Poll Res. 39 (November Suppl. Issue) : S64-S69 (2020)

ISSN 0257–8050

INFLUENCE OF PHYSICO-CHEMICAL AND RADIOLOGICAL PARAMETERS IN THE GROUND WATER OF LAKHISARAI DISTRICT OF BIHAR, INDIA

SUBHASH PRASAD SINGH* AND PALASH KUMAR DUTTA

Department of Chemistry, A.N. College, Patna (Bihar), India

(Received 27 May, 2020; accepted 27 June, 2020)

ABSTRACT

This paper presents groundwater quality in Lakhisarai district of Bihar, India. Various analytical methods of water were used for various parameters. LED Fluorimetry has been used to measure the concentration of uranium in the ground water samples collected from the selected study locations of the study zone. The concentration of uranium in the collected water samples is found to vary in the range from 0.6 µg/L to 26.04 µg/L with a geometric mean value of 9.81 µg/L during pre-monsoon whereas in the range 0.54 µg/L to 29.86 µg/L with a geometric mean value of 10.70 µg/L during post-monsoon. All the water samples show the concentration of uranium well within the safe limit of 30 µg/L, set by the WHO. Few physicochemical parameters of water such as pH, EC, DO, Total dissolved solids (TDS), ORP, salinity, major cations, and major anions were also measured. Fluoride content in 19.04% water samples during pre-monsoon was found to be greater than BIS acceptable limit of 1 ppm-1.5 ppm. The correlation coefficient among the measured parameters was determined to find the dependence, if any, on the concentration of uranium in the water samples.

KEYWORDS: Groundwater, LED fluorimeter, Major cations, Major anions

INTRODUCTION

Groundwater is being used by the residents of Lakhisarai district (Bihar) as drinking water.. Hence, the measurement of concentration of uranium in drinking water was thought to be important to be assessed along with associated water quality parameters. Uranium is a naturally occurring radioactive trace element found in all matrices of environment. Lithology, geomorphology, other geological conditions and anthropogenic activities in the region affects the physico-chemical and radiological condition of groundwater (ATSDR/ USA, 1999). The physicochemical parameters of water influence the concentration of uranium in water (Sridhar *et al.,* 2008). Despite chemical and radiological toxicity of uranium (Srivastava, 2015 and Sharma *et al.,* 2016), it has not been routinely measured as an indicator of drinking water quality. The two important organs that is kidneys and lungs have been reported to be affected by excess dose of uranium (Singh *et al,* 2003, Shivaprasad, 2012 and Yasovardhan *et al.,* 2013). The physicochemical parameters (pH, TDS, EC, ORP, DO, hardness, alkalinity, major cations, major anions, and trace elements) of water samples collected were analysed to find the correlation if any with the uranium concentration measured so that ecological risk assessment (Mittal *et al.,* 2014 and Tchounwou *et al.,* 2012) could be made.

Description of the study area

Lakhisarai district has a historical importance. It is located in southern part of Bihar state and extends from 25^0 01′ to 25^0 22′ North Latitude and 85^0 50′ to 86^0 17′ East Longitudes with a geographical area of 1301 km². The district forms a part of Phalgu-Kiul sub-basin of Ganga Basin (Singh, 1965). The district comprises catchments of Ganga and Kiul river systems. The district is having moderate to low drainage density with dendritic and radial patterns dominating in the hilly regions, while parallel to

sub-parallel drainage pattern in the plains. The district has a diverse landscape ranging from hills to flood plains. The major geomorphic units are rocky upland, pediplain, alluvial plain and flood plains. It consists mainly of Inceptisols, Entisols and Alfisols group of soils generated under different lithological and pedogenic conditions. Hydrogeologically, the district is divided into two parts (a) hard rock/ fissured formation (b) unconsolidated / porous formations. The hard rock / fissured formation comprise rocks of Chotanagpur Gneissic Complex (CGC) and Kharagpur formation. They are composed mainly of granite gneisses (Singh *et al.*, 2018), quartzites and phyllites. In general, these rocks possess poor aquifers until or unless they have developed secondary porosities by means of weathering and/or fracturing. The alluvium comprises clay, silt and sand of various thicknesses. Crystalline silica has long been a serious hazard in mining, with the risk of silicosis. Silicosis has been subject to considerable investigation. As far as impact on surface water is concerned, during mining and transportation, there are chances of contamination of surface water resources (pond, well etc.) with dust or by other means. Aquifers in this formation occur under unconfined to semi-confined conditions. Fig. 1 shown below reflects India map-Bihar State Map-Lakhisarai district map.

MATERIALS AND METHODS

Sample Collection

Extensive sampling of drinking water / groundwater from study area was carried out in pre- and post- monsoon. Sample was collected preferably from the centre of each grid. The place of sampling and sampling point was located in the grid using the grid map and GPS. Fig. 2 reflects the grid map of Lakhisarai district (optimized grid size of 6km x 6km using latitude-longitudes reference coordinates).

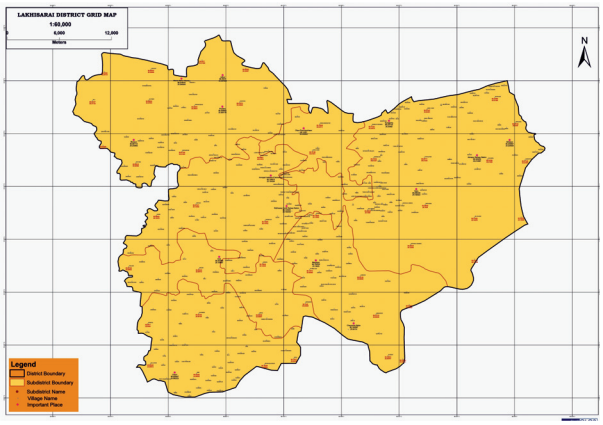

Fig.2. Grid map of Lakhisarai district

Potable ground water samples were carefully collected from the study area as per the established guidelines in cleaned plastic containers. Radiation meter was used to measure gamma radiation at the sampling site. The pH, temperature, TDS, dissolved oxygen, oxidation reduction potential, salinity and electrical conductivity of the fresh water samples were measured immediately on the spot. The filtered (Whatmann 42) water samples were analyzed for the concentration of uranium using a pre-calibrated LED Fluorimeter, LF-2A (NUP/ BARC, 2016). The methods/instruments used for the analysis of various parameters are listed in Table 1 given below:

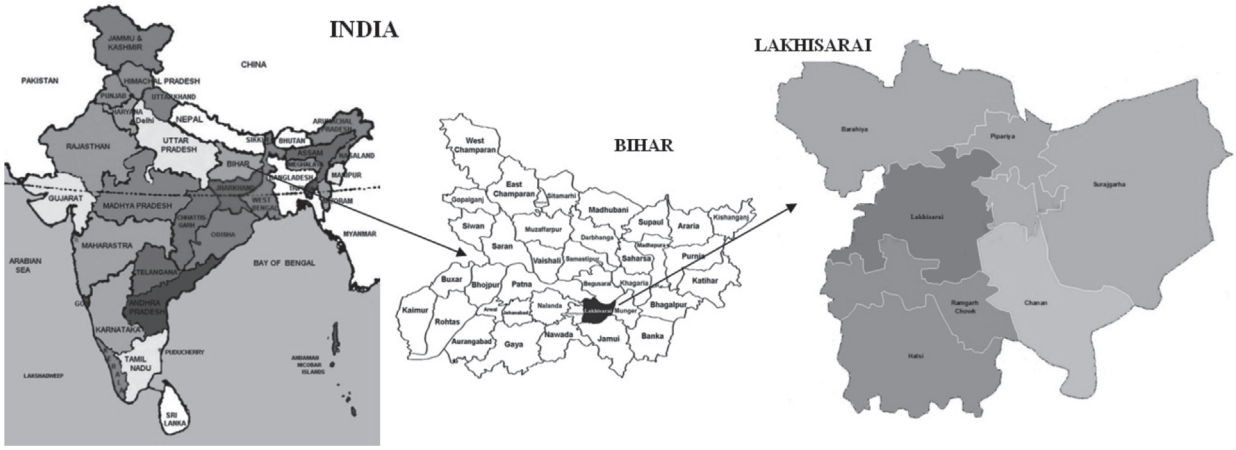

Fig 1. India map-Bihar State Map-Lakhisarai district map

Table 1. Method/Instruments used for the analysis of different parameters

Sl. No.	Parameters	Technique / Method used for analysis (APHA, 2012)
1	pH	Portable pH sensor (Electrode based)(Water Analyser 371, Systronics make)
2	EC (Electrical Conductivity)	Portable EC sensor (Electrode based)(Water Analyser 371, Systronics make)
3	TDS (Total Dissolved Solids)	Portable TDS Sensor (Electrode based)(Water Analyser 371, Systronics make)
4	Salinity	Portable Salinity Sensor (Electrode based)(Water Analyser 371, Systronics make)
5	ORP (Oxidation Reduction Potential)	ORP Tester (Electrode based)(Water Analyser 371, Systronics make)
6	Temperature	Temperature sensor (Water Analyser 371, Systronics make)
7	DO (Dissolved Oxygen)	Membrane based (Water Analyser 371, Systronics make)
8	TH (Total Hardness)	Titrametric method (EDTA Titration)
9	TA (Total Alkalinity)	Titrametric method (H_2SO_4 Titration)
10	Carbonate	Theoretically estimated
11	Bicarbonate	Theoretically estimated
12	Fluoride	VIS Spectrophotometer 106 (Systronics) / Ion Selective method
13	Chloride	Titration
14	Nitrate	Titration / UV Spectrophotometer (Systronics)
15	Sulphate	VIS Spectrophotometer 106 (Systronics)
16	Phosphate	VIS Spectrophotometer 106 (Systronics)
17	Uranium	LED Fluorimeter LF-2a (Quantalase, Indore)

RESULTS AND DISCUSSION

The descriptive statistical data obtained in the present investigation for the concentration of uranium and the physicochemical parameters for the drinking water samples collected from the study area during pre- and post-monsoon are presented in Table 2.

The concentration of uranium in the water samples is found to vary in the range 0.6 µg/L to 26.04 µg/L with a geometric mean value of 9.81 µg/L and median value of 7.96 µg/L during pre-

Table 2. Descriptive statistical analysis of Uranium and associated water quality parameter

Parameters	Pre-monsoon				Post-monsoon				BIS limits (BIS, 2012) (Desirable – Permissible)
	Min	Max	Average	Median	Min	Max	Average	Median	
pH	6.4	7.9	7.34	7.4	6.8	7.98	7.4	7.38	6.5 – 8.5
TDS (ppm)	180	5446	615.83	345.5	244	4590	654.02	442.5	500ppm – 2000ppm
EC (µS/cm)	362	9723	1208.07	721.50	429	8010	1172.81	773.5	-
Salinity (ppm)	178.47	4793.44	595.66	355.59	270	4860	708.81	470	
ORP (mV)	-105	270	72.57	99.5	-46	8.0	-15.64	-15.5	-
Temp. (°C)	27	33	29.88	30	24.4	28.5	27.40	27.9	-
DO (ppm)	1.2	9.6	3.42	2.8	3.1	7.9	4.94	4.8	-
F^- (ppm)	0.67	2.96	1.41	1.32	0.17	2.8	0.75	0.66	1ppm - 1.5ppm
Cl^- (ppm)	10.64	1056.41	90.398	37.22	17.72	1722.87	129.56	49.63	250ppm – 1000ppm
NO_3^- (ppm)	0.5	16.6	4.724	3.9	0.5	17.1	5.105	4.3	45ppm – 100ppm
SO_4^{2-} (ppm)	1.0	91.0	15.99	3.75	0.83	261.56	40.39	18.15	200ppm – 400ppm
PO_4^{3-} (ppm)	0.21	0.98	0.32	0.28	0.31	1.16	0.39	0.34	-
U (ppb) (WHO)	0.6	26.04	9.81	7.96	0.54	29.86	10.70	6.96	60ppb (AERB)30ppb
Total Hardness (ppm)	55	635	157.26	137.50	105	1290	256.19	215	300ppm-600ppm
Ca Hardness (ppm)	25	435	92.02	82.5	80	860	193.69	170	-
Mg Hardness (ppm)	10	200	65.24	55	5.0	430	62.5	37.5	-
Total Alkalinity (ppm)	45	980	161	122.5	65	995	183.57	155	200ppm – 600ppm
Bicarbonate(mg of $CaCO_3$)	45	980	161	122.5	65	995	183.57	155	

monsoon whereas it varies in the range 0.54 µg/L to 29.86 µg/L with a geometric mean value of 10.70 µg/L and median value of 6.96 µg/L during post-monsoon. All the samples show concentration of uranium within the safe limit of 30 µg/L and 60 µg/L as set by USEPA (USEPA, 2011), WHO (WHO, 2011) and AERB (AERB, 2004) respectively. Fig. 3 and 4 show Pre- & post histogram of uranium, and hotspot of uranium in the study area respectively.

pH, EC, TDS, Salinity and ORP in the water samples were found to vary in the range of 6.4-7.9, 6.8-7.9; 362 µS/cm-9723µS/cm, 429µS/cm-8010 µS/cm; 180 ppm-5446 ppm, 244 ppm-4590 ppm; 178.47 ppm-4793 ppm, 270 ppm-4860 ppm and -105mV to 270mV, -46mV to 8.0mV during pre- & post-monsoon, respectively.

The TDS level was found to be higher than the BIS acceptable limit of 500 ppm-2000 ppm for 4.76% water samples in pre-monsoon and 7.14ppm in post-monsoon.

Fluoride (Ahda *et al.*, 2017) concentration was measured in the range of 0.67 ppm-2.96 ppm with the median value of 1.32 ppm during pre-monsoon and in the range of 0.17 ppm-2.8 ppm with the median value of 0.66 ppm during post-monsoon.

2.38% of water samples each in pre- & post-monsoon were found to have chloride level more than that of the BIS acceptable limit of 250 ppm-1000 ppm. The values of chloride concentration were measured in the range of 10.64 ppm-1056.41 with a median value of 37.22 ppm and 17.72 ppm-1722.87 ppm with a median of 49.63 ppm during pre- & post-monsoon respectively.

2.38% of water samples each in pre- and post-monsoon were found to have. Total Hardness concentration more than that of the BIS acceptable limit of 300 ppm-600 ppm. The values of TH were measured in the range of 55 ppm-635 ppm with a

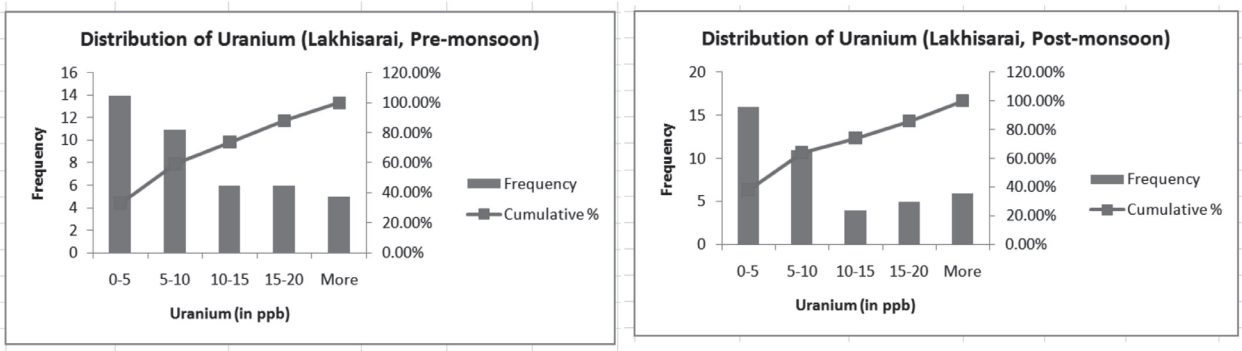

Fig. 3. Pre- & post-monsoon histogram of uranium (µg/L) in the ground water samples of the study area

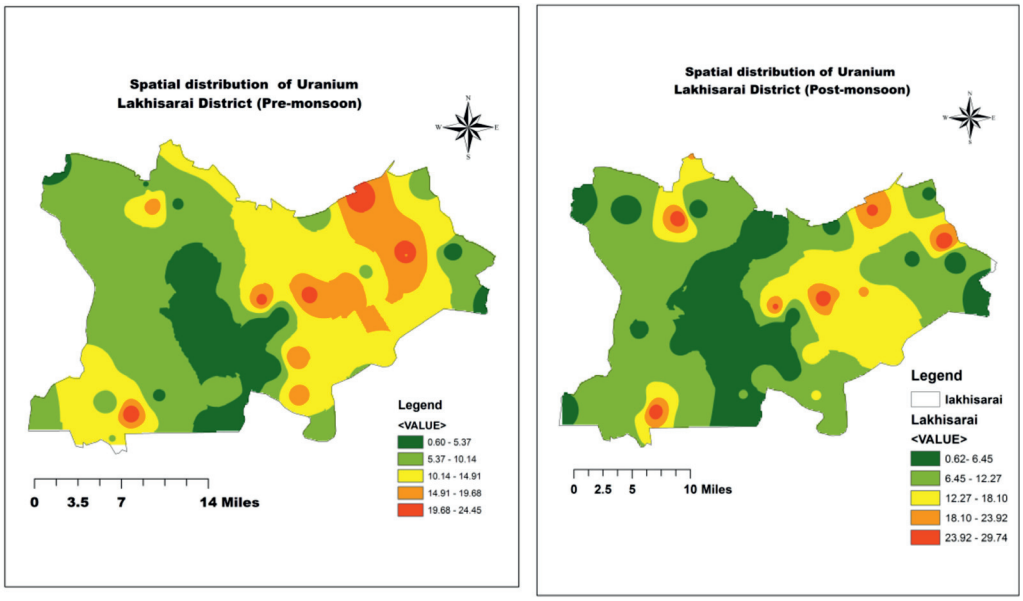

Fig. 4. Pre- & post-monsoon hot spot of uranium

median value of 137.5 ppm and 105 ppm-1290 ppm with a median of 215 ppm during pre- & post-monsoon respectively.

2.38% of water samples each in pre- & post-monsoon were found to have Total Alkalinity (TA) more than that of the BIS acceptable limit of 200 ppm-600 ppm. The values of TA concentration were measured in the range of 45 ppm-980 ppm with a median value of 122.5 ppm and 65 ppm-955 ppm with a median of 155 ppm during pre- & post-monsoon respectively.

Nitrate (Nolan *et al.,* 2015) and Sulphate level in water sample during pre- & post- monsoon were found to be lesser than BIS acceptable limit of 45 ppm-100 ppm and 200 ppm-400 ppm respectively.

The correlation analysis of the various parameters measured in the present study revealed that there existed a positive correlation of uranium with total hardness, calcium, magnesium, and total alkalinity during pre-monsoon whereas in post-monsoon evidence of having positive correlation of uranium (Singh *et al.,* 2003) with TDS, EC, salinity, sulphate and magnesium was observed during post-monsoon. A high value (approaching +1.00) is a strong direct relationship, values near 0.50 are considered moderate and values below 0.30 are considered to show weak relationship. A low negative value (approaching -1.00) is similarly a strong inverse relationship, and values near 0.00 indicate little, if any, relationship.

CONCLUSION

The concentration of uranium in all of the ground water samples collected from the study area of Lakhisarai is well within the permissible limit set WHO (2011), US EPA (2011) and AERB (2004). There seems to have good correlation of Uranium concentration with TDS, EC, Salinity, Chloride and Sulphate during pre- & post- monsoon. Fluoride content in 19.04% water samples during pre-monsoon and in 2.38% water samples during post-monsoon were found to be greater than BIS (2012) acceptable limit of 1 ppm-1.5 ppm. However, other associated water quality parameters in general along with Uranium were found well within the recommended limit of BIS. The levels of different parameters in general were appeared to have hardly any significant risk. Hence water samples analyzed were found suitable in general as potable water after proper required treatment.

ACKNOWLEDGEMENT

The authors are thankful to the residents of the study area for their cooperation during the sample collection. We owe special thanks to Dr Ajay Kumar, Health Physics Division, BARC, Mumbai along with the member of TSC-4, NRFCC, BRNS, HPD, HS & E Group, BARC and NUP team members for their continual support in the execution of the study. Thanks are also due to the Dept of Chemistry, A N College for their support as and when needed.

REFERENCES

Ahda, C. P. and Suthar, S. 2017. Assessment of human health risk associated with high groundwater fluoride intake in southern districts of Punjab India. *Exposure and Health.* 11 : 267-275.

APHA (American Public Health Association), *Standard Methods for Examination of Water and Wastewater*, 22nd Edition, 2012.

Atomic Energy Regulatory Board AERB, 2004. Limit on uranium in drinking water, Atomic Energy Regulatory Board.

The Bureau of Indian Standard DRINKING WATER-SPECIFICATION (Second Revision), IS 10500 : 2012

Mittal, S., Kaur, G. and Vishwakarma, G.S. 2014. *Human and Ecological Risk Assessment.* 20 : 366-387.

Nolan, J. and Weber, K. A. 2015. Natural uranium contamination in major US aquifers linked to nitrate. *Environmental Science and Technology Letters.* 2(8) : 215-220.

NUP, BARC Standard Protocol for National Uranium Project, 2016.

Sharma, N. and Singh, J. 2016. Radiological and chemical risk assessment due to high uranium contents observed in the ground water of Mansa District (Malwa region) of Punjab state, India: An area of high cancer incidence. *Exposure and Health.* 8 (4) : 513-525.

Shivaprasad, N.G. 2012. Studies on natural radiation level in the environment of Bangalore, India.Bangalore: Bangalore University.

Shrivastava, B. K. 2015. Elevated uranium and toxic elements concentration in groundwater in Punjab state of India: extent of the problem and risk due to consumption of unsafe drinking water. *Water Qualiy, Expore and Health.* 7 : 407-421.

Singh, S., Rani, A., Mahajan, R.K. and Walia, T.P. 2003. Analysis of uranium and its correlation with some physic-chemical properties ofdrinking water samples from Amritsar, Punjab. *J Environ Monit.* 5: 917-921.

Singh, K. P., Kishore, N., Tuli, N., Loyal, R. S., Kaur, M., and Taak, J. K. 2018. Uranium Contamination of

Groundwater in Southwest Parts of Punjab State, India, with Special Reference to Role of Basement Granite. In: *Clean and Sustainable Groundwater in India* (pp. 95-106). Springer, Singapore.

Singh, U. 1965. Ditribution and Character of Cities of the Ganga Plain. *National Geographical Journal of India* XI P.37.

Sridhar Babu, M.N., Somashekar, R.K., Kumar, S.A., Shivanna, K., Krishnamurthy, V. and Eappen, K.P. 2008. Concentration of uranium levels in groundwater. *Int J Environ Sci Tech.* 5 : 263-266.

Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K. and Sutton, D.J. 2012. *National Institute of Health Public Aces,* doi:10.1007/978-3-7643-8340-4_6.

Toxicological Profile for Uranium. 1999. US Department of Health Physics and Human Service. Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, USA

US EPA (Environmental Protection Agency), Edition of the Drinking Water Standards and Health Advisories, 2011.

World Health Organization (WHO), Guidelines for Drinking Water Quality, 4th Edition-2011.

Yasovardhan, N., Basha, A.M., Satyanarayana, S.V., Reddy, G.V., Vishwa Prasad, K. and Padma Savithri, P. 2013. Seasonal assessment of natural uranium in drinking water around *Tummalapalle uranium* mining site, Kadapa district, India. *Int J Recent Sci Res.* 4 : 1406-1409.