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Spatial Distribution of Uranium and its associated Water Quality Parameters in Thane District, Maharashtra

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Abstract: **Systematic district-wise grid sampling plan was followed in the present study and samples were selected on the basis of population density. The estimation of uranium was done by using LED fluorimeter. Along with uranium, its associated physico-chemical parameters such as pH, Electrical Conductivity, Temperature, Total Alkalinity, Total Hardness, Magnesium hardness, Calcium hardness, Total Dissolved Solids, Chloride, Fluoride, Sulphate, Phosphate, Nitrate, Salinity, and Oxidation Reduction Potential (ORP) were also processed and analyzed using the BARC Standard Protocol. Statistical tools were applied to analyze the data and its spatial distribution. The more focused was on Uranium which is widespread in nature and has been identified in many different minerals and exists in several chemical oxidation states as well as a mixture of 3 radioisotopes. However, the major health effects apropos to uranium are due to its chemical toxicity. This guideline technical document reviews and assesses all identified health risks associated with Uranium and other physic-chemical parameters in groundwater/ drinking water. It incorporates new studies and approaches and takes into consideration the availability of appropriate treatment technology. Finally the variations were crosschecked with respect to recommendations given by BIS/WHO limits. Uranium varies from 0.2 - 8.1 ppb, in pre monsoon and & 0.2 - 6.7 ppb in post monsoon which was well below the recommended permissible limits suggested by various organizations (WHO/AERB).**

Key words: **Drinking Water, Ground Water, LED Fluorimeter, Thane district, Uranium,**

1. INTRODUCTION

WHO reports that approximately 36% of urban and 65% of rural Indian were without access to safe for drinking water. Fresh water is one of the most important resources crucial for the survival of all the living beings as it depends upon for food production, Industrial and Waste Disposal **[1].** Distribution of groundwater and its study is called Hydrogeology. As groundwater is cheaper, it is more convenient and less vulnerable to pollution and therefore commonly used and it also depends on ambient water quality in human life. Due to weathering of rocks the quality of water and its physical and chemical parameters fluctuate. Groundwater is naturally replenish from precipitation, streams which reaches the water table. Generally water contains Iron, Sodium, Potassium, Calcium, Magnesium, Manganese, Uranium, Silica, Carbonates and Bicarbonates, etc. which are responsible for salinity of water. When that quantity of these elements enhance then they affect the body systems and cause destruction of health. Uranium is a naturally occurring radioactive element present in nature. Uranium is released from mill tailings, coal combustion, from natural deposits and mostly from the use of uranium-containing phosphate fertilizer. It can be harmful both chemically and radiologically. Human activities are also included in the release of uranium which includes mill tailings, emissions from nuclear activity and the combustion from the coal and the other fuels. Natural uranium is a mixture of three isotopes which includes ^{238}U, ^{235}U and ^{234}U. The nucleotide decay is due to the alpha particle emission. They result in very low specific activity for natural uranium because they possess very long half-lives. Due to this property uranium is considered. The chemical effect associated with uranium and its compounds leads to kidney toxicity. Exposure of uranium can take place by either breathing the air containing uranium dust particles or by drinking or eating substances containing uranium compounds. This compound enters into the bloodstream, once in the bloodstream it gets filtered by kidney thus damaging the kidney cell. This can cause acute kidney damage or death. Some important uranium isotopes found include pitchblende, uraninite, carnotite, autunite and torbernite. The half-life of these uranium isotopes U-234(abundance=0.0055%), U-234(abundance=0.72%), U 238(abundance=99.27%) [3]. The study was done to know the concentration level of uranium and its associated water quality parameters such as pH, TDS, EC, salinity, ORP, Temp., DO, Fluoride, Chloride, Nitrate, Phosphate, Total Hardness, Calcium Hardness, Magnesium hardness, Total Alkalinity, Carbonate and Bicarbonate in drinking / groundwater sample which is been consumed by the residents from the study area.

2. MATERIALS AND METHODS

The basic criteria for selection the sampling site are that each sampling site location should represent the area of the study. The present study is focused on estimation of uranium in drinking water followed by the physico-chemical parameters. The following points should be considered while selecting the sampling locations:

- Location of the area should be representative off the region of interest
- Site should be potentially impacted but different types of sources
- Easy to accessible

The present study was carried out by as per the BARC standard protocol prepared for the National Uranium Project. The areas of Thane is around 9558 sq.km so by grid mapping, the areas are been divided into grits of 6km x 6km distance and the village which falls in the mid area is selected using latitude and longitude as reference coordinators for screening. It consists of 3.11% of the total Maharashtra area. The district has 13 talukas which include Badlapur, Kalyan, Vasai, Bhiwandi, Shahapur, Mokhada, Jwahar, Wada, Palghar, Dahanu, Talasari, Ojhar, and Murbad out of which Shahapur taluka is the largest area of 1555 Sq. kms and Talasari taluka is the smallest area of 268 Sq. km. The soil of Thane district is black soil containing sand followed by red soil in the eastern region mostly of slopes and brownish-black soil in patches of the valleys mostly lying between the coastal plains and the hilly slopes of Sahyadri. The black of soil is found in Dahanu, Palghar, Vasai which is fertile and used for horticulture, paddy cultivation, whereas the red soil is found in Mokhada, Talasari and the brownish-black is found in Bhiwandi, Kalyan and Shahapur taluka. From the present district area 137 samples were collected from both pre-monsoon and post-monsoon season. Along with uranium, its associated physico-chemical parameters such as pH, Electrical Conductivity, Temperature, Total Alkalinity, Total Hardness, Magnesium hardness, Calcium hardness, Total Dissolved Solids, Chloride, Fluoride, Sulphate, Phosphate, Nitrate, Salinity, and Oxidation Reduction Potential (ORP) were also processed and analysed by using BARC Standard Protocol. Statistical tools were applied to analyze the data and its spatial distribution.

3. RESULTS AND DISCUSSION

In the present study, 137 drinking water samples were collected and analyzed for various physico-chemical parameters that are given below in Table 1 for pre-monsoon and post-monsoon respectively. Gamma radiation level found was between 42 nSv/h to 180nSv/h, the maximum level was found to be 120 nSv/h & the average was found to be 69.4 nSv/h. There is no standard range prescribed for gamma radiations. Radiation is a fact of life & the cosmic radiation contributes to about 31 nSv/h in mean sea level. pH value of water varies from 6.2 to 8.5. The primary and most common reason for the fluctuation of pH is the soil composition and bedrock where the water is located. The pH of water here can also be influenced by the rock type; the acidity of water can still be neutralized. Another reason for the fluctuation of pH can be the organic material and plant growth near the water which may also affect its acidity. The minimum TDS value of the sample was found to be 110 ppm and maximum was found to be 1582 ppm. According to BIS/WHO standards, the TDS was found to be exceeding the permissible limits i.e. 500 ppm. The reason for increase in TDS may be due to the large number of dissolved solids that are found in natural waters, the common ones are carbonates, bicarbonates, chlorides, sulphates, phosphates, and nitrates of Ca, Mg, K, and Mn. organic matter and other particles and the reason for the high concentration of Hardness which includes Calcium and Magnesium in the rocks that the rain percolates through on its way to the river or reservoir and eventually the water treatment plant. The electrical conductivity of water of Thane district ranges from 325-1246 µS/cm in premonsoon & from 123-1911 µS/cm in post monsoon. Summary of the results is presented in Table 1 for pre-monsoon and post-monsoon, respectively and for all the other parameters i.e., Salinity, ORP, Temperature, Dissolved Oxygen, Fluoride, Chloride, Nitrate, Sulphate, Phosphate, Uranium, Total Hardness and Total Alkalinity. In the 137 water samples collected from Thane District, the Chloride and Total Hardness Level was found to be higher than the prescribed limit 250 and 200mg/l whereas other water quality parameters were found to be within the permissible limit. Uranium level detected for all areas was found to be within the permissible limit. The average value was found to be 2 ppb. The limits given by WHO is 60 ppb (AREB), hence found to be within the limits. Uranium is a naturally-occurring element commonly which is commonly found in soil and rocks. Though the concentration of uranium in water is typically very small, it still changes from region to region; depending on the type of minerals in the soil and bedrock. Uranium collects into drinking water sources when groundwater dissolves minerals that contain uranium. Studies of humans exposed to abnormally high levels of uranium and laboratory animal studies show that uranium can be chemically toxic to the kidneys. Most uranium from drinking water is eliminated from the body. However, a small amount is absorbed and carried through the bloodstream. Once in the bloodstream, the uranium compounds are filtered by the kidneys, where they can cause damage to the kidney cells. The potential health effects from uranium in drinking water come from its heavy metal characteristics and not its radioactivity, which is very low. There have been few studies addressing long-term low level exposure of the kind likely to be associated with exposure to uranium in drinking water in the UK and all over the world. There is no evidence to suggest that exposure to low levels of naturally occurring uranium is associated with cancer. Uranium is radioactive, but exposure to radioactivity from the uranium in your drinking-water is insignificant compared with your everyday overall exposure to radioactivity from natural sources in the environment. However these studies suggest that there may be minor damage to kidney tissue which does not affect kidney function, at those higher levels).In the short term, levels that moderately exceed the guideline are unlikely to have an effect on health\ and hence certain ways are there:

- switch to an alternate source of water;
- treat the water in your well to reduce uranium levels; or
- if no other options are available, use bottled water for drinking and food preparation

4. CONCLUSION

pH, EC, TDS and Salinity in the water samples were found to vary in the range of 6.2-8.5, 123-1911 µS/cm, 110-1582 ppm and 62-956 ppm respectively. Fluoride, Chloride, Nitrate and Sulphate levels were found to be within the permissible limit. Uranium levels were found to vary from 0.14-6.3 ppb in pre-monsoon and post-monsoon respectively. Hence the water samples analyzed in the present study were found suitable as potable water but it is recommended that the water requires proper treatment Drinking water treatment devices can be used to remove specific contaminants, such as uranium, from drinking water. There are drinking water treatment devices available to reduce the levels of uranium in drinking water to levels below the guideline level of 0.02 mg/L. A water treatment professional should be consulted for advice on particular situation so that they will provided with an accurate cost of the available systems, as well as installation and maintenance costs, based on specific water quality. If the levels of Uranium exceed its permissible limits, than techniques like Reverse osmosis which is a process that filters most impurities from water by passing it through a very fine membrane. Contaminants such as uranium are left behind on the membrane while treated water passes through. You may need to install a pre-filter before the reverse osmosis system and also distillation system works by boiling water into water vapour, then returning it to its liquid state. The minerals and contaminants such as uranium form scales and are trapped in the boiling chamber. The condensed water is collected in a storage container for consumption followed by Anion exchange is a form of ion exchange similar to that used for water softening. The principle of ion exchange is the removal of undesirable ions, by exchanging them for other ions as the water passes through a bed of a specialized resin. Ion exchange resins are specific to the types of ions you wish to remove. The type of resin used for removing uranium is an anion based resin, which is different than the resin used in water softeners.

GUIDELINES

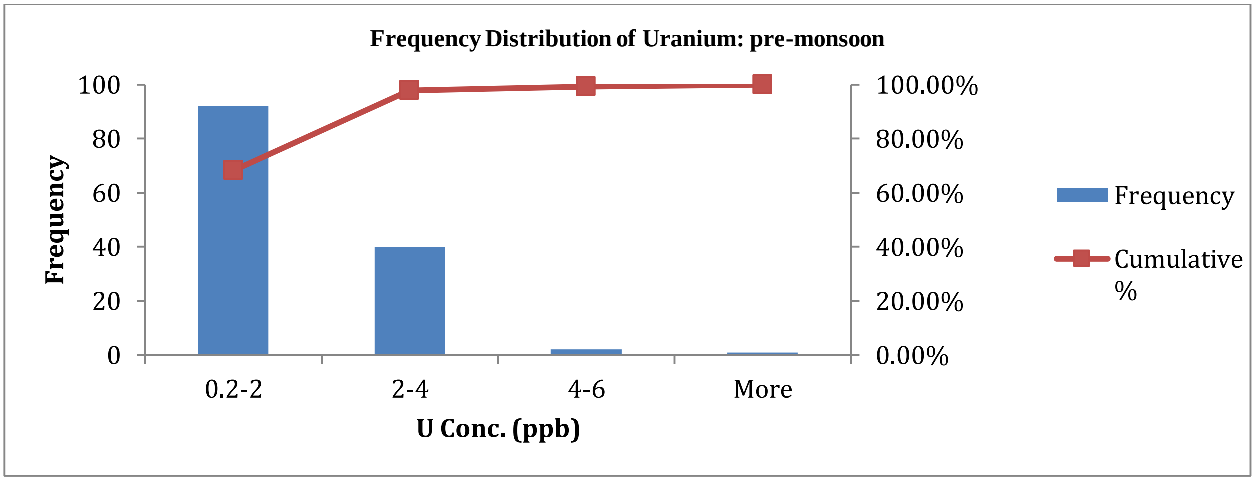
There are insufficient data regarding the carcinogenicity of uranium in humans and experimental animals. The guideline value for the chemical toxicity of uranium was therefore derived using a TDI approach. As no adequate chronic study was identified, the TDI was derived using the results of the most extensive sub chronic study conducted to date in which uranium was administered in drinking-water to the most sensitive sex and species (Gilman et al., 1998a). In the 91-day study in rats, the LOAEL for degenerative lesions in the proximal convoluted tubule of the kidney in males was considered to be 0.96 mg of uranyl nitrate hexahydrate per litre, which is equivalent to 0.06 mg of uranium per kg of body weight per day. A TDI of 0.6 µg/kg of body weight per day was derived using the LOAEL of 60 µg/kg of body weight per day and an uncertainty factor of 100 (for intra- and interspecies variation). There is no need to apply an additional uncertainty factor to account for the use of a LOAEL instead of a NOAEL because of the minimal degree of severity of the lesions being reported.

Also, an additional uncertainty factor for the length of the study (91 days) is not required because the estimated half-life of uranium in the kidney is 15 days, and there is no indication that the severity of the renal lesions will be exacerbated following continued exposure. This TDI yields a guideline value of 15 µg/litre (rounded figure), assuming a 60-kg adult consuming 2 litres of drinking-water per day and an 80% allocation of the TDI to drinking water. The allocation of 80% of the TDI to drinking-water is supported by data on the low intake of uranium from food. The guideline value is supported by data from epidemiological studies. Several methods are available for the removal of uranium from drinking-water, although some of these methods have been tested at laboratory or pilot scale only.

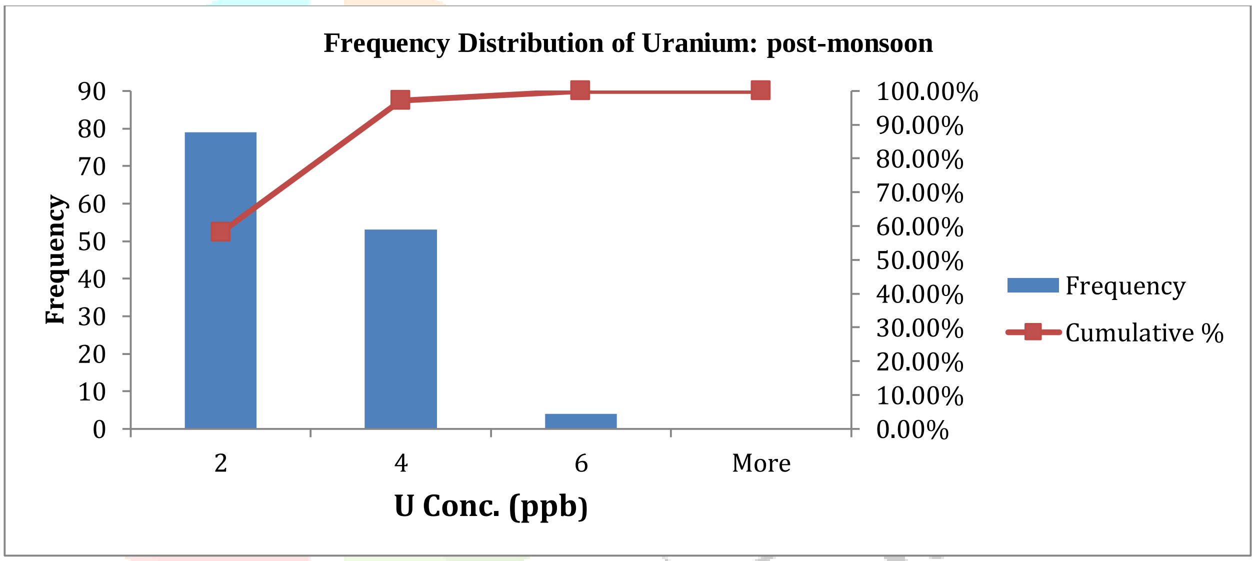
Coagulation using ferric sulfate or aluminium sulphate at optimal pH and coagulant dosages can achieve 80–95% removal of uranium, whereas at least 99% removal can be achieved using lime softening, anion exchange resin or reverse osmosis processes. In rural areas with high natural uranium levels, uranium concentrations lower than the guideline value may be difficult to achieve with the treatment technology available (WRc, 1997). The guideline value for uranium is therefore provisional because it may be difficult to achieve with the treatment technology available and because of limitations in the database on health effects and the need for more analytical epidemiological studies. It must be noted that the concentration of uranium in drinking-water associated with the onset of measurable tubular dysfunction remains uncertain, as does the clinical significance of the observed changes at low exposure levels. Indeed, a guideline value of up to 30 µg/litre may be protective of kidney toxicity because of uncertainty regarding the clinical significance of changes observed in epidemiological studies. **[3, 4]**

Table 1. Summary of Uranium and water quality parameters in Thane District, Maharashtra (Pre-monsoon and Post-Monsoon)

Parameters	**Pre-monsoon**				**Post-monsoon**				**BIS/ WHO limits**
	Min	**Max**	**Average**	**Median**	**Min**	**Max**	**Average**	**Median**	
pH	6.9	8.2	7.7	7.8	6.2	8.5	7.4	7.5	**6.5-8.5**
TDS (ppm)	213	741	424	420	110	1582	514	495	**500**
EC (µS/cm)	325	1246	640	624	123	1911	661	621	**-**
Salinity (ppm)	106	370	212	210	62	956	331	311	**-**
ORP (mV)	128	900	338	320	93	740	271	215	**-**
Temp. (^{o}C)	21	29	24.6	24.5	22	27	25	25.2	**-**
DO (ppm)	5	6.8	5.7	5.7	3	6.9	5.5	5.6	**-**
F^- (ppm)	0.3	1.6	0.74	0.7	0.72	0.99	0.56	0.58	**1**
Cl^- (ppm)	25	200	107	105	31	478	165	155	**250**
NO_3^- (ppm)	0.3	2.9	0.8	0.8	0.1	5.4	0.7	0.6	**45**
SO_4^{2-} (ppm)	0.5	54	8.8	6.8	0.5	57	13.4	9	**200**
PO_4^{3-} (ppm)	0.11	6	0.6	0.6	0.05	2	0.74	0.6	**-**
U (ppb)	0.14	6.3	1.4	1.2	0.21	3.4	2	1.8	**60(AERB)**
Total Hardness (ppm)	116	360	182	178	24	528	154	148	**200**
Ca Hardness (ppm)	46	144	73	71	10	211	62	59	**-**
Mg Hardness (ppm)	70	216	109.3	107	14	317	92	89	**-**
Total Alkalinity (ppm)	18	56	40	40	4	64	21	20	**200**
Bicarbonate (mg of $CaCO_3$)	18	56	40	40	4	64	21	20	**-**



Discrepancy in Uranium during pre-monsoon



Discrepancy in Uranium during post-monsoon

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