07 | 100 | 390 |
| Vadaku poyyur | Hand pump | 530 | 105.41 | 203.57 | 0.43 | 156 | 604 |
| Irukkai | Hand pump | 1200 | 90.52 | 210.78 | 0.18 | 116 | 794 |
| Kovil kannappur | Hand pump | 200 | 46.88 | 53.14 | ND | 24 | 136 |
| Prathaparama puram | Hand pump | 125 | 72.49 | 93.76 | 0.37 | 112 | 278 |
| Pulavanur | Hand pump | 130 | 90.67 | 27.2 | 0.02 | 52 | 238 |
| Vettaikaraniruppu | Hand pump | 130 | 48.56 | 75.23 | 0.27 | 80 | 220 |
| Karapidagai | Hand pump | 170 | 93.78 | 52.13 | 1.93 | 40 | 170 |
| Thannilapadi | Hand pump | 100 | 51.86 | 45.58 | ND | 40 | 170 |
| Arasanakkudi | Hand pump | 105 | 49.4 | 89.51 | 2.24 | 32 | 128 |
| Eralacheri | Hand pump | 50 | 42.13 | 3.2 | ND | 40 | 160 |
| Pichchakkattalai | Hand pump | 240 | 106.13 | 153.83 | 0.01 | 56 | 314 |
| Kutti andiyur | Hand pump | 120 | 61.37 | 56.52 | 1.46 | 32 | 158 |
| Vadakarai | Hand pump | 50 | 71.89 | 5.61 | 0.08 | 28 | 142 |
| Thillaiyadi | Hand pump | 40 | 126.52 | 12.69 | 2.99 | 12 | 58 |

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|----------------|-----------|-----|--------|-------|------|----|-----|
| Nalladai | Hand pump | 130 | 75.02 | 68.05 | 1.12 | 72 | 228 |
| Kumaramangalam | Hand pump | 140 | 52.75 | 42.45 | ND | 52 | 278 |
| Mukkarumbur | Hand pump | 100 | 39.82 | 43.78 | 0.03 | 28 | 168 |
| Veppancheri | Hand pump | 680 | 182.71 | 146.2 | 4.35 | 96 | 394 |
| Vadapillali | Hand pump | 50 | 53.3 | 20.59 | ND | 36 | 164 |

NAG-Nagapattinam, KVR- Kizhvelur, TPI- Tarangampadi, WGD- Ground Water Drinking, ND-Not Detectable

Table.3. The concentration of Uranium, TDS, pH, Chloride, Fluoride, Ca and Mg Hardness and other parameter in the water sample from Vedaranyam tehsil of Nagapattinam District, Tamilnadu, India.

| Locations | Source of water | U (µg/L) | pH | TDS (mg/L) | EC (µS/cm) | Salinity (ppt) | F (mg/L) |
|----------------------|-----------------|----------|------|------------|------------|----------------|----------|
| Venmanahcheri end | Hand pump | 0.17382 | 7.45 | 296 | 610 | 2.9 | 0.9 |
| Madapuram | Hand pump | 0.3815 | 7.11 | 328 | 673 | 3.3 | 0.8 |
| Natthapallam | Hand pump | 1.7283 | 7.21 | 1056 | 2091 | 10.7 | 0.8 |
| Kachchanagaram | Hand pump | 4.9626 | 7.32 | 2178 | 4190 | 22.2 | 0.1 |
| Mudhaliappan kandiur | Surface water | 13.4792 | 7.49 | 8060 | 14430 | 83.6 | 1 |
| Thalainayar i setti | Hand pump | 12.0334 | 7.31 | 1502 | 2940 | 15.2 | 0.9 |
| Vattakudi | Hand pump | 8.8048 | 7.59 | 1884 | 3640 | 19.1 | 0.6 |
| Avarikadu | Hand pump | 0.9986 | 7.52 | 387 | 792 | 3.9 | 0.7 |
| Naaluvadappatti | Hand pump | 0.6985 | 7.61 | 441 | 898 | 4.4 | 0.9 |
| Pushpavanam | Hand pump | 0.2852 | 7.64 | 515 | 1045 | 5.2 | 0.6 |
| Topputhurai | Hand pump | 2.2171 | 7.43 | 756 | 1514 | 7.6 | 0.5 |
| Vedharanyam | Hand pump | 0.4425 | 7.5 | 871 | 1737 | 8.8 | 0.7 |
| Andarkkadu | Hand pump | 0.0442 | 7.8 | 468 | 952 | 4.7 | 1 |
| Koyil thavur | Hand pump | 0.9706 | 8.12 | 1440 | 2820 | 14.6 | 0.2 |
| Kattripulam | Hand pump | 1.9938 | 8.24 | 1333 | 2620 | 13.5 | 2 |
| Panayadi kuthahai | Hand pump | 2.6365 | 7.25 | 2.3 | 4410 | 23.4 | 0.3 |
| Senbagrayanallur | Hand pump | 1.0844 | 7.35 | 628 | 1266 | 6.3 | 0.4 |
| Ayakkarambalam | Hand pump | 0.6725 | 7.73 | 470 | 955 | 4.7 | 2 |
| Tagattur | Hand pump | 0.7645 | 7.25 | 1125 | 2220 | 11.4 | 0.1 |
| Thennadar | Openwell | 2.5461 | 8.15 | 29.8 | 4720 | 25.2 | 0.7 |
| Annapettai | Hand pump | 1.1621 | 7.35 | 870 | 1734 | 8.7 | 0.4 |

| Locations | Source of water | Cl (mg/L) | NO ₃ ⁻ (mg/L) | SO ₄ ²⁻ (mg/L) | PO ₄ ³⁻ (mg/L) | Ca (mg/L) | Mg (mg/L) |
|----------------------|-----------------|-----------|-------------------------------------|--------------------------------------|--------------------------------------|-----------|-----------|
| Venmanahcheri end | Hand pump | 100 | 61.39 | 33.91 | ND | 28 | 122 |
| Madapuram | Hand pump | 120 | 93.67 | 8.89 | 0.2 | 44 | 186 |
| Natthapallam | Hand pump | 380 | 101.45 | 134.73 | 2.27 | 88 | 332 |
| Kachchanagaram | Hand pump | 345 | 125.48 | 200.39 | 1.77 | 128 | 612 |
| Mudhaliappan kandiur | Surface water | 5298 | 327.8 | 273.36 | 0.28 | 325 | 2605 |
| Thalainayar i setti | Hand pump | 610 | 89.9 | 227.08 | 0.48 | 168 | 542 |
| Vattakudi | Hand pump | 730 | 38.52 | 143.42 | ND | 32 | 238 |
| Avarikadu | Hand pump | 150 | 226.13 | 33.95 | 2.49 | 44 | 146 |
| Naaluvadappatti | Hand pump | 80 | 41.84 | 10.29 | 0.34 | 80 | 260 |
| Pushpavanam | Hand pump | 90 | 94.14 | 1.21 | 0.19 | 68 | 252 |
| Topputhurai | Hand pump | 145 | 103.35 | 94.01 | 0.18 | 100 | 370 |
| Vedharanyam | Hand pump | 350 | 200.29 | 34.24 | 2.5 | 92 | 328 |
| Andarkkadu | Hand pump | 170 | 101.01 | 48.66 | 0.63 | 56 | 214 |
| Koyil thavur | Hand pump | 640 | 160.89 | 151.95 | 2.25 | 92 | 428 |
| Kattripulam | Hand pump | 2069 | 240.48 | 289.57 | 0.3 | 40 | 920 |
| Panayadi kuthahai | Hand pump | 495 | 194.9 | 265.72 | ND | 192.5 | 577.5 |
| Senbagrayanallur | Hand pump | 160 | 85.32 | 109.78 | 0.24 | 100 | 290 |
| Ayakkarambalam | Hand pump | 110 | 93.8 | 76.57 | ND | 56 | 264 |

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|------------|-----------|-----|--------|--------|------|-----|-----|
| Tagattur | Hand pump | 410 | 86.22 | 188.66 | 0.4 | 140 | 340 |
| Thennadar | Openwell | 600 | 288.25 | 243.81 | 3.69 | 76 | 544 |
| Annapettai | Hand pump | 370 | 129.35 | 172.27 | 0.03 | 132 | 398 |

TKI- Thirukkuvalai, VDM- Vedaranyam, WGD- Ground Water Drinking, WGN-Ground Water Not Drinking, ND-Not Detectable.

Table.4. The overall consolidated data for Uranium and other associated parameters

| Parameters | Pre Monsoon | | | | BIS / WHO Limits |
|-------------------------------------|-------------|-------|------|--------------------|------------------|
| | Min | Max | Mean | Standard Deviation | |
| Gamma Radiation (nSv/hr) | 43 | 566 | 82.7 | 69.6 | - |
| pH | 6.9 | 8.2 | 7.42 | 0.28 | 6.5 – 8.5 |
| TDS (ppm) | 23 | 8060 | 987 | 1204 | 500 |
| EC (μ S/cm) | 27 | 14430 | 2057 | 2196 | - |
| ORP (mV) | -138 | 246 | 35 | 80 | - |
| Temp ($^{\circ}$ C) | 28.5 | 34.4 | 30.5 | 1.1 | - |
| DO (ppm) | 2.0 | 7.2 | 4.1 | 1.1 | - |
| F ⁻ (ppm) | 0.1 | 2 | 0.68 | 0.35 | 1 |
| Cl ⁻ (ppm) | 40 | 13436 | 633 | 1847 | 250 |
| NO ₃ ⁻ (ppm) | 33 | 328 | 112 | 66.3 | 45 |
| SO ₄ ²⁻ (ppm) | BDL | 336 | 110 | 87.7 | 200 |
| PO ₄ ³⁻ (ppm) | BDL | 4.3 | 0.74 | 1.06 | - |
| U (ppb) | <0.2 | 13.5 | 2.09 | 2.82 | 60 (AERB) |
| Total Hardness (ppm) | 70 | 4430 | 510 | 666 | 200 |
| Ca Hardness (ppm) | 12 | 400 | 91.2 | 83.7 | - |
| Mg Hardness (ppm) | 58 | 2605 | 361 | 370 | - |
| Total Alkalinity (ppm) | 90 | 940 | 343 | 165 | 200 |

4. CONCLUSIONS

The present study has been identified the concentration of Uranium and associated water quality parameters such as pH, TDS, Turbidity, Electrical Conductivity, Fluoride, Chloride, Mg, Ca and Total hardness, Sulphate, Phosphate, Nitrate and Alkalinity in drinking water of Nagapattinam District, Tamil Nadu. The obtained values are varied with the different locations of samples.

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