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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, Suplhate, Phosphate, Nitrate and Alkalinity were studies 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 10º25' and 11º40' and eastern longitude 76º49' and 80º01'. 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 uaranium is analyzed by fluorescence techniqueIn 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× (fluorescence from sample- 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 Mhore's methods by adding sivernitrate to give siverchloride precipitate. The alkalinity is determined by titration with HCl and indictor 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 (I_0). The ratio I/I_0 is called transmittance. Generally UV-Visible spectrometer obeys the Beer-Lambart law. It also events reflectance when light reflected from sample (I) and compared from reference material (I_0).

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 kandiyur. Maximum concentration of uranium is found in the village Mudaliyappan kandiyur. 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 kandiyur 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 kandiyur. 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 kandiyur 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 Kaththiripulam 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 Katthiripulam. 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 kandiyur, whereas the Fluoride Concentration lies in between 0.1 in Kachchanagaram and 2.0 in Kaththiripulam. Ayakkarambalam I setti and Katthiripulam have higher value of fluoride.

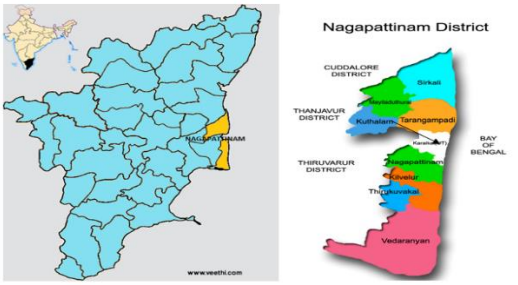

Figure.1. Location map for Nagapattinam District

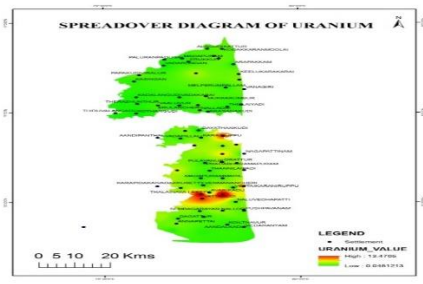

Figure.2. Uranium distribution in Nagapatinam District

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
Neppatthur	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

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
Thiruvalangadu	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
Neppatthur	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
Thiruvalangadu	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- Mayiladudurai, 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
Nagappatinam	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

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
Vadakku 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
Vadakku 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

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 kandiyur	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
Naaluvedappatti	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 kandiyur	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
Naaluvedappatti	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

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 (µS/cm)	27	14430	2057	2196	-
ORP (mV)	-138	246	35	80	-
Temp (˚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, Suplhate, 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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REFERENCES

Abdulkader M, Rushdi Sadaqah, Mustafa Al Kausi, Uranium and potential toxic metal during the mining, benefication and processing of phosphorite and their effects on ground water in jordan, journal of mine water and environment, 27, 2008, 171-182.

Arul P, Asian Tsunami, Ecological implications and rehabilitation process along Nagapattinam coast using remote sensing and GPS data, Unpublished PhD Thesis, Bharathidasan University, chapter 3, 2010, 59-78.

Barker FB, Johnson JO, Edwards KW, Robinson BP, Determination of Uranium in natural water, Geological survey water supply paper, 1965, 2-24.

Beniamino Barbieri, A short history of Fluorescence The discovery and understanding of the phenomenon, The Fluorescence Foundation, 2010.

BIS, The Bureau of Indian Standards, Water quality standards, Indian standards for drinking water specification, 1992.

Brown PL, Guerin M, Hankin SI, Lowson RT, Uranium and other contaminant migration at a tropical Australian uranium mine, Journal of Contaminant Hydrology, 35(1–3), 1998, 295–303.

Chandrasekharan H, Sarangi A, Natarajan M, Chandra Sekharan B, Anbhazhagan S, Variability of soil water quality duo to Tsunami- 2004 in coastal belt of Nagapattinam District, Tamilnadu, Journal of Environmental management, Volume 89, 2008, 63-72.

Cothern CR, Lappenbusch WL, Occurance of uranium in drinking water in the US, Health Physics, 45 (1), 1983, 89-99.

Fernando P, Carvalho, Joao M, Oliveira, Isabel Faria, Alpha Emitting Radionuclides in Drainage from Quinta do Bispoand Cunha Baixa Uranium Mines (Portugal) and Associated Radio toxicological Risk, Bulletin of environmental contamination and toxicology, 83, 2009, 668-673.

Francis AJ, Dodge CJ, Remediation of soils and wastes contaminated with uranium and toxic metals, Environmental Science and Technology, 32(24), 1998, 3993–3998.

Hakonson-Hayes AC, Fresquez PR, Whicker FW, Assessing potential risks exposure to natural uranium in well water, Journal of Environmental Radioactivity, 59, 2002, 29–40.

International Commission on Radiological Protection (ICRP) 103, the Recommendations of International Commission on Radiological Protection, Ann ICRP, 37 (2-4), 2007.

International Commission on Radiological Protection (ICRP)-30, Limits for intake of radionuclides by workers, Oxford, UK, Pergamon, 1979.

Joga Singh, Harmanjith Singh, Surinder Singh, Bajwa BS, Estimation of uranium and radon concentration in some drinking water samples of Upper Siwaliks, India, Environmental monitoring and assessment, 154, 2009, 15-22.

Joseph R Lakowicz, Principle of fluorescence spectroscopy (3rd edi), Analytical and Bioanalytical chemistry, 390, 2008, 1223-1224.

Kenya Moore Dias da Cunha, Helenes Henderson, Bruce, M Thomson, Adam A Hecht, Ground water contamination with 238U, 234U, 235U, 226Ra and 210Pb from past uranium mining, cove wash, Arizona, Environmental geochemistry and health, 36, 2014, 477-487.

Kumaraperumal R, Natarajan S, Sivasamy R, Chellamuthu S, Ganesh SS, Ananda Kumar G, Impact of Tsunami 2004 in coastal villages of Nagapattinam District, India, Science of Tsunami hazards, 93, 2007.

Kwang Woo Jung, Jeong Moog Kim, Cheol Jung Kim and Jong Min Lee, Trace analysis of uranium in Aqueous samples by Laser induced fluorescence spectroscopy, Journal of Korean Nuclear society, 19(4), 1987, 242-248.

Madbouly M, Nassef MH, Diab AM, El-Mongy SA, A comparative anlysis of uranium ore using Laser fluorimetric and Gamma spectrometry techniques, Journal of Nuclear and Radiation physics, 4, 2009, 75-81.

Mukesh Kumar, Surinder Singh, Rakesh Kumar Mahajan, Trace level determination of Zn, Cd, Pb, Cu in drinking water samples, Environmental monitoring and assessment, 112, 2006, 283-292.

Nada Rapantova, Monika Licbinska, Ondrej Babka, Arnost Gronela, Pavel Pospisil, Impact of uranium mines closure and abandonment on ground water quality, Environmental pollution research, 20(11), 2002, 7590-7602.

Nozaki T, Neutron activation analysis of uranium in human bone, drinking water and daily diet, Journal of Radioanalytical Chemistry, 6, 1970, 33–40.

Patnaik R, Lahir S, Chahar V, Study of uranium mobilisation from Himalayan siwaliks to the Malwa region of Punjab state in India, Journal of Radio analytical and nuclear chemistry, 308, 2015, 913-918.

Rude RK, Magnesium deficiency, A cause of heterogenous disease in humans, Journal of Bone and Mineral research, 13, 1998, 749-758.

Sahoo SK, Mohapatra S, Chakrabarty A, Sumesh CG, Jha VN, Tripathi RM, Purani VD, Determination of uranium at ultra-level in package drinking water by laser fluorimeter and consequent ingestion dose, Radio prodection, 2016, 55-66.

Saris NEL, Mervaala E, Karuppanen H, Khawaja JA, Lewenstam A, Magnesium an update on physiological, clinical and analytical aspects, Clinica Chimica Acta, 294, 2000, 1-26.

Sidle WC, Lee PY, Uranium contamination in the Great Miami aquifer at the Fernald environmental management project, Ground water, 34(5), 1996, 876.

Singh NP, Singh S, Virk HS, Uranium and radon concentrations in Ganges waters in UP Himalayas-some preliminary results, Indian Journal of Pure and Applied Physics, 25, 1987, 87–89.

Singh Pl, Analysis of uranium and its correlation with some physico-chemical properties of drinking water samples from Amritsar, Punjab, Journal of Environmental Monitoring and assessment, 5, 2003, 917–921.

Skoog, Dougles A, Holler F James, Crowth, Stanley R, Principle of Instrumental analysis,6th edition, 2007, 169-173.

Talukdar BC, Chaudhary PK, Pathak KM, On uranium concentration in water, Journal of Pure and Applied physics, 21, 1983, 381-182.

Taras MJ, Greenberg AE, Hook RD, Rand MC, Standard methods for the examination of water and waste water, American Public Health Association, Washington DC, 13, 2003, 178.

Tosheva Z, Stoyanova K, Nikolchev, Comparison of different methods for uranium determination in water, Journal of Environmental Radioactivity, 72, 2004, 47-55.

United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR), Sources, Effects and Risks of Ionizing Radiation, United Nations, New York, 2000.

United States Environmental Protection Agency (USEPA), Current drinking water standards, Ground water and drinking water protection agency, Report prepared by Wade Miller Associates, 2003, 1–12.

Weir, Erica, Uranium in drinking water naturally, Canadian medical association journal, 170, 2004, 950-952.

World Health Organisation (WHO), Guidelines for drinking water quality, 2nd edition, Geneva, Switzerland, WHO, 1997.

World Health Organisation (WHO), Guidelines for drinking water quality, 3rd edition, Geneva, Switzerland, WHO, 2004.

World Health Organisation (WHO), Uranium in drinking water-background document for development of WHO Geneva, Switzerland, WHO, Guidelines for drinking water quality, 2012.