Asian Journal of Water, Environment and Pollution, Vol. 7, No. 1, pp. 71-76.

Elevated Alpha Radiation Level in Water of River Subarnarekha and Tube Well at In-and-Off Zone of Jaduguda Mine, India

Dipak Ghosh[1,2], Argha Deb[1,2], Biswajit Das[3] and Rosalima Sengupta[1,2]

[1]Biren Roy Research Laboratory for Radioactivity and Earthquake Studies
School of Studies in Environmental Radiation and Archaeological
Sciences, Jadavpur University, Kolkata 700 032, India
[2]Nuclear and Particle Physics Research Centre, Department of
Physics, Jadavpur University, Kolkata 700 032, India
[3]Sitananda College, Nandigram, Purba Medinipur, West Bengal, India

Received March 12, 2009; revised and accepted December 8, 2009

Abstract: The Subarnarekha river is a major river rising from the Chota Nagpur plateau of Jharkhand State, India. After passing through Jharkhand state, the river enters the Indian state of West Bengal, Orissa and finally falls into the Bay of Bengal. Jaduguda mine which is the foundation on which the Indian nuclear fuel chain rests is situated at Jharkhand state near the R. Subarnarekha course. In order to observe the contamination effect of Jaduguda mine on the river, we have collected river water samples from nine different locations along the path of the river and measured alpha activity in those samples. High level of alpha radioactivity is found in all the samples even at far sites from mine region and it is interestingly seen that alpha activity decreases as we go near-to-far locations from the mine. Tube-well samples were also collected from the same locations and in that case also similar trend was seen.

Key words: R. Subarnarekha, Jaduguda mine, alpha activity, river and tube-well water.

Introduction

Mining of metals invariably leaves its marks on the environment by producing huge amount of waste materials which in turn are piled up and dumped on the land surface. These dumped waste material or rock leaches in water and surface body and thus plays the role of potential source of pollution system. This pollution turns into hazardous contamination when it relates with radioactive material mines like uranium mine. Uranium is a natural lithophilic element and is contained almost everywhere on earth – though evidently its concentration is much higher near its mine area. It has both chemical and radiological toxicity with the two important target organs – kidney and lungs (WHO, 1998; ATSDR, 1990, 1999). It also appears to effect the brain. The leaching of uranium from its mine area to adjacent areas increases in case of any river flows through that region and water bodies – may it be ground or surface – get contaminated with high level of uranium concentration. Water containing above a few μg/l of uranium concentration is not at all safe for drinking purpose (Mehra et al., 2007). Hence the need of estimation of radioactivity in uranium mine area is very much essential and important as well. All around the globe some important works have been done on assessment pollution level of waste dump from mines. In China, chemical assessment has been done in leached dump at Dexin copper mine (Wu et al., 2009). Radium activity and radon exhalation rate has been measured by SSNTD and Alpha Guard from phosphate ore at Egyptian mine regions (Saad, 2008). In Poland some important works have been done on observation of radiological impact due to radioactive discharge into Golaweicki river (Skubacz et al., 1993); coal mine discharge into river (Chalupnik et al., 2001). According to Polish Atomic Energy Agency, water containing more than 0.7 kBq/m^3 of ^{226}Ra must be treated as waste material enhanced with radioactivity (Decree, 1989). The environmental waste management programme in two uranium production units in Brazil was carried out by Fernandes and team (Fernandes et al., 2008).

In India, all of the uranium of Pressurised Heavy Water Reactors (PHWR) comes from a single processing plant at Jaduguda, a sprawling complex fed by three underground uranium mines. The uranium ore is mined from underground and brought to the surface. Uranium is then extracted and processed to make ‘yellow cake’ which is used in fuel nuclear plants. The left behind ‘tailings’ or effluents comprises radioactive products which are mixed into slurry and pumped into tailing ponds. These ponds are situated between adjoining villages. In this site the leaching of uranium in river water and ground water is very much influenced by river Subarnarekha. It flows near the Jaduguda uranium mine area and merges into Bay of Bengal. Concentration of heavy metals in the sediments of Subarnarekha river has been measured in India (Panda et al., 2006). Assessment of radioactivity at uranium mining at Jaduguda has been done by Tripathi et al. (2008). The uranium and ^{226}Ra in groundwater sources in tailing pond was found as 3.6 µg/l and 23 mBq/l respectively. No more exhaustive study on measurement of radioactivity in this mine area has been done yet.

The knowledge of distribution of radionuclides and radioactivity levels in the environment is important for assessing the radiation exposure to the population. The importance of assessment of radioactivity drives us to take a programme in this regard. We have chosen nine different places in the course of river Subarnarekha starting from Jaduguda and ending near its mouth. The places of water collection are 3-50 km apart from one another depending on the accessibility of collection. We emphasized on measurement of alpha radiation as alpha radiation is 1000 times more carcinogenic than gamma radiation (DiFranza and Winters, 1982). It can produce large number of ion pairs in substances with which it interacts due to its double positive charge, limited range in tissue and enormously high energy. DNA chromosome damage by alpha particle radiation is much greater, by 100 times, than by exposure of DNA to other types of radiation (Kilthau, 1996).

In all the places both the river water as well as tube-well water has been collected for measurement of alpha activity. In one place well water has also been collected, no well was available at other sites. Our work is the first ever attempt on radioactivity measurement in water system on river bank of Subarnarekha from Jaduguda uranium mine area towards the river mouth.

Description of Study Area

Jaduguda which comes from the word ‘Jaragora’ (means a grove of the castor oil tree) lies in the east Singbhum district of Jharkhand state. The area is the heart of the tribal homeland. The Subarnarekha river is one of the major rivers in India rising from the Chota Nagpur plateau of Jharkhand state. The literal meaning of Subarnarekha is ‘the golden line’ or ‘the streak of gold’. After passing through Jharkhand state, the river enters the state of Orissa, West Bengal and empties into the Bay of Bengal. The location of study area is shown in Figure 1: (a) Map of India; (b) Location of sampling sites along river course. The places from where we have collected river water and tube-well water are Ghatsila, Jamsola, Gopiballavpur, Harekrishnapur (near Rohini), Kulboni, Bhasraghat, Balidangrighat (near Dantan), Sonakonia and Rajghat – in order of mine to river mouth direction. The distances between the consecutive places are 44 km, 31 km, 26.5 km, 14 km, 3.6 km, 15.3 km, 10.5 km and15 km respectively.

Experimental Method

Estimation of alpha activity in all the water samples has been performed using CR-39 – Solid State Nuclear Track Detector (SSNTD), obtained from Page Mouldings (pershore) Ltd, England. The SSNTD plates were attached with a glass rod stand which was dipped into the water sample taken in a beaker for both side exposures of the SSNTD plates. The exposure continued for 48 hours in undisturbed condition. The exposed plates were etched in 6N NaOH solution at 70°C for six hours in a constant temperature bath. Temperature of the solution was never allowed to vary more than 0.1°C. Etched plates were washed thoroughly in running water. The tracks were scanned under a Leitz Metalloplan Microscope and a Carl Zeiss Janaval Microscope provided with image analysis system. The number of etched pits formed by the alpha particles in the plates were counted using optics 10X objective in conjunction with 10X ocular lens. The number density of alpha track (track/sq cm) was converted to activity in Bq/l following the method suggested by Henahaw (1989). In each case background count was subtracted from the measured value. Radioactivity in all the samples was found to be above the detector’s limit (1.86 Bq/l).

(a)

(b)

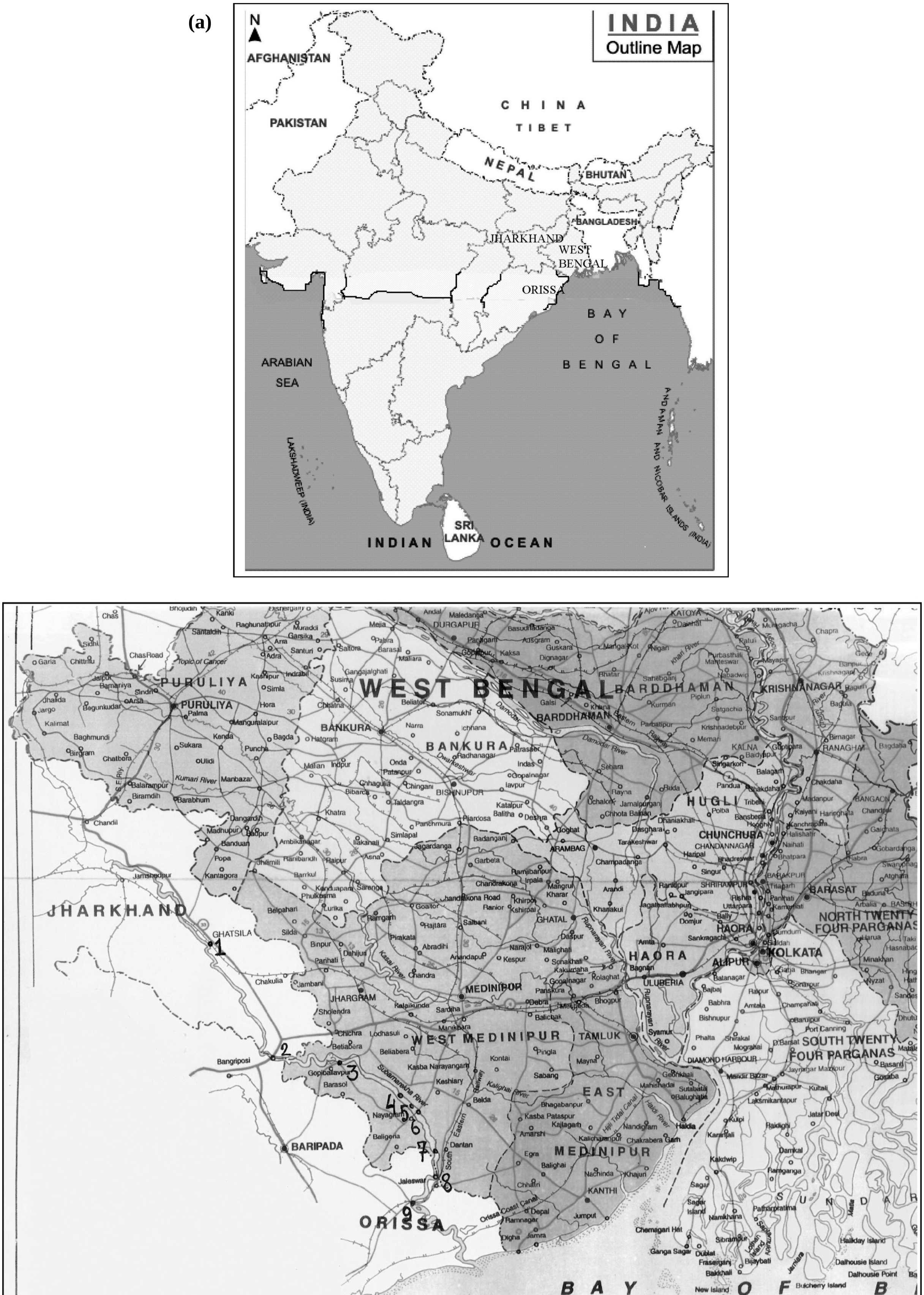

Figure 1: (a) Map of India, (b) Location of sampling sites along the course of the R. Subarnarekha.

Table 1: Alpha radioactivity in R. Subarnarekha and tube-well water sample

Location		*Subarnarekhea river water*								*Tube well water*									
Site No.	*Site Name*	*Total no. of alpha track in plate*		*Area of plate (cm^2)*		*Track/cm^2*		*Alpha activity (Bq/l)*		*Depth of the tube-well(ft)*		*Total no. of alpha track in plate*		*Area of plate (cm^2)*		*Track/cm^2*		*Alpha activity (Bq/l)*	
		1st Phase	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*	*1st Phase*	*2nd Phase*
1	Ghatsila	-	142	-	0.40	-	355	-	663	-	250	-	114	-	0.36	-	316	-	590
2	Jamsola	-	161	-	0.56	-	288	-	538	-	70	-	147	-	0.57	-	258	-	482
3	Gopiballavpur	105	116	0.57	0.50	184	232	343	433	30	30	112	94	0.48	0.41	234	229	437	427
4	Harekrishnapur (near Rohini)	-	141	-	0.53	-	266	-	496	42	42	143	88	0.56	0.36	255	244	476	455
5	Kulboni	96	95	0.54	0.38	178	250	332	467	35-40	35-40	126	73	0.57	0.32	221	228	412	426
6	Bhasraghat	134	82	0.84	0.41	160	200	299	373	40-50	40-50	117	98	0.65	0.44	180	223	336	416
7	Balidangrighat (near Dantan)	152	138	0.55	0.50	276	276	515	515	40-50	40	148	165	0.67	0.66	221	250	412	467
8	Sonakonia	115	103	0.66	0.41	174	251	325	468	60	125	90	71	0.43	0.37	209	192	390	358
9	Rajghat	65	106	0.56	0.53	116	200	216	373	320	320	89	96	0.43	0.54	207	178	386	332

Result and Discussion

The result observed in our experiment is very much interesting indeed. The detail of the observation has been shown in Table 1. The samples were collected at two stages with an interval of six months. In first stage the sample collection was started from Gopiballavpur site and ended at Rajghat. In second stage of collection two more sites, Ghatsila and Jamsola, more near to mine area were included. It is seen interestingly that the maximum alpha radioactivity has been found in samples collected from near mine area and as we go away from the mine area, the alpha radioactivity in water samples decreases. Only with exception in Balidangrighat (near Dantan) site (515 Bq/l), there is gradual decrease in alpha activity in river water samples with maximum of 343 Bq/l at Gopiballavpur (starting site) to minimum of 216 Bq/l at Rajghat (end site). In case of tube-well water there is also evidence of decrease in activity value from mine area (Gopiballavpur: 437 Bq/l) towards river mouth (Rajghat: 386 Bq/l) – though some exception at Harekrishnapur and Balidangrighat was seen. In well water at Jamsola site the activity value has been found as 482 Bq/l. In the second stage, similar trend of decreasing alpha activity in river as well as tube-well water from mine (Ghatsila: 663 Bq/l) to river mouth area (Rajghat: 373 Bq/l) has been observed though the decrease is not gradual. Alpha activity in tube well water was found maximum at Ghatsila (590 Bq/l) and minimum at Rajghat (332 Bq/l). While there is no EPA Standard for radon in water, now a maximum contaminant level (MCL) of 11 Bq/l is being considered for public water supplies. All the measured values of alpha activity in our samples are much higher than this MCL value and also much higher than world average value of 10 Bq/l (UNSCEAR, 1993; WHO, 1996).

Thus it is seen that uranium gets leached in huge amount near mine area and it decreases as we go away from mine area. The water system gets severely contaminated near uranium mine area. In summary:

- In all the collected samples high level of alpha radioactivity has been found – the alpha activity is much higher than the MCL value mentioned above even at farthest site from the mine area. Thus health effect associated with the local population is extremely necessary to consider.
- The river body describes the feature of level of contamination very well as in course of its path, the contamination level gradually decreases towards its mouth.
- The result is very much useful and important in two aspects: it depicts a clear picture of the radiation level in water system in Jaduguda mine area and also along the path of river Subarnarekha and secondly, as no such work has been done till yet in this area, it will serve as an important document.

Acknowledgement

The authors would like to acknowledge Prof. Asok Nath Basu, former Vice-chancellor, Jadavpur University, for his extraordinary enthusiasm, inspiration and active guidance. They are also grateful to Dr. Debasis Ghose, VECC, Kolkata, for his valuable suggestions during the work.

References

ATSDR (1990). Toxicological profile for uranium. Agency for toxic substances and disease registry, Report TP-90–29, Atlanta, USA.

ATSDR (1999). U.S. agency for toxic substances and disease registry toxicological profile for Uranium, September 1999.

Chalupnik, S., Michalik, B., Wysocka, M., Skubacz, K. and A. Mielnikow (2001). Contamination of settling ponds and rivers as a result of discharge of radium-bearing waters from Polish coal mines. *Journal of Environmental Radioactivity*, **54(1):** 85-98.

Decree (1989). Decree of the president of Polish atomic energy agency — a guide of classification of radioactive waste materials. *Monitor Polski*, **18:** 125 (in Polish).

DiFranza, J.R. and T.H. Winters (1982). Radioactivity in Cigarette Smoke. *New England Journal of Medicine*, **306(6):** 364.

Fernandes, H.M., Gomiero, L.A., Peres, V., Franklin, M.R., F. Filho, F.L.S. (2008). Critical analysis of the waste management performance of two uranium production units in Brazil. Part II: Caetite production center. *Journal of Environmental Management*, **88(4):** 914-925.

Henahaw, D.L. (1989). Proceedings of the International Workshop on Radon Monitoring in Radioprotection, Environmental Radioactivity and Earth Sciences. ICTP, Trieste, Italy 1989; April 3-14: 70.

Kilthau, Gustave F. (1996). Cancer risk in relation to radioactivity in tobacco. *Radiologic Technology*, **67(3):** 217.

Mehra, R., Singh, S. and K. Singh (2007). Uranium studies in water samples belonging to Malwa region of Punjab, using track etching technique, *Radiation Measurements*, **42:** 441-445.

Panda, U.C., Rath, P., Sahu, K.C., Majumdar, S. and S.K. Sundaray (2006). Environmental Quantification of Heavy Metals in the Subarnarekha, Estuary and Near-shore

Environment, East Coast of India. *Asian Journal of Water, Environment and Pollution*, **3(2):** 85-92.

Saad, A.F. (2008). Radium activity and radon exhalation rates from phosphate ores using CR-39 on-line with an electronic radon gas analyzer "AlphaGUARD", *Radiation Measurements*, **43:** S463-S466.

Skubacz, K. et al. (1993). Assessment of the radiological impact of the discharge of radium-bearing waters into Golawiecki River, Wiadomosci Gornicze, **5:** 93, Katowice (in Polish).

Tripathi, R.M., Sahoo, S.K., Jha, V.N., Khan, A.H. and V.D. Puranik (2008). Assessment of environmental radioactivity at uranium mining, processing and tailings management facility at Jaduguda, India. *Applied Radiation and Isotopes*, **66(11):** 1666-1670.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (1993). Sources and effects of ionizing radiation. 1993 report to the General Assembly, United Nations, New York.

Wu, A., Yin, S., Wang, H., Qin, W. and G. Qiu (2009). Technological assessment of a mining-waste dump at the Dexing copper mine, China, for possible conversion to an in situ bioleaching operation. *Bioresource Technology*, **100:** 1931-1936.

WHO (World Health Organization) (1996). Indoor quality: A risk-based approach to health criteria for radon indoors: report on a WHO working group, Eilat, Iseael, 28 March-4 April. 1993. EUR/ICP/CEH 108(A). WHO Regional office for Europe. Denmark.

WHO (World Health Organization) (1998). Guidelines for drinking-water quality, addendum to vol. 1, recommendations. Geneva, Switzerland: WHO.