© 2018 IJSRSET | Volume 4 | Issue 4 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology

Study of Uranium Contamination & Its Health Effect in Ground Water of Balod District of Chhattisgarh State, India

Vijita Diwan[1], Santosh Kumar Sar[1], Shweta Singh[1], Megha Sahu[1], Manoj Kumar Jindal[1], Arun Arora[2], Supriya Biswas[3]

[1]Department of Applied Chemistry, Bhilai Institute of Technology, Durg, Chhattisgarh, India
[2]Mechanical Engineering Department, Bhilai Institute of Technology, Durg, Chhattisgarh, India
[3]Department of Applied Chemistry, Shri Shankaracharya Technical Campus, Bhilai, Chhattisgarh, India

ABSTRACT

Uranium content in ground water samples from Balod District of Chhattisgarh state was measured using laser fluorimetric technique. Uranium concentration of water samples was found in range 0.563 - 78.93μgl^{-1}. The uranium concentration in most of the water samples was found lower than the safe limit (30μgl^{-1}) recommended by WHO and EPA except Deur Tarai village (78.93μgl^{-1}). The annual effective dose due to ingestion of ground water was calculated using ICRP recommendations. The annual effective dose in one of the samples was found to be greater than WHO-recommended level (100 μSv/y). The cancer mortality risk and morbidity risk varied from 1.51×10^{-6} to 2.12×10^{-4} and, from 2.32×10^{-6} to 3.25×10^{-4} respectively which indicate minor carcinogenic risk. Hazard quotient for 25 % samples >1 which indicates health risk due to chemical toxicity of uranium in groundwater.

Keyword : Fluorimetric Technique, Annual Effective Dose, Cancer Mortality Risk, Morbidity Risk, Hazard Quotient

I. INTRODUCTION

Uranium is a naturally occurring, alpha-emitting radioactive metal with atomic number 92 and a molar mass of 238.03 g/mol. Due to its chemical and radiological properties, uranium is one of the technologically important elements. It is an unavoidable part of our environment since it is present in variable amounts in rock, soil, air and water [1]. In recent years, many cases of presence of uranium in ground water have reported in India [2-5]. Most natural waters contain detectable amounts of uranium. Natural sources like leaching from natural deposits and anthropogenic sources like release in mill tailings, emissions from the nuclear power plants, combustion of coal and other fuels, and the use of uranium containing phosphate fertilizers are responsible factors for uranium contamination of ground water [6]. The uranium concentration and its mobility in water depends on pH, the oxidation-reduction potential (ORP), and presence of carbonates, phosphates, fluorides, sulphates, etc.[7]

People who work with materials and products that contain uranium may be exposed at work on the other hand for most people, food and drinking water are the main sources of uranium exposure. Uranium shows both chemical and radiological hazards. From 0.1–6% of the ingested uranium is absorbed into the blood in adults[8]. Uranium that is absorbed is mainly deposited in the bones, liver, and kdneys. The kidney is considered to be the main target organ for the chemical toxicity of uranium. There are some literatures which report toxic effect of uranium on kidneys [9-11]. In addition to kidneys, bone may be another target of chemical toxicity of uranium in humans. The concentration of uranium in drinking water is a matter of concern and it is monitored by different health organization. The World Health Organization (WHO, 2004)[12] had previously suggested a reference level 15 μgl^{-1} but now the permissible limit of U in drinking water by WHO is 30 μgl^{-1}(WHO, 2011)[13]. The reference level is derived from epidemiological studies, established on the hypothesis of a 60 kg adult consuming 2 litres of drinking water per day and 80% allocation of the Tolerable Daily Intake (TDI) to drinking water. United States environmental protection agency (EPA) added a radionuclide rule on December 7, 2000 under the Safe Drinking Water Act (SDWA) in which EPA established a Maximum Contaminant Level (MCL) of 30 micrograms per liter (μg/l) for uranium [14]. To prevent from the adverse health effects of uranium in drinking water, it is recommended to monitor the uranium concentration in different drinking water resources. The purpose of this study is to estimate the uranium concentration in drinking water collected from Balod district of Chhattisgarh state, India using laser induced fluorimetry and calculation of health risk due to drinking of this water.

Geology of study area

In the central part of the Chhattisgarh State Balod district is densely populated which covers an area of 3527 Km^2. It lies between latitude 20°23' to 21°03' N and longitude 80°48’ to 81°30 E. Fig. 1 shows the geographic location of the Balod district. It is surrounded by Durg districts in the north, Rajnandgaon District in the west, Dhamtari districts in the east and Kanker district in the south. Mineral deposit of Balod district includes Iron Ore, Flagstone, Sandstone, Quartzite, Laterite sand etc. Geologically, the district comprises of rocks of Archaean basement of Meso to neo-Proterozoic ages. The oldest rocks belong to Archaean and mainly comprise the basement granite gneiss with metasedimentary and metaigneous enclaves belonging to the Bengpal Group. The overlying bailadila Group includes banded iron formation, shale and phylite belonging to Archaean-lower Proterozoic age.

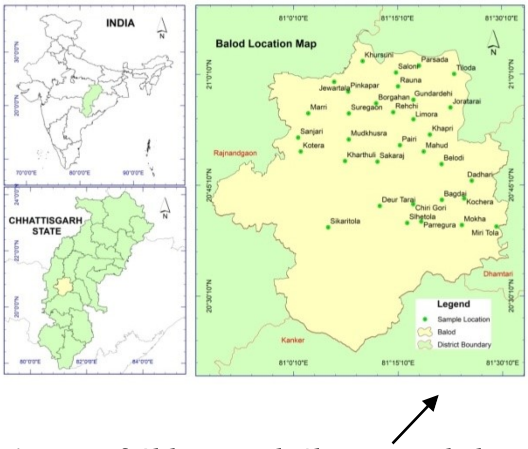

Figure 1. Map of Chhattisgarh Showing Balod District (Study Area).

II. MATERIALS AND METHODS

Sampling

31 water samples were collected from bore wells and open wells from different locations of the study area during the month of May 2017. Samples were collected in clean plastic bottles which were pre-rinsed with distilled water at the time of sampling. Each sample brought to the laboratory was slightly acidified by adding 0.2 ml of nitric acid to minimize the loss of uranium through absorption in the bottles. The samples were labelled, denoting the details of time, place and date of sampling. Uranium analysis in water samples was carried out by using LED fluorimeter.

Laser induced fluorimetry

Concentration of uranium in water samples was measured using laser induced fluorimetric technique by the LED Fluorimeter LF-2a developed by Quantalase Enterprises Pvt. Ltd. Indore. The Quantalase LED Fluorimeter is an instrument for detection and measurement of trace quantities of uranium present in aqueous samples. In this instrument Pulsed UV LED excites fluorescence in uranium (VI) complexes in the sample. A suitable sharp cut off filter transmits only light of wavelength shorter than 440 nm from the LED so that fluorescence due to organic species present in natural water is blocked. By proper time gating of photomultiplier tube, the remaining fluorescence from organic matter can be completely eliminated. Hence the excitation source is the pulsed source. Lenses appropriately arranged focus the LED light on the sample in the cuvette. After excitation uranium complexes emit green fluorescence, which can be measured by a sensitive Photomultiplier Tube (PMT).Since the fluorescence yield is proportional to the intensity of excitation source and concentration of uranium in sample, measurement of fluorescence will give information about concentration of uranium in sample.

Analysis

Samples were filtered using 0.45 micron whatmann filter paper for removal of suspended particles. Instrument was calibrated with standard uranium solutions, then water samples were analysed by standard addition method to overcome matrix effect. The fluorescence yield varies for different complexes of uranium therefore an inorganic reagent SPP (Sodiumpyrophosphate) is added to the sample to convert all the complexes into single form having same fluorescence yield. By this technique concentration down to 0.5 ppb can be measured

III. REAGENTS & CHEMICALS

Preparation of buffer

Five percent solution of sodium pyrophosphatewasprepared in double distilled water & orthophosphoricacid was added to adjustpH~7.

Preparation of standard uranium solution

Standard uranium solutions were prepared by dilution of uranium plasma emission standard solution from Accu Std ,USA Lot No 216035031.

Dose and Health Risk Due To Uranium in Drinking Water

Annual Effective Dose

The probable effective dose due to ingestion of the uranium contaminated ground water was calculated from the uranium concentration in ground water from all sampling locations. The results are given in Table 1. The dose was calculated by:

AD = AC x E x AWI

Where AD is the annual effective dose ($\mu Sv\ y^{-1}$), AC is activity concentration of uranium ($Bq\ l^{-1}$) (1 µg/l of U = 0.02528 Bq/l), and E is effective dose coefficient for ingestion (4.5×10^{-8} Sv/ Bq)[15] and AWI is the average water intake (4.05liters per Day =1478.25 litres per year).

Cancer Risk

Cancer risk was calculated using following formula:

CR=AC × R

Where 'CR' is cancer risk, 'AC' is Activity Concentration of Uranium (Bql^{-1}) and 'R' is Risk Factor.

The risk factor R, associated with ingestion of Uranium from the drinking water may be calculated by the product of the risk coefficient (r) and per capita activity intake I. The risk coefficient is found $1.13 \times 10^{-9}\ Bq^{-1}$ for cancer mortality and $1.73 \times 10^{-9}\ Bq^{-1}$ for cancer morbidity from literature [16, 17]. 'I' for Uranium is calculated as product of life expectancy as 63.7 years, i.e. 23250 days and daily consumption of water as ($4.05\ lday^{-1}$)[18].

$I = 4.05\ lday^{-1} \times 23250$

R = r x I

Chemical Risk Assessment

The chemical risk assessment for uranium is done through the Hazard Quotient.Hazard quotient (HQ) gives the degree of the harm produced due to the drinking of uranium contaminated water.

$HQ = \frac{LADD}{RfD}$

RfD is the reference dose = 0.6($\mu g\ kg^{-1}day^{-1}$)[19] and LADD is life time average daily dose which is given by:

$$LADD = \frac{EPCX\ IRXEDXEF}{ATXBW}$$

Where LADD, lifetime average daily dose ($\mu g.kg^{-1}.day^{-1}$); EPC is the exposure point concentration ($\mu g.l^{-1}$); IR is the water ingestion rate ($l.day^{-1}$); EF is the exposure frequency ($days.year^{-1}$); ED is the total exposure duration (years); AT is the average time (days) and BW is the body weight (kg). Using therefore, IR = 4.05 $l\,day^{-1}$; EF = 365 days, ED = 63.7 y, AT = 16,607.5 (obtained from 63.7 × 365) and BW = 53 kg (for an Indian standard man)[20].

IV. RESULTS AND DISCUSSION

Results of uranium concentration, corresponding annual effective dose, cancer risk and hazard quotient (HQ) in 31 drinking water samples from Baled district of Chhattisgarh state, analyzed by means of the Laser flourimetric technique are tabulated in Table 1. Overall uranium concentration in collected water samples of the study area have been found to be varying between 0.56 -78.93 $\mu g l^{-1}$. Minimum uranium concentration is found in Kochera village (0.56 $\mu g l^{-1}$) and maximum in Deur Tarai village (78.93$\mu g l^{-1}$). In 96 % of water samples uranium concentration was found lower than a Maximum Contaminant Level (MCL) of 30 micrograms per litre ($\mu g l^{-1}$) established by EPA(USEPA 2000) [14]. For comparison the range of uranium content in the drinking water samples in different countries and in different states of India are given in Table 2 & 3 respectively. Direct radiation effect of uranium, if ingested, is due to its alpha emission which can produce gene mutation, cancer and abnormalities in children and developing foetus [22]. Studies show that elevated levels of uranium from any source, including drinking water, can increase a person's risk of kidney damage. The kidney is the most sensitive organ for damage by uranium [9]. In this view the assessment of radiological and chemical toxicity is important. The annual effective dose due to the ingestion of uranium is found to be in the range 0.95-132.7 µSv/y. Only one water sample show the annual effective dose greater than the permissible dose of 100 µSv/y as recommended by WHO (2004)[12].The cancer mortality risk varied from 1.51×10^{-6} to 2.12×10^{-4} while morbidity risk, ranged between 2.32×10^{-6} and 3.25×10^{-4}. The values reported for cancer risk are low compared to the acceptable level of 10^{-3} for the radiological risk[19]. In present study LADD varied from 0.043 to 6.031 $\mu g.kg^{-1}day^{-1}$. LADD values of 19% water samples were higher than 1 $\mu g.kg^{-1}day^{-1}$which is accepted by World Health Organization WHO (2011) [13]. 25 % samples showed HQ values >1.0, representing significant risk due to chemical toxicity.

V. CONCLUSION

Water is essential for life. Therefore determination of uranium concentration in water becomes more important. The Uranium concentration in ground water of the study area has been found to vary between 0.56-78.93 $\mu g l^{-1}$. Only in Deur Tarai area uranium concentration exceeds the threshold value of 30 $\mu g l^{-1}$ as established by EPA and WHO. The values reported for cancer risk are low compared to the acceptable level of 10^{-3} for the radiological risk. The HQ values are below the threshold value of one as recommended by EPA at 75% locations. In Deur tarai village HQ was found 10.05 which require proper attention and remedial action is required in this area. Finally it is concluded that there is no radiological risk to humans but non-carcinogenic health risks may be due to chemical toxicity of uranium in the study area.

Table 1. Concentration and activity of uranium in ground water in addition with radiological and chemical risk

S.No.	Sampling Loaction	Uranium Concentration ($\mu g l^{-1}$)	Activity Concentration ($Bq l^{-1}$)	Annual Effctve Dose ($\mu Sv y^{-1}$)	Cancer Mortality Risk	Cancer Morbidity Risk	LADD ($\mu g.kg^{-1}.day^{-1}$);	HQ
1	Parsada	3.02	0.076	5.08	$8.13 X 10^{-6}$	$1.24 X 10^{-5}$	0.231	0.38
2	Tiloda	8.95	0.226	15.06	$2.41 X 10^{-5}$	$3.68 X 10^{-5}$	0.684	1.14
3	Joratarai	3.08	0.077	5.18	$8.29 X 10^{-6}$	$1.26 X 10^{-5}$	0.235	0.39
4	Limora	1.37	0.034	2.30	$3.69 X 10^{-6}$	$5.65 X 10^{-6}$	0.104	0.17
5	Rahchi	0.58	0.014	0.990	$1.58 X 10^{-6}$	$2.42 X 10^{-6}$	0.045	0.07
6	Borgahan	1.21	0.030	2.04	$3.27 X 10^{-6}$	$5.01 X 10^{-6}$	0.092	0.15
7	Suregaon	2.72	0.068	4.58	$7.34 X 10^{-6}$	$1.12 X 10^{-5}$	0.208	0.34
8	Pinkapar	0.57	0.014	0.97	$1.56 X 10^{-6}$	$2.38 X 10^{-6}$	0.044	0.07
9	Rauna	22.19	0.560	37.31	$5.97 X 10^{-5}$	$9.13 X 10^{-5}$	1.695	2.82
10	Saloni	23.42	0.592	39.38	$6.3 X 10^{-5}$	$9.64 X 10^{-5}$	1.789	2.98
11	Khursuni	0.97	0.024	1.63	$2.61 X 10^{-6}$	$3.99 X 10^{-6}$	0.074	0.12
12	Sanjari	0.94	0.023	1.58	$2.54 X 10^{-6}$	$3.88 X 10^{-6}$	0.072	0.12
13	Kotera	0.99	0.025	1.67	$2.69 X 10^{-6}$	$4.11 X 10^{-6}$	0.076	0.12
14	Kharthuli	6.85	0.173	11.52	$1.84 X 10^{-5}$	$2.82 X 10^{-5}$	0.523	0.87
15	Mudkhusra	0.59	0.015	1.00	$1.61 X 10^{-6}$	$2.46 X 10^{-6}$	0.045	0.07
16	Sakaraj	14.65	0.370	24.63	$3.94 X 10^{-5}$	$6.03 X 10^{-5}$	1.119	1.86
17	Pairi	9.64	0.243	16.22	$2.59 X 10^{-5}$	$3.97 X 10^{-5}$	0.737	1.22
18	Gundardehi	1.69	0.042	2.84	$4.55 X 10^{-6}$	$6.97 X 10^{-6}$	0.129	0.21
19	Khapri	1.61	0.040	2.7	$4.35 X 10^{-6}$	$6.65 X 10^{-6}$	0.123	0.20
20	Mahud	1.30	0.032	2.18	$3.5 X 10^{-6}$	$5.35 X 10^{-6}$	0.099	0.16
21	Belodi	5.38	0.136	9.04	$1.45 X 10^{-5}$	$2.21 X 10^{-5}$	0.411	0.68
22	Dadhari	19.57	0.494	32.91	$5.26 X 10^{-5}$	$8.05 X 10^{-5}$	1.495	2.49
23	Kochera	0.56	0.014	0.94	$1.51 X 10^{-6}$	$2.31 X 10^{-6}$	0.043	0.07
24	Bagdai	4.02	0.101	6.76	$1.08 X 10^{-5}$	$1.65 X 10^{-5}$	0.307	0.51
25	ChiriGori	14.80	0.374	24.89	$3.98 X 10^{-5}$	$6.09 X 10^{-5}$	1.131	1.88
26	Deur Tarai	78.93	1.995	132.73	$2.12 X 10^{-4}$	$3.25 X 10^{-4}$	6.031	10.05
27	Miri Tola	5.16	0.130	8.68	$1.39 X 10^{-5}$	$2.12 X 10^{-5}$	0.394	0.65
28	Mokha	0.62	0.015	1.05	$1.69 X 10^{-6}$	$2.59 X 10^{-6}$	0.048	0.08
29	Parregura	3.63	0.091	6.10	$9.77 X 10^{-6}$	$1.49 X 10^{-5}$	0.277	0.46
30	Slhetola	0.57	0.014	0.97	$1.55 X 10^{-6}$	$2.38 X 10^{-6}$	0.044	0.07
31	Sikaritola	1.19	0.030	2.01	$3.22 X 10^{-6}$	$4.92 X 10^{-6}$	0.091	0.15

Table 2. Uranium concentrations in drinking water samples in different countries of world

Sl. No.	Country	Uranium concentration range ($\mu g.l^{-1}$)	References
1	Greece	0.015–1.4	21
2	Odeda area Nigeria	20.55-272.82	22
3	Argentina	0.04–11	23
4	Jordan	0.04–1400	24
5	Okchun belt Korea	0.5-263	25
6	Ghana	<0.001-266	26
7	San Joaquin Valley, California USA	0.04-2,500	27
8	Turkey	0.2-17.6	28
9	South Greenland	0.5-1.0	29

Table 3. Uranium concentration in drinking water samples in different states of India.

Sl. No.	States/cities of India	Uranium concentration range ($\mu g.l^{-1}$)	References
1	Aandhrapradesh Vishakhapatnam	0.6–12.3	6
2	Himachal Pradesh, Kulu	0.3–2.5	30
3	Karnataka, Bangalore	0.2-770.1	31
4	North Rajasthan	2.54-133	32
5	Karnataka, Chamarajnagar	0.03-4.63	33
6	Punjab, Bathinda	9.72-186.6	2
7	West Haryana	0.3-256.4	3
8	Eastern Uttar Pradesh	11-63.33	4
9	south coast districts of Kerala	0.31 - 4.92	5
	Present Study	0.563-78.93	

VI. ACKNOWLEDGEMENT

Authors are thankful to Board of Research in Nuclear Sciences (BRNS), Department of Atomic Energy (DAE), Project no 36 (4)/14/90/2014-BRNS for providing financial support. We are also grateful to BIT Durg for giving lab facility for conducting this research work.

VII. REFERENCES

[1]. Denek Hon, Jan osterreicher, Leos Navratil (2015) Depleted uranium and its effects on humans,Sustainability, 7, 4063-4077.

[2]. VirkH.S., (2016) Measurement of Concentration of Natural Uranium in Ground Waters of Bathinda District (S. Punjab) for the Assessment of Annual Effective Dose,Global journal of Human Social Science (B) 16 (5).

[3]. Balvinder Singh , Garg V. K. , Poonam Yadav, Nawal Kishore, Vandana Pulhani (2014)Uranium in groundwater from Western Haryana, India,J Radioanal Nucl Chem.

[4]. Meher Prabodha Kumar, Sharma Prerna, Khare Akash, Mishra Kaushala Prasad (2015) Uranium in Ground water of Eastern Uttar Pradesh, India: A preliminary study,.International Research Journal of Environment Sciences, 4(6), 70-74.

[5]. Ben ByjuS., SunilA., ReebaM.J., ChristaE.P., VaidyanV.K., PrasadR., Jojo P.J. (June 2012) Uranium in drinking water from the south coast districts of Kerala, India, Iran. J.Radiat. Res.,10 (1), 31-36.

[6]. BhangareR. C., TiwariM., AjmalP. Y., SahuS. K., PanditG. G. (July 2013) Laser flourimetric analysis of uranium in water from Vishakhapatnam and estimation of health risk, Radiation Protection and Environment, 36 (3), 128-132.

[7]. Ajay Kumar, Sabyasachi Rout, Usha Narayanan, Manish K. Mishra,TripathiR. M., Jaspal Singh, Sanjeev Kumar, H. S. Kushwaha (May 2011)Geochemical modelling of uranium speciation in the subsurface aquatic environment of Punjab State in India, Journal of Geology and Mining Research, 3(5), 137-146.

[8]. U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Agency for Toxic Substances and Disease Registry (ATSDR) Feb 2013.

[9]. Kurttio P., Auvinen A., Salonen L. (2002) Renal effects of uranium in drinking water, Environ Health Perspect, 110, 337-342.
[10]. Hakonson-Hayes A.C., Fresquez P.R., Whicker F.W., (2002) Assessing potential risks from exposure to natural uranium in well water, J Environ Radioact, 59, 29-40.
[11]. Michael J Thun, BakerB., Kyle Steenland, Alexander B Smith, William Halperin, Thomas Berl. Scand (1985) Renal toxicity in uranium mill workers, J Work Environ Health, 11, 83-90.
[12]. World Health Organisation (WHO) (2004) Guidelines for Drinking- Water Quality.Vol. 1.3 rd ed.Recommendations. Geneva: World Health Organisation Geneva 2004.
[13]. WHO, (2011) Guidelines for drinking-water quality (4th Ed.)World Health Organization, Geneva, Switzerland.
[14]. U.S. Environmental Protection Agency (EPA): National primary drinking water regulations: Radionuclides; final rules. Federal Register 2000; 65:76708-53.
[15]. International Commission on Radiological Protection (ICRP). Age-Dependant Doses to Members of the Public from Intake of Radionuclides: Part 5. Compilation of Ingestion and Inhalation Coefficients. Ann ICRP 26.Oxford: ICRP Publication 72, PergamonPress; 1996.
[16]. Environmental Protection Agency (EPA) (1999). Cancer risk coefficients for Environmental exposure to radionuclides. United State Environmental Protection Agency. Federal Guidance Report No -13 (EPA. 402 R-99-001).
[17]. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (2000). Sources, effects and risks of ionizing radiation. Report to the General Assembly. ISBN 92-1-142238-8, New York.
[18]. HDR (2009) Human development report. Mumbai, India: National Resource Centre for Urban Poverty and All India Institute of Local Self Government.
[19]. Ye-shin K., Hoa-sung P., Jin-yong K., Sun-ku P., Byong-wook C., Ig-hwan S., Dong-Chun S., (2004) Health risk assessment for uranium in Korean groundwater, J Environ Radioact, 77(1),77–85.
[20]. Dang H.S., Jaiswal D.D., Parameswaran M., Krishnamony S. (1994) Physical, anatomical, physiological and metabolic data for reference Indian Man—a proposal, Bhabha Atomic Research Centre, Mumbai.
[21]. United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembly, UNSCEAR, 2008. Annex B. New York, United Nation.
[22]. Amakom C. M. and JibiriN. N. (July 2010) Chemical and radiological risk assessment of uranium in borehole and well waters in the Odeda Area, Ogun State, Nigeria, International Journal of the Physical Sciences, 5 (7), 1009-1014.
[23]. Bomben A.M., Equillor H.E., Oliveira A.A. (1996) Ra 226 and natural uranium in Argentina bottled mineral waters, Radiat Prot Dosim, 67, 221, 24.
[24]. GedeonR., SmithB., AmroH., Jawadeh J. (1994) Natural radioisotopes in groundwater from the Amman-Zarka basin Jordan. Hydrochemical and regulatory implications. Applications of tracers in arid zone hydrology, IAHS Press, Wallingford, UK IAHS Publication 232.
[25]. Lee M.H., Choi G.S., Cho Y.H., Lee C.W., Shin H.S. (2001) Concentrations and activity ratios of uranium isotopes in the groundwater of the Okchun Belt in Korea, J Environ Radioact, 57, 105–116.
[26]. Rossiter H.M.A., Owusu P.A., Awuah E., MacDonald A.M., Schafer A.I. (2010) Chemical drinking water quality in Ghana: water costs and scope for advanced treatment, Sci Tot Environ, 408 (11), 2378–2386.
[27]. Jurgens B.C., Fram M.S., Belitz K., Burow K.R., Landon M.K. (2009) Effects of groundwater

development on uranium: Central Valley, California, USA. USGS Staff -Published Research.

[28]. Kumru M.N. (1995) Distribution of radionuclides in sediments and soils along the Büyük Menderes River ,Proceedings of the Pakistan Academy of Sciences, 32, 51–56.

[29]. Brown A., Steenfelt A., Kunzzenorf H. (1983) Uranium districts defined by reconnaissance geochemistry in South Greenland, J Geochem Explor, 19, 127-145.

[30]. SinghS., MalhotraR., KumarJ., SinghB., SinghL. (2001)Uranium analysis of geological samples, water and plants from Kulu Area, Himachal Pradesh, India ,Radiation Measurements, 34, 427–431.

[31]. Nagaiah N., Mathews G., Balakrishna K.M., Rajanna A.M., Naregundi K. (2013) Influence of physico-chemical parameters on the distribution of uranium in the ground water of Bangalore, India, Radiat Prot Environ, 36,175-80.

[32]. Asha Rani, Rohit Mehra, Vikas Duggal, BalaramV. (2013) Analysis of uranium concentration in drinking water samples using ICPMS, Health Physics, 251-255.

[33]. NagarajuK.M., ChandrashekaraM.S., Pruthvi RaniK. S., ParameshL. (June-August 2014)Estimation of radiation dose due to uranium in water to the public in Chamarajanagar district, Karnataka State, India., American International Journal of Research in Science, Technology, Engineering & Mathematics, 7(2), 144-147 .