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RESEARCH ARTICLE

SEASONAL ASSESSMENT OF NATURAL URANIUM IN DRINKING WATER AROUND TUMMALAPALLE URANIUM MINING SITE, KADAPA DISTRICT, INDIA

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ABSTRACT

Uranium Corporation of India Limited (UCIL) has established a new uranium mining and milling facility at Tummalapalle which is under geological region of Cuddapah basin, Andhra Pradesh, India. A study is carried out to measure the background concentration of natural uranium and other physicochemical parameters in drinking water around Tummalapalle uranium mining and milling site. Drinking water samples were collected from 24 locations in Post monsoon (March-May) and Pre monsoon (Oct-Dec) seasons during 2010-11. P^H, EC, Salinity and TDS were analyzed in-situ using Systronics water analyzer kit and uranium concentration was estimated using Laser Flourimeter at Nuclear Fuel Complex, Hyderabad. The uranium concentration varied from 3±1 µg/l to 29±5 µg/l and was below the drinking water guideline value of 30 µg/l set by WHO. The correlation studies between the analyzed parameters were also carried out.

INTRODUCTION

Uranium is a heavy metal commonly thought of as rare, more common in nature than other trace elements like cadmium, selenium and other rare elements [1]. Uranium occurs naturally and is wide spread in groundwater and surface water, occurring in granites, various other mineral deposits and in food materials. In groundwater uranium is present both in dissolved and particulate form due to minerals such as Uranitie and Pitchblende or as secondary mineral in the form of complex oxides of Silicates Phosphates, Vanadates, Lignite and Monazite sands [2].The variation in Uranium levels in ground water depends upon the geological feature of the concerned area and other environmental variables. Low concentration of Uranium is invariably present in most of the environmental compartment, including drinking water. Activity and processes that occurs at mining and ore processing sites may also affect the quality and quantity of ground water surrounding the site [3]. Earlier studies have suggested that in the areas of uranium mining and ore processing, the significant radionuclide contributing to drinking water exposure pathway is natural uranium. Uranium mining and processing industry produce a large quantity of low specific activity solid as well as liquid waste in the form of slurry known as tailings. Due to continuous discharge of tailings, the tailings pond is a potential source of exposure for members of public residing nearby.Uranium isotopes during their disintegration course decay into other radioactive elements and eventually decay to stable lead isotopes, in the process emits beta and gamma radiation [4]. High levels of Uranium can lead to kidney damages and Nephritis is chemical toxicity [5-6]. In the present study an attempt has been made to estimate the U(nat.) in ground water sources adjoining and away from uranium mining and ore processing site of Tummalapalle within 30 km of radial distance, Correlation between physical parameters and Uranium (nat.) and assessment of seasonal study in Pre monsoon(PRM) and Post monsoon (POM) has also been carried out.

MATERIALS AND METHODS

Study area and sampling locations

Tummalapalle uranium mining site is located in the Vemula (Mandal) of Kadapa district of Andhra Pradesh at a distance of 70 km from district headquarter. The nearest towns are Pulivendula and Kadiri which are about 15 km from the site (by road). The uranium mining site is located under the survey of India Toposheet No. 57 J/3 and 57 J/7 between latitudes $14^0$18'36" N - $14^0$20'20" N and longitudes $78^0$15'16" E - $78^0$18'3" E. Its altitude from sea level is about 350 feet. The total study area is divided into three zones of concentric circles with mining site as center point. The zones named based on the radial distance from the mining site are as Core zone, Buffer zone-1 and Buffer zone-2. Here, the Core zone which is covering area of 0-5 km radial distance, contains 8 sampling locations, Buffer zone-1 which is spreading over the radial distance from 5-16 km area around the mining site and contains 9 sampling locations and finally Buffer zone-2 which is covering area of 16-30 km radial distance contains 7 sampling locations. A Total of 24 water sampling locations were selected in and around the Tummalapalle Uranium

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mining site within 30 km radial distance (Fig. 1). Collection of samples was based on the proximity of the source with the site and consumption by the local inhabitants. The sampling locations with their radial distance from the Uranium mining site and their Global Positioning System (GPS) measured longitude and longitude are shown in the Table.1.

Collection of water samples

The sample collection bottles were thoroughly cleaned with hydrochloric acid. They were further rinsed washed with tap water to render free of acid and then washed with distilled water and finally kept dried for the sampling. Water samples were collected in Polythene bottles of 1.0 litre capacity. The physical parameters of water like pH, conductivity, Salinity and total dissolved solids were estimated in-situ itself by using Systronics water analyzer 371. For the uranium analysis, water samples were filtered through whatmann filter paper no.42. Filtered samples were preserved in dilute nitric acid (pH~2) to avoid wall deposition /adsorption losses. The details of samples collection and processing are available elsewhere [7]. Uranium level in water was estimated using Laser Induced Flourimetry (LIF) instrument. LIF is more sensitive for aqueous medium and is widely used for the determination of Uranium [8].

RESULTS AND DISCUSSION

Physical parameters of water and uranium concentration observed in pre-monsoon (Oct-Dec) and post monsoon (March-May) seasons in the period of 2010-11 are shown in Table 2. The observed concentrations are discussed parameter wise and with respect to seasonal (PRM and POM) variations.

Table 1 The detailed illustration of the sampling locations and their sources

S.No.	Location	Zones	RD in km	Nature of Sample	Latitude	Longitude
1	Tummalapalle	Core zone	1.2	Bore well	14°19'37.62"	78°15'20.28"
2	Akkayagari kona (s)		1.8	Dug well	14°18'36.30"	78°16‘35.28"
3	Mabhuchintalapalle		1.9	Bore well	14°20'12.36"	78°15'18.80"
4	Rachakuntapalle		3.8	Dug well	14°18'24.12"	78°17'46.38"
5	Rachakuntapalle(s)		3.8	Surface	14°18'19.68"	78°17'44.46"
6	Bhumaiahgaripalle		4.1	Bore well	14°19'45.36"	78°18'12.54"
7	M. Kota		4.2	Bore well	14°20'01.26"	78°18'50.58"
8	Velpula		5.0	Bore well	14°22'03.42"	78°16'15.90"
9	Bestavaripalle	Buffer zone 1	7.7	Bore well	14°23'08.70"	78°14'08.58"
10	Vemula		8.2	Bore well	14°22'16.86"	78°19'24.78"
11	Gidingivaripalle		10.0	Bore well	14°18‘52.50"	78°21‘46.20"
12	Bakkanagaripalle		11.0	Bore well	14°20‘04.74"	78°22‘03.24"
13	V. Kottapalle		11.2	Bore well	14°22'10.44"	78°21'29.46"
14	Batrepalli (s)		11.3	Surface	14°14'15.00"	78°11'10.80"
15	Batrepalle		13.0	Bore well	14°14'08.58"	78°11'04.62"
16	Dugganagaripalle		13.6	Bore well	14°22'34.86"	78°22'45.36"
17	JNTUACE P		14.1	Bore well	14°26'50.70"	78°14'09.42"
18	Iverillu	Buffer zone 2	21.1	Bore well	14°09'57.66"	78°09'18.00"
19	Kalasamudram		21.6	Bore well	14°19'23.58"	78°15'56.76"
20	Javakkala (s)		20.7	Surface	14°09‘41.58"	78°10‘06.18"
21	Dorigillu		21.9	Bore well	14°25'31.08"	78°02'19.20"
22	Gandi		23.8	Bore well	14°19‘23.34"	78°29‘14.16"
23	IIIT, Idupulapaya		23.8	Dug well	14°20‘20.52"	78°32‘13.44"
24	Gandi (s)		23.9	Surface	14°19‘22.50"	78°29‘14.16"

*RD = radial distance of the location from the Uranium mining site, (s) =Surface water

pH

pH is an important water quality indicator. Generally it is able to influence most of the bio-chemical and chemical reactions in water. The estimated results of pH at insitu in PRM and POM at different selected sampling sites are shown in Table 2. The results reveal that the maximum numbers of samples are within the permissible limits (6.5-8.5) of the WHO (2011).The pH for the present studied water samples varied between 6.3±0.1 to 8.9±0.9 (Table 4) and these values ranged from a minimum value in POM to a maximum value in PRM. The pH having higher values may be due to the release of acid forming substances such as sulphate, nitrates, phosphate etc. into the water body [9].The maximum pH value (8.9±0.9) at Batrepalli surface water was recorded in the PRM and minimum (6.3±0.1) in the month of POM. The factors like air temperature bring about changes in the pH of water. The reduced rate of photosynthetic activities reduces the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH. The low oxygen values coincided with high temperature during the summer month [10].

Electrical Conductivity

Electrical Conductivity is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water. Electrical Conductivity is found in the range of 0.26±0.09 to 2.6±0.11 mS. It was found maximum in PRM season at Tummalapalle and low in POM at Rachakuntapalle (s). It is observed that water with high Electrical Conductivity values are predominant with sodium and chloride ions and further it is noted that the Electrical Conductivity is higher during PRM. With respect to type of water samples, EC was found to be higher in bore well as well as river water.

Salinity

The average values of salinity in POM and PRM are tabulated in the Table. 2. The values of salinity provide idea of natural basicity and bicarbonates present in water. In studied water samples salinity was found in range 110±26 to 1465±150 mg/l. With respect to seasonal variation, quite high range was found in PRM. Salinity in itself is not harmful to human beings [11].

The salinity values are well correlate with the EC results. In all the seasons Tummalapalle location was having high values compared with other locations.

Total Dissolved Solids

Total dissolved solids (TDS) in water consist of dissolved mineral salts that change the physical and chemical properties of the water.

Table 2 Average and standard deviation of results of water at selected locations in POM and PRM seasons

S.No.	Parameter	pH		EC (mS)		TDS (mg/l)		Salinity (mg/l)		Uranium (nat) (µg/l)	
	Location/ Season	POM	PRM	POM	PRM	POM	PRM	POM	PRM	POM	PRM
1.	Tummalapalle	7.2±0.1	7.3±0.1	2.05±0.78	2.60±0.11	713±58	1483±78	800±295	1465±150	6±1	5±2
2.	Akkayagari Kona (s)	6.7±0.2	6.9±0.1	0.32±0.06	0.75±0.17	158±24	311±57	160±36	297±68	5±2	4±1
3.	Mabuchintalapalle	6.9±0.1	7.2±0.1	0.93±0.05	0.92±0.11	429±29	494±64	393±35	456±83	6±1	8±4
4.	Rachakuntapalle	6.6±0.1	6.9±0.1	0.29±0.08	0.33±0.07	135±30	195±39	110±26	152±32	6±4	6±2
5.	Rachakuntapalle (s)	6.3±0.1	6.9±0.1	0.26±0.09	0.35±0.01	122±29	178±20	127±21	135±25	6±4	10±3
6.	Bumaiahgaripalle	7.2±0.1	7.4±0.1	0.51±0.10	1.16±0.08	500±52	589±73	470±46	559±113	7±2	11±7
7.	M. Kota	7.6±0.2	7.5±0.1	1.06±0.04	0.64±0.73	510±56	595±59	503±12	557±83	7±5	8±3
8.	Velpula	7.6±0.2	7.2±0.1	1.61±0.74	2.25±0.33	547±23	1229±256	470±53	1163±258	8±3	6±2
9.	Bestavaripalle	7.3±0.1	7.4±0.3	1.23±0.07	1.53±0.13	583±51	748±99	543±58	676±160	19±6	17±11
10.	Vemula	7.1±0.1	7.5±0.2	1.19±0.01	1.05±0.90	591±199	987±98	530±180	927±156	17±3	19±1
11.	Gidingivaripalle	7.1±0.1	7.6±0.1	0.96±0.07	2.01±0.08	447±31	637±111	393±35	590±157	5±.2	7±4
12.	Bakkanagaripalle	6.9±0.2	7.7±0.4	1.87±1.12	1.22±1.00	805±44	874±5	853±355	813±90	3±1	4±1
13.	V.Kottapalle	7.2±0.1	7.6±0.5	1.17±0.06	1.35±0.35	529±13	673±169	494±16	637±185	9±3	12±3
14.	Batrepalle (s)	8.2±0.3	8.3±0.9	0.58±0.40	0.90±0.32	322±162	404±178	293±150	401±211	15±1	19±2
15.	Batrepalle	7.1±0.1	7.9±0.4	0.69±0.03	0.45±0.54	333±17	389±69	307±6	333±116	24±1	23±6
16.	Dugganipalle	7.5±0.1	7.6±0.6	1.41±0.28	0.71±0.90	732±48	756±106	675±19	611±217	11±4	20±8
17.	JNTUACE P	7.6±0.1	7.7±0.4	1.66±0.30	0.46±0.12	645±50	692±55	617±76	620±106	15±7	15±11
18.	Javakkala (s)	7.9±0.4	8.1±0.1	0.62±0.16	0.89±0.04	337±84	404±83	373±45	380±104	22±9	22±13
19.	Iverillu	7.2±0.1	7.3±0.1	1.08±0.10	0.66±0.21	529±28	635±69	483±42	605±112	16±1	20±4
20.	Kalasamudram	7.2±0.1	7.5±0.1	0.55±0.25	1.12±0.21	546±71	554±25	500±53	495±23	23±6	14±3
21.	Dorigillu	7.6±0.1	7.8±0.4	0.78±0.06	1.09±0.08	382±24	492±83	354±14	457±89	8±6	7±1
22.	Gindi	7.8±0.1	7.9±0.1	1.13±0.06	0.66±0.19	525±36	568±96	477±21	537±122	19±10	21±12
23.	IIIT Idupulapaya	6.8±0.1	6.8±0.1	0.71±0.18	0.98±0.16	320±84	524±67	290±69	491±90	21±9	29±5
24.	Gindi(s)	7.7±0.4	8.0±0.5	1.04±0.21	0.76±0.11	515±70	596±171	470±69	575±190	30±1	19±1
	Guideline levels[12]	6.5-8.5		Not Available		500 mg/l		Not Available		30 µg/l	

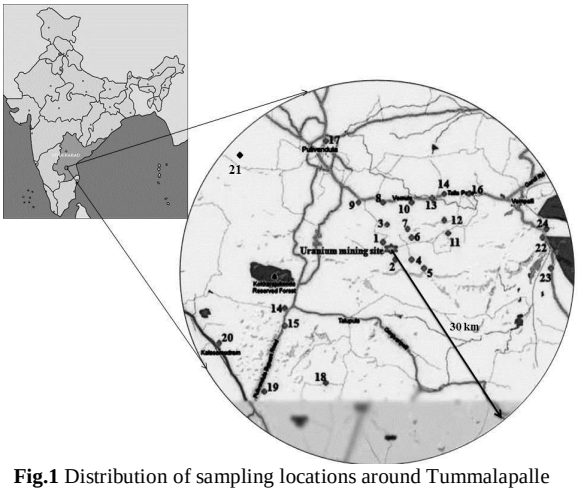

Fig.1 Distribution of sampling locations around Tummalapalle Uranium mining site

This is a measure of the solid materials dissolved in the water. Total dissolved solids in all the locations and seasons varied from122±29 to1483±78 mg/l. At many locations the observed values of TDS were higher than the WHO standards of 500 mg/l.

Uranium (nat.) analysis

According to WHO, the provisional guideline value of uranium in drinking water based on its chemical toxicity is 30 µg/l [12]. The obtained results (Table.2.) of Uranium in most of the samples were within the lmit. The values were ranging 3±1 µg/l to 29±5 µg/l.

Table 3 Correlation matrix of parameters in PRM

Component	pH	EC	TDS	Salinity	U
pH	1.00				
EC	0.21	1.00			
TDS	0.34	0.81	1.00		
Salinity	0.30	0.83	0.98	1.00	
U	0.39	-0.18	0.01	-0.06	1.00

It was found that in POM and PRM there are no major changes in Uranium concentrations.The lower value among the obtained results is 3 ± 1 µg/l at Bakkanagaripalle bore well in POM and higher value 29 ± 5 µg/l is observed in PRM at IIIT Idupulapaya Open well. The statistical study of estimated uranium concentrations like maximum, minimum and average levels in PRM and POM seasons for each location are shown in Fig. 1 and Fig. 2.

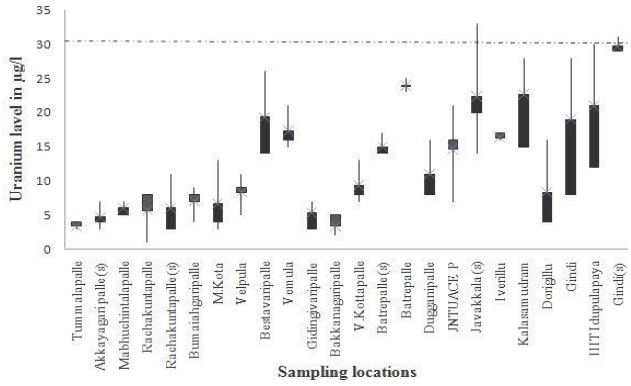

Fig.2 Distribution of Uranium (nat.) in POM season at different locations

Table 4 Correlation matrix of parameters in POM

Component	pH	EC	TDS	Salinity	U
pH	1.00				
EC	-0.04	1.00			
TDS	0.02	0.80	1.00		
Salinity	0.03	0.82	0.90	1.00	
U	0.32	-0.37	-0.18	-0.19	1.00

Correlation Study

Correlation matrix between the analyzed parameters of water samples in different seasons (PRM and POM) are shown in the Table 3 and Table 4. The data reveals that the correlation in PRM season is relatively high between EC- TDS (r= 0.81), EC- Salinity

(r= 0.83) and TDS- Salinity (r= 0.98). There is a positive correlation between U (nat.) and pH with low concentration coefficient (r= 0.39). There is no significant correlation of U (nat.) with EC, TDS and Salinity (Table 3).When considering POM season, the results are quite comparable with PRM season with small fluctuations in the values (Table 4). The strong correlation between EC-TDS (r=0.80), EC-Salinity (0.82) and TDS- Salinity (r=0.90) and positive correlation between U (nat.) and pH (r= 0.32) is observed in POM season also.

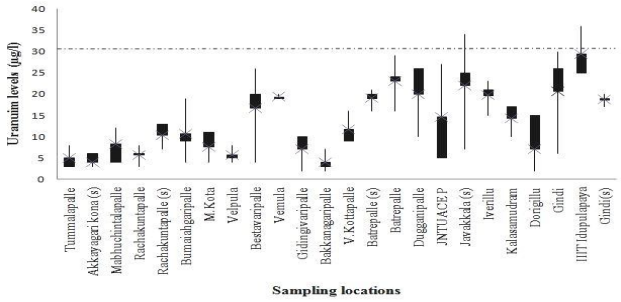

Fig.3 Distribution of Uranium (nat.) in PRM season at different locations

CONCLUSION

The present study observes that the concentration of uranium varies significantly from place to place. This wide variation of Uranium concentrations is likely due to the heterogeneous distribution of uranium deposits in earth crust and geological formations of surroundings of Tummalapalle mining site. The statistical analyses of the parameters and correlation matrix between the parameters reveal that there is no remarkable change in the levels of Uranium (nat.) is found in POM and PRM seasons. The natural uranium concentration in drinking water varied similar to the variation in pH. There is no alarmingly high uranium concentration in any of the samples analyzed. About 96 % of the drinking water samples had uranium concentration within the guide line value (30µg/l) set by USEPA for drinking purpose.

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