International Journal of Advance and Innovative Research
Volume 9, Issue 3 July - September 2022
ISSN 2394 - 7780

EVALUATION OF URANIUM CONCENTRATION IN GROUND WATER AND ITS HUMAN HEALTH IMPACT IN A PART OF ATRU TEHSIL OF BARAN DISTRICTS OF HADOTI REGION OF RAJASTHAN, INDIA

R. Meena[1]*, S. K. Sharma[2] and A. Rani[3]
[1]Department of Chemistry, Govt. College Kota, Rajasthan, India
[2, 3]Department of Pure and Applied Chemistry, University of Kota, Rajasthan, India

ABSTRACT
Uranium concentrations in ground water samples collected from some villages of Atru tehsil of Baran districts of Rajasthan have been measured using a LED fluorimetry technique. The source of water is ground water and the water sources are mainly hand pumps, tube wells and open wells. The uranium concentration in ground water samples is found to vary from 1.1ppb to 13.1ppb in pre monsoon with a mean, median, mode, standard deviation value of 4.09ppb, 3.91ppb, 4.10ppb, 2.66ppb and 2.4ppb to 15.6ppb in post monsoon with a mean, median, mode, standard deviation value of 5.8ppb, 5.25ppb, 5.10ppb and 3.21ppb. Along with uranium, its associated physico-chemical parameters of water such as pH, electrical conductivity, temperature, total alkalinity, phenolphthalein alkalinity, total hardness, magnesium hardness, calcium hardness, chloride, fluoride, sulphate, phosphate, nitrate, total dissolved solids (TDS) and oxidation reduction potentials (ORP) were also determined using standard Bhabha Atomic Research Centre (BARC) protocols [(1)]. Statistical tools were applied to analyze the data and its spatial distribution. The study will be helpful in identification of the health risks associated with uranium and other physico-chemical parameters in ground water used as potable water. The analytical data for all water parameters and uranium were cross checked with respect to recommendations given by BIS/WHO limits to identify the pollution level.

Keywords: Uranium, Groundwater, Atru, Baran, LED fluorimetry.

INTRODUCTION
Ground water is an indispensable natural resource for domestic and potable water supply in terms of its global contribution as unfrozen fresh water reserve[(2)]. Ground water plays a major role in supplying water for drinking, agricultural, and industrial uses [(3-5)]. Uranium is a widely known actinide, radioactive, lithophilic and naturally occurring heavy trace element found mostly in igneous rocks, soils, granites and earth crust [(6)]. In nature, uranium generally occurs in tetravalent state as insoluble species and hexavalent state as highly soluble species. Precipitation being the principal source for ground water; the responsibility to preserve this resource from pollution is increasing owing to the erratic nature of precipitation and near utilization of surface water resources (CGWB, 2015) [(7)] . The occurrence of ground water and groundwater potential in hard rock areas in various parts of india were documented by several authors (Javed and Wani, 2009; Gopalan, 2011; Sivaramakrishnan et al, 2015; Vittala et al, 2005) [(8-11)] . Application of uranium in ground water depends on lithology, geomorphology and other geology conditions of region (Michel et al. 1991; Ortega et al. 1996; Kumar et al. 2011) [(12-14)]. Uranium concentration in most of the ground water are generally lower, in ranges of 0.1 to 1 ppb, but it can leach, easily dissolved and transported in oxidizing groun dwater due to the presence of oxygen. Hence, it can be transported distant away from its original occurrence (Bucur et al. 2006) [(15).] Mostly uranium is attending in ground water rather than surface water, so there is a need to evaluate the amount of uranium present in ground water higher amounts of uranium content can affect some parts of the body (Brugge and Oldmixon et al. 2005) [(16)] . Higher amount of uranium content can affect the kidneys and it is reason due to its chemical nature and not due to radioactive property (Kurttio et al. 2006) [(17)]. Uranium isotopes during their disintegration course decay into other radioactive elements and ultimately decay to stable lead isotopes in the process emits beta and gamma radiation (Fontes et al. 1983) [(18)]. The decay products of 238U (234Th and 234 Pa) and 234 U (231Th) are responsible for the presence of beta and gamma radiations in purified natural uranium (Bleise et.al 2003) [(19)]. Even though Climate change affects ground water, buffering capacity makes it more resilient to the effects of climate change than surface water. Thus, the role of ground water in water supplies likely becomes more dominant in arid regions with large scale climatic variations (Jac, 2012) [(20)]. Therefore, the aim of this study was to investigate the quality of the ground water, the analysis of uranium and its correlation with some physico-chemical properties of drinking water samples of Atru tehsil of Baran districts of Rajasthan, India.

Study Area

Fig.1: Study map of Atru tehsil of Baran districts of Rajasthan with the locations

Atru is a town in the Baran district in Rajasthan, India. It is located in the southeast of northern Indian state of Rajasthan. It is tehsil of Baran. It is located around 30 kilometers south of the Baran district [21] . Fig.1 shows study map of Atru tehsil of Baran districts of Rajasthan with the locations. Atru tehsil is the biggest tehsil of the Baran district, and has 141 villages under its administration. There are many facilities like a railway station, a hospital, schools, markets, well equipped rods for traffic. The town has a dry climate except during monsoon. The summer runs from March to mid of June, as in most parts of the country. The period from mid of June to September is the monsoon season followed by the months October to mid of November constitutes the post monsoon or the retreating monsoon. January is generally the coldest month with an average daily maximum temperature of **24.3** °C and the average daily minimum temperature of **10.6** °C. Usually, the town has a dry climate but in monsoons, the weather becomes humid. The months from November to February constitute winter. The average rainfall experienced by the town is around 895.2 mm.

METHODOLOGY

Estimation of Uranium in Ground Water Samples

Uranium analysis was done in LED fluorimeter LF-2 (Quantalase Enterprises Pvt. Ltd., India). Calibrate the fluorimeter with four uranium standards to check the instrument performance and the linear dynamic range. One uranium standard of 500 ppb can be prepared; each time 50 micro liter can be added to 5 ml ultrapure water and 0.5 ml buffer, to avoid the error in the preparation of lower ppb level standards. Also, the ppb level standards require fresh preparation before analysis. If the TDS level is low (less than 1500ppm) in clear drinking water samples, then the water sample can be directly analyzed for uranium using a fluorimeter, no chemical processing is required. Take 5 ml of water sample in a cleaned and dry suprasil quarts cuvette, add 0.5 ml of buffer (fluorescence enhancing agent that is 5 % sodium pyrophosphate solution, pH is almost 7 adjusted using phosphoric acid). Record the fluorescence response of the sample only, in terms of counts, minimum 4 repetitions. Add 50microliter of 500 ppb uranium standard onto the cuvette that contains the sample and buffer, record the fluorescence response of the first standard added (amount of standard additions depends on the sample fluorescence counts). Again add 50microliters of 500ppb uranium standard onto the cuvette and record the fluorescence response. **Estimation of Physico-chemical parameters in groundwater samples**

The measurement of ORP, TDS, EC (electrical conductivity), pH, Temperature, Salinity, DO, resistivity, was done using an in-situ using eutech instruments technology made easy cyber scan series 600 waterproof portable meter used portable electrode sensors. Measurement of nitrate, chloride, fluoride was done using a eutech instruments technology made easy cyber scan series 600 waterproof portable meter used portable electrode sensors. The measurements of total-hardness and Ca-hardness in groundwater/drinking water samples by EDTA Complex metric titration method. Here to determine Mg hardness by the simple difference between the values of Total hardness and Ca hardness. The measurements of total alkalinity were found by the H_2SO_4 titration method using methyl orange as an indicator, in the groundwater samples which was due to bicarbonate

ISSN 2394 - 7780

alkalinity only. The phosphate, sulphate concentrations were determined respectively by UV-Visible Spectrophotometer Instrument (Lab India UV/VIS Spectrophotometer). A UV-Visible spectrophotometer was used for the above techniques [1].

RESULTS AND DISCUSSION

The analytical results of uranium and other parameters of 34 drinking water samples collected from different villages in Atru tehsils of Baran district study area are presented in **table 1** for pre-monsoon and post-monsoon samplings. Gamma radiation level at the sampling sites was found between 79nSv/h to 114nSv/h with a mean value of 91.83nSv/h both in pre mansoon and post monsoon. There is no standard range prescribed for gamma radiation the cosmic radiation contributes to about 31nSv/h in mean sea level. pH value of ground water/drinking water ranged from 7.23 to 7.89, with an average, median, mode, standard deviation of pH is 7.55, 7.53, 7.45, 0.17 in pre monsoon and 7.18 to 7.78, with an average, median, mode, standard deviation of pH is 7.45, 7.46, 7.35, 0.16 in post monsoon. The minimum total dissolved solids value in the sample was estimated to be 667ppm while maximum as 1601ppm, mean of TDS is 996.67ppm in pre monsoon and minimum 616.1ppm and maximum 1327ppm, mean of TDS is 907.56ppm in post monsoon. TDS is found higher to BIS/WHO standards, TDS was found to be exceeding the permissible due to the large number of dissolved solids that are found in natural waters of the area. Fig.2 and 3 depicts spatial distribution of uranium in ground water samples during pre and post monsoon of atru tehsil of baran district. The electrical conductivity of ground water/drinking water of atru tehsil ranges between 663.4-1588µS/cm, mean of electrical conductivity is 983.27 in pre monsoon & from 600-1276µS/cm, mean of electrical conductivity is 872.41 in post monsoon . ORP values of analyzed water samples vary from 35.2 to 161.5mV, having average value of ORP is 78.05 in pre-monsoon and ranged between 36.10 to 162.2mV, with mean of ORP is 79.75 in post-monsoon. Fig.4 and 5 depicts percentage of uranium in groundwater samples under uranium range (pre and post monsoon) in the study area. Salinity value of water varies from 220-2456ppm, mean of salinity is 596 in pre monsoon and 618.3-1366ppm, mean of salinity is 918.10 in post monsoon. Fluoride value of water varies from 0.23-1.1ppm, mean of fluoride is 0.66 in pre monsoon and 0.36-1.3ppm, mean of fluoride is 0.85 in post monsoon. According to WHO/BIS standards, the fluoride was established to be exceeding the permissible limits i.e. 1.0ppm. The main cause of increase in fluoride may be due to the large number of accidental contamination of drinking water or fires or explosions. Chloride value of water varies from 42-1100ppm, mean of chloride is 294.38 in pre monsoon and 39-1000ppm, mean of chloride is 294.93 in post monsoon. According to WHO/BIS standards, the chloride was established to be exceeding the permissible limits i.e. 250ppm. The main cause of increase in chloride may be due to the anthropogenic or human-caused factors such as road salt, sewage contamination and water softeners. Nitrate value of water varies from 43-170ppm, mean of nitrate is 88.33 in pre monsoon and 38-250ppm, mean of 103.62 in post monsoon. The main cause for increase in nitrates may be due to the large number of well constructions, well location, overuse of chemical fertilizers, or improper disposal of human and animal waste. Total alkalinity value of water varies from 200-900mg/l, mean of total alkalinity is 509.44 in pre monsoon and 250-780mg/l, mean of total alkalinity is 498.12 in post monsoon. The total hardness value of water varies from 120-800mg/l, mean of total hardness is 287.55 in pre-monsoon and 110-780mg/l, mean of total hardness is 279.75 in post-monsoon. According to WHO/BIS standards, the Total hardness was found to be exceeding the permissible limits i.e. 200ppm. The reason for the increase in total hardness may be due to a large number of dissolved polyvalent metallic ions from sedimentary rocks, seepage and runoff from soils. Calcium and magnesium, the two principal ions, are present in many sedimentary rocks, the most common being chalk and limestone. The calcium hardness value of water varies from 56-620mgl/l, mean of Ca hardness is 191.44 in pre monsoon and 50-610mg/l, mean of Ca hardness is 186.25 in post-monsoon. Mg hardness value of water varies from 20-190mg/l, mean of Mg hardness is 96.11 in pre-monsoon and 20-170mg/l, mean of Mg Hardness is 93.5 in post-monsoon. The phosphate value of water varies from 0.16-0.98mg/l, the mean of phosphate is 0.55 in pre-monsoon and 0.42-0.96mg/l, mean of phosphate is 0.72 in post monsoon. The sulphate value of water varies from 18-93mg/l, mean of sulphate is 47.61 in pre monsoon and 15-90mg/l, mean of sulphate is 47 in post monsoon. Carbonate value of water varies from 0-360mg/l, mean of carbonate is 136.66 in pre monsoon and 0-360mg/l, mean of carbonate is 86.25 in post monsoon. Bicarbonate value of water varies from 20-800mg/l, mean of bicarbonate is 367.77 in pre monsoon and 90-660mg/l, mean of bicarbonate is 411.87 in post monsoon. Uranium value of water varies from 1.1-13.1ppb, mean of uranium is 4.09 in pre monsoon and 2.4-15.6ppb, mean of uranium is 5.8 in post monsoon. The total hardness, fluoride, chloride, nitrate, total alkalinity level was found to be higher than the prescribed limit 200ppm, 1ppm, 250mg/l, 45ppm and 200ppm whereas other physic-chemical water quality parameters were found to be within the permissible limit. The minimum uranium value was establish to be 1.1 ppb and maximum uranium value was establish to be 13.1ppb, mean value of uranium is 4.09 in pre monsoon and the minimum uranium value was establish to be 2.4ppb and maximum uranium value was established to be 15.6ppb, mean value of uranium is 5.8 in post

ISSN 2394 - 7780

monsoon in the study area. The uranium level determined for some villages areas of Atru tehsil of Baran districts of Rajasthan was established to be within the permissible limit. Fig.6 to 9 shows correlation of the Uranium with F^-, NO_3^-, SO_4^-, PO_4^{-3} in drinking water samples in pre monsoon and post monsoon in the study area.

Human Health Impact of Uranium

Uranium is a radioactive element that discharges first and foremost alpha particles and is correlated with many health risks. Uranium is a deadly chemical only if it is taken in to the body as it is an alpha emitter. The Uranium adulterate water does not cause any radiological effects although chemically it can affect the human body. Kidneys are the primary attack of uranium contamination. A higher Uranium trace causes the failure of the functioning of the kidneys. The passage between the pharynx and stomach cancers are also an effect of regularly consumption of uranium pollute water [23].

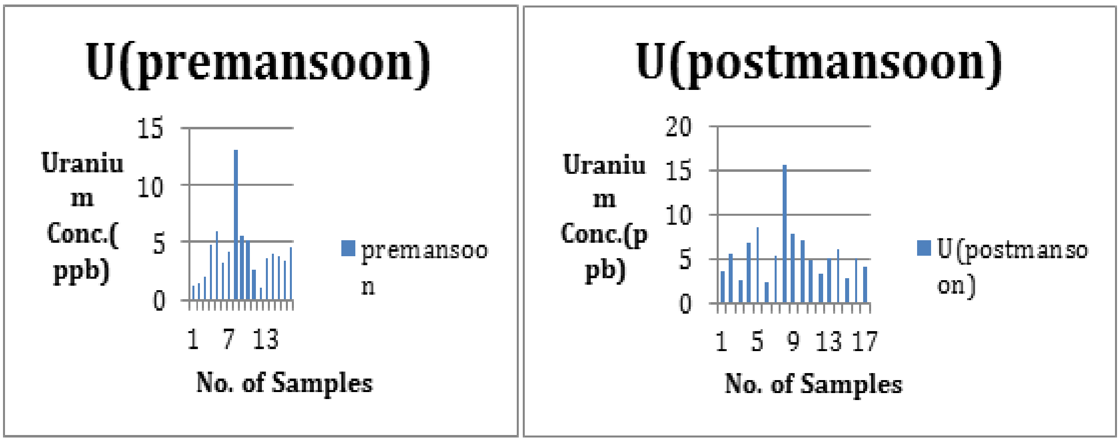


Fig. 2 and 3: Spatial distribution of uranium in groundwater samples during pre and post monsoon of atru tehsil of baran district

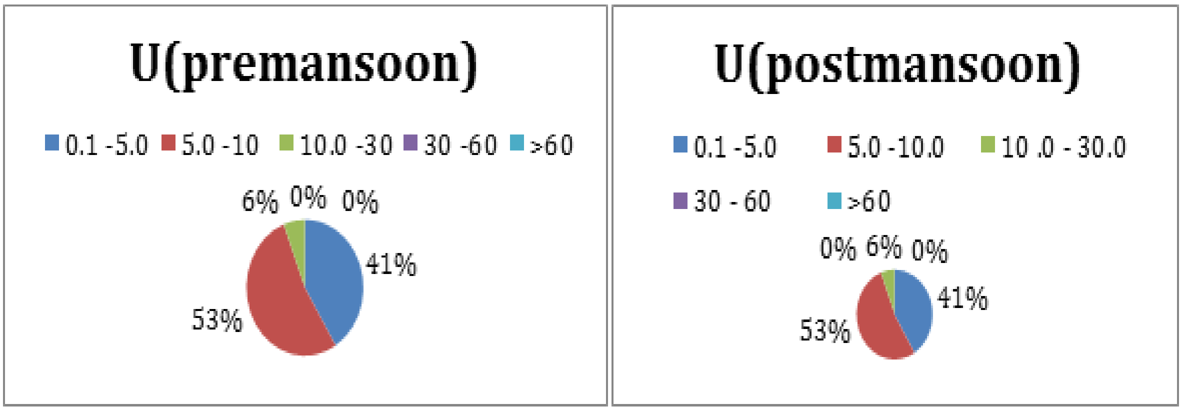


Fig.4 and 5: Percentage of uranium in groundwater samples under uranium range (pre and post monsoon)

Correlation coefficient = r

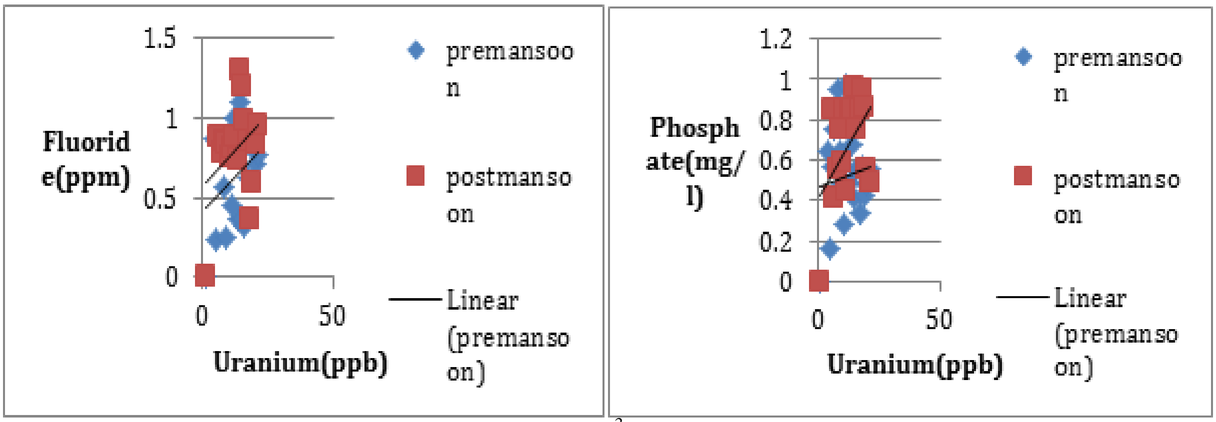
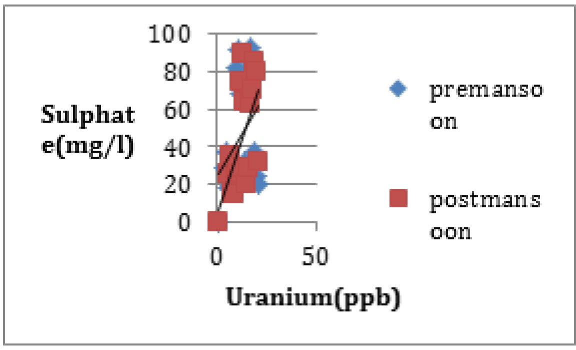


Fig.6 and 7: Correlation of the Uranium with F^-, PO_4^{-3} in drinking water samples in pre monsoon and post monsoon (r = 0.217269 (pre mansoon), r = 0.36377(post mansoon) and r = 0.01474 (pre mansoon), r = 0.325635(post mansoon))



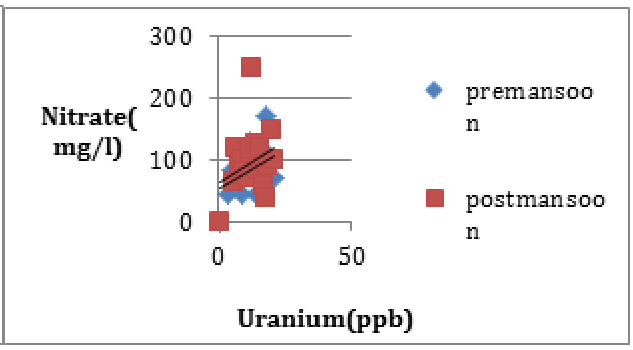


Fig.8 and 9: Correlation of the Uranium with Sulphate, Nitrate in drinking water samples in pre monsoon and post monsoon (r = 0.257513 (pre mansoon), r = 0.321573 (post mansoon) and r = 0.362589 (pre mansoon), r = 0.701957(post mansoon))

Table.1: Summary of Maximum, Minimum, Mean, Median, Mode of Uranium and Physico-chemical water quality parameters in Atru tehsil of Baran district of Rajasthan, India (pre monsoon and post monsoon).

Parameter	**Pre-monsoon**						**Post-monsoon**						**BIS/WHO limits**
	Maximum	Minimum	Mean	Median	Mode	STD EV	Maximum	Minimum	Mean	Median	Mode	STD EV	
pH	7.89	7.23	7.55	7.53	7.45	0.17	7.78	7.18	7.45	7.46	7.35	0.16	6.5-8.5
TDS(ppm)	1601	667	996.67	911.15	-	265.21	1327	616.1	907.56	855.35	-	213.57	500
EC(µS/cm)	1588	663.4	983.27	906.65	-	257.42	1276	600	872.41	826	-	208.64	-
ORP(mV)	161.5	35.2	78.05	74.10	-	31.35	162.2	36.10	79.75	74.7	44.2	33.03	-
Temp.	33.8	20.8	31.63	32.4	32.4	2.78	21.8	19.4	20.63	20.6	20.4	0.83	-
Salinity(ppm)	2456	220	596	447	663	531.76	1366	618.3	918.10	884.10	-	213.13	-
DO(%)	8.34	3.26	6.66	5.81	-	1.17	8.26	5.36	7.16	7.21	-	0.74	-
Fluoride(ppm)	1.1	0.23	0.66	0.36	0.36	0.27	1.3	0.36	0.85	0.84	0.89	0.21	1.0
Chloride(ppm)	1100	42	294.38	195	157	273.36	1000	39	294.93	225	140	259.46	250
Nitrate(ppm)	170	43	88.33	85	45	33.54	250	38	103.62	95	120	48.18	45
Total alkalinity(mg/l)	900	200	509.44	530	450	184.78	780	250	498.12	490	490	149.18	200
Total Hardness(mg/l)	800	120	287.55	235	180	169.18	780	110	279.75	245	-	172.66	200
Ca Hardness(mg/l)	620	56	191.44	135	100	134.87	610	50	186.25	120	120	141.23	-
Mg Hardness(mg/l)	190	20	96.11	103	120	50.29	170	20	93.5	105	110	47.77	-
Phosphate (mg/l)	0.97	0.16	0.55	0.56	0.64	0.20	0.96	0.42	0.72	0.80	0.85	0.18	-
Sulphate(mg/l)	93	18	47.61	34.5	37	27.44	90	15	47	33.5	25	27.08	200

Carbonate (mg/l)	360	0.0	136.66	180	0.0	112.77	360	0.0	86.25	80	0.0	100.05	-
Bicarbonate (mg/l)	800	20	367.77	330	-	221.18	660	90	411.87	420	650	165.98	-
Uranium(ppb)	13.1	1.1	4.09	3.91	4.10	2.66	15.6	2.4	5.8	5.25	5.10	3.21	60(AERB)

CONCLUSION

Uranium levels were established to vary from 1.1-13.1ppb in pre monsoon and 2.4-15.6ppb in post-monsoon respectively. Hence the ground water samples analyzed by LED Fluorimeter in the present study of Atru tehsil of Baran districts of Rajasthan, India were found suitable as ground 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 a particular situation so that they will be provided with an accurate cost of the available systems, based on specific water quality. If the levels of Uranium exceed its permissible limits, then 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 vapors, then returning it to its liquid state. The minerals and contaminants such as uranium form scales and are trapped in the boiling chamber. However, it is well within the safe standard limit of BIS, WHO, USEPA and AERB.Uranium with fluoride nitrate, sulphate, phosphate weak positive correlation during pre-mansoon and post-mansoon in the study area. These types of significant positive correlation between the ions indicated that the ions are from the same source of origin. Times to time quantitative and qualitative measurements are needed to constantly monitor the physic-chemical water quality parameters from the various groundwater sources to adopt appropriate remediation strategies [(24)].

ACKNOWLEDGEMENTS

This study was funded by BRNS, DAE under NUP. The Authors would like to acknowledge members of SIESASCN, TSC-4, NRFCC, BRNS; HPD, HS&E Group, BARC and NUP team members for their continuous support in the execution of the project.

REFERENCES

1. BARC. (2012).Standard methods for the examination of water. Bhabha Atomic Research Centre (BARC), India.
2. Ministry of Jal Shakti Per Capita Availability of Water Posted on :02 MAR 2020 by PIB Delhi.
3. Rao, K.N., Latha, P.S.(2020). Groundwater quality assessment using water quality index with a special focus on vulnerable tribal regions of Eastern Ghats hard rock terrain, Southern India. Arab. J. Geosci, 12, 1–16.
4. Maharjan, A.K., Kamei, T., Amatya, I.M., Mori, K., Kazama, F., and Toyama, T.(2020). Ammonium-Nitrogen (NH4 +-N) Removal from Groundwater by a Dropping Nitrification Reactor: Characterization of NH4 +-N Transformation and Bacterial Community in the Reactor. Water , 12, 599.
5. Nurtazin, S., Pueppke, S., Ospan, T., Mukhitdinov, A., and Elebessov, T.(2020). Quality of Drinking Water in the Balkhash District of Kazakhstan's Almaty Region. Water, 12, 392.
6. UNSCEAR,. (2016). Sources and effects of ionizing Radiation, United Nations Scientific Committee on the Effect of Atomic Radiation, Annex D – Biological effects of selected internal emitters – Uranium, United Nations, New York.
7. Central Ground Water Board (2015).
8. Javed A, Wani MH (2009). Delineation of groundwater potential zones in Kakund watershed, eastern Rajasthan, using remote sensing and GIS techniques. J Geol Soc India 73(2): 229–236.
9. Gopalan CV (2011). A comparative study of the groundwater potential in hard rock areas of Rajapuram and Balal, Kasaragod, Kerala J Ind Geophys Un 15(3), pp:179–186.

ISSN 2394 - 7780

10. Sivaramakrishnan J, Asokan A, Sooryanarayana KR, Hegde SS, Benjamin J (2015). Occurrence of Ground Water in Hard Rock Under Distinct Geological Setup, International conference on water resources, coastal and ocean engineering , Aquatic Procedia, Volume 4, Pp :706-712.

11. Vittala SS, Govindaiah S, Gowda HH (2005). Evaluation of groundwater potential zones in the sub-watersheds of North Pennar river basin around Pavagada, Karnataka, India using remote sensing and GIS techniques. J Indian Soc Remote Sens 33(4), pp:483–493.

12. Michel J, Richard Cothern CR, Rebers PA (1991). Relationship of radium and radon with geological formations, Radon, Radium and Uranium in Drinking Water, 2nd ed, Lewis Publishers, Chelsea, MIp, Pp: 83– 96.

13. Ortega, X., Valles, I. and Serrano, I. (1996). Natural radioactivity in drinking water in Catalonia (Spain). Environment International 22(1): S347- S354.

14. Kumar, C (2011). Glutathione revisited: a vital function in iron metabolism and ancillary role in thiol-redox control. EMBO J 30(10):2044-56.

15. Bucur C, Olteanu M, Pavelescu M (2006). Radionuclides diffusion in geological media. Romania," Journal of Physics, Vol. 51(3–4) p. 469–478.

16. Brugge, D. and Oldmixon, B.: Exposure pathways and health effects associated with chemical and radiological toxicity of natural uranium: a review, Reviews on environmental health, 20(3), 177-194, 2005.

17. Fontes, J., (1983). Dating of groundwater, In: Guidebook of Nuclear techniques in Hydrology, Technical Report Series No. 91, International Atomic Energy Agency, Vienna, 285- 317.

18. Kurttio, P., Harmoinen, A., Saha, H., Salonen, L., Karpas, Z., Komulainen, H. and Auvinen, A. Kidney toxicity of ingested uranium from drinking water. American journal of kidney diseases, 47(6), 972-982. 2006.

19. Bleise A, Danesi PR, Burkart W (2003). Properties, use and health effects of depleted uranium (DU): a general overview. Journal of environmental radioactivity, 64(2), 93-112.

20. Jac VG (2012). Groundwater and Global Change: Trends, Opportunities and Challenges side publications series: 01, United Nations world water assessment programme, UNESCO.

21. Falling Rain Genomics, Inc-Atru.

22. Hydrogeological Atlas of Rajasthan Baran District.(2013).Groundwater Department of Rajasthan.

23. Parimalarenganayaki,S., Rahul,A., Thabrez,M.H., Anbuchzhian,R., Manoj,S., and Elango, L. Assessment of Uranium concentrations in groundwater and its human health impact in a part of Northern Tamil Nadu, India.Drink.Water Eng.Sci.Discuss.2019, 1-17.

24. Koiliyar,J.G.,Pital,P.and Mukadam, A.(2021).Spatial Distribution of Uranium and its associated Water Quality Parameters in Thane Districts Maharashtra.IJCRT.9(4),2992.