ASSESSMENT OF PUBLIC EXPOSURE TO IONIZING RADIATION ARISING FROM MINING ACTIVITIES IN AZARA TOWN NASARAWA STATE, NIGERIA.

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Abstract

It was observed by United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000) and International Commission on Radiation Protection (ICRP, 1991) that there could be some exposure in some environment which would require regulatory control but is not really considered. In recent years there has been rampant dumping of mining tailings within Azara, a town surrounded by hundreds of mining sites, and mining is the major activity of the inhabitants. The people of Azara are faced with risks of radiation exposures due to the presence of naturally occurring radioactive materials (NORM) in the earth and in the products, by-products, and wastes derived from mining operations. The objective of this work is to assess the exposure level in Azara town due to mining activities and dumping of tailings within the town. Gamma dose rates of ten Areas in Azara, a town in southern Nasarawa state, were measured in situ using an environmental radiation detector. The exposure levels of ten different areas were measured 1metre above the ground using an inspector alert nuclear radiation meter and it was found that the annual dose rate ranges from (0.50 ± 0.19 mSv/h) to (0.90 ± 0.67 mSv/h).The absorbed dose rate were converted to annual effective dose rate in order to compare it with the public exposure limits by ICRP, it was found that the annual effect dose rate is between 0.76 mSv/yr – 1.10 mSv/yr. The average absorbed dose rate for the ten areas was found to be 0.66±0.31mSv/hr 1m above the ground level while the average annual effective dose rates were found to be 0.81mSv/yr which is below the public exposure limits and may not necessarily result to any hazard. It was established that Gindin Rimi has the highest annual effective dose rate of about1.10 mSv/yr which is very high compare to public exposure limits by ICRP, people leaving in this area are bound to face long time radiation health effect. People living in areas identified with high background radiation levels in this study should therefore be informed of the potential radiation related health problems, while government should also do more to stop the common practice of using mine wastes for foundation fillings and block construction because of the radiological implications.

Keywords: *Absorbed Dose Rate, Effective Dose Rate, Azara, Tailings, Exposure, Protection.*

INTRODUCTION

Natural radioactive mineral deposits are found in suitable geological environments like unconformity contact, veins and surficial. (Bhaumik et al., 2004). Their occurrences in outcrop enhance the background radiation of the area. This high exposure level may be harmful for people residing in the region. According to the United Nations Scientific Committee on Effects of Atomic Radiation Report (UNSCEAR, 2000), the greatest contribution to mankind's exposure comes from natural background radiation, and the worldwide average annual effective dose is 2.4 mSv. However, much higher levels of exposure are usual for inhabitants of natural high background radiation areas (HBRAs). High level of radiation above the earth is mainly due to naturally occurring radioactive elements in the earth's crust such as Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K). Areas at high altitudes are also more affected by cosmic radiations (NCRP, 1987; UNSCEAR, 1993; Bennett, 1997).

Human beings have always been exposed to ionizing radiations of natural origin, namely terrestrial and extraterrestrial radiation. Radiation of extra-terrestrial origin is from high energy cosmic ray particles and at sea level it is about 30 $nGyh^{-1}$ (UNSCEAR, 2000), while that of terrestrial origin is due to the presence of naturally occurring radionuclides; mainly potassium, rubidium and the radionuclides in the decay chains of thorium and uranium. These radionuclides have half-life which is comparable to the age of the earth. Natural radioactivity in geological materials, mainly rocks and soil, comes from ^{232}Th and ^{238}U series and natural ^{40}K. Artificial radionuclides such as ^{137}Cs which result from weapon testing and nuclear accident could also be present (UNSCEAR, 2000). The levels due to the terrestrial background radiation are related to the types of rock from which the soils originate. Higher radiation levels are associated to igneous rocks such as granite and lower levels with sedimentary rocks. There are some exceptions however, since some shale and phosphate rocks have a relatively high content of radionuclides (NCRP Report, 1993).

Radiation is all around us. Some radioactive materials occur naturally, and others are created by humans. Human exposure to naturally occurring radiation can also be increased by human activities such as mining or air travel. Many naturally occurring materials in our environment are radioactive (NRC 2003). For example, thorium and potassium in the earth's crust are naturally radioactive, and radon is a naturally occurring gas in most soils. Humans create and use radiation sources in a variety of applications, such as electricity generation, healthcare, scientific research, and food irradiation. As humans we cannot detect ionizing radiation with our senses: we have to use instruments to measure radiation. The type of detector depends on the type and location of the radiation. The mandate to control nuclear and radiation generating sources in Nigeria is vested with the Nigerian Nuclear Regulatory Authority which is authorized by law to ensure that radiation protection and safety regulations are adhered to. Several studies have been conducted in Nigeria to assess the environmental radiation and radioactivity levels within most part of the country. Among the recent ones are dose assessment within the mines in Benue State (Abga, et al., 2006), outdoor radiation level (Uwah and Inyang, 1998, Akinloye and Olomo, 2002), dose measurements along the creeks of Calabar River (Uwah and Akpan, 2005), radioactivity in roots (Akpabio and Ituen, 2006). More data on radioactivity and radiation levels in Nigeria are also available (Jibiri and Farai, 1999 and Olomo, et al,. 1994).

The release of radon gas and progeny from the mining sites has long been recognized as a potential radiological health hazard. The standards for exposure to radon and progeny have decreased over time as the understanding of their health risk has improved. In recent years there has been rampant dumping of mining tailings within Azara, a town surrounded by hundreds of mining sites, and mining is the major activities of the inhabitant. The people of Azara are faced with risks of radiation exposures due to the presence of naturally occurring radioactive materials (NORM) in the earth and in the products, by-products, and wastes derived from mining operations. The objective of this study is to assess the exposure level in Azara town due to mining activities and dumping of tailings within the town. This assessment revealed the air absorbed external gamma-radiation exposure, annual effective radiation dose, and external radiation hazard index. The data generated in this study will provide base line values of exposure to radiation in an environment where mining activities is taking place and may be useful for authorities in the implementation of radiation protection standards for the general population in the country, as well as to conduct further studies on this issue.

MATERIALS AND METHODS

The Study Area.

The area under study is Azara located at Awe Local Government Area of south-eastern part of Nasarawa State. It forms part of the Benue Basin in North-central Nigeria. It lies between latitude 8° 05′ N and 8° 07′ N, and longitudes 9° 05′ E and 9° 10′ E and it covers the area of approximately 2529 km^2 (Fig. 1). The area is within the tropical sub-humid climatic belt and is characterized by Guinea savannah vegetation type with daily temperature ranging from 26ºC to 32ºC, a mean rainfall of 1120 to 1500 mm and relative humidity of 60 to 80%. The topography is gentle and the elevation range from 100 to 145m (Fig 1). The major commercial activity in the area is farming, fishing and mining. The minerals mined in the area include; Lead, Copper Zinc and Barites.

The instruments used in the field are:

- Inspector Alert Nuclear Radiation Monitor: The Inspector Alert is a health and safety instrument that is optimized to detect low levels of radiation. It measures alpha, beta, and gamma radiation.
- Global Position System (G.P.S): This is a space- based satellite navigation system that provides location and time information in all weather, anywhere or near the earth. This was used to locate coordinates and measure the elevation of each area.

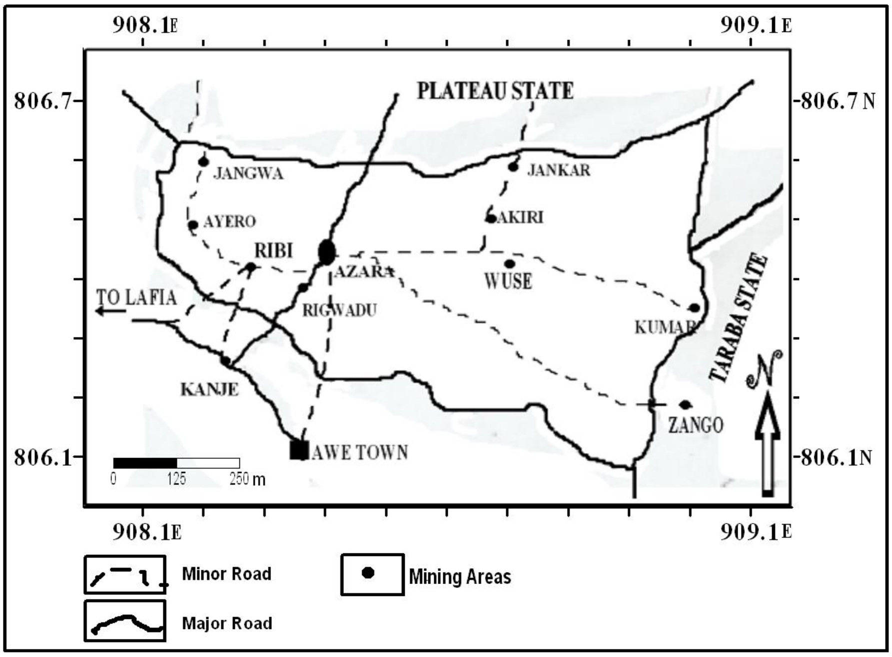

Fig.1 Map of the study area (Works Department, Azara Development Area Secretariat).

Methods

Ten (10) different locations (ungwa) in the town were selected for the study. These locations cover the entire town and each has its Geographical characteristics. A radiation survey of each area was conducted using an exposure meter (inspector alert nuclear radiation monitor (SN: 35440) with halogen- quenched GM – tube of effective diameter 45mm and mica window density of 1.5 – 2.0mg/cm^2).

During the measurement, the meter was held above the ground (sea level) with the the entrance window of the meter pointing any direction.The measurement was repeated at least ten (10) times in each different location in CPM. The absorbed dose rates in air in μSvh^{-1} were computed and converted to nGyh^{-1}.

The annual effective dose rate was evaluated using the conversion coefficient factor of 0.7 SvGy^{-1} as recommended by UNSCEAR.

Effective dose rate (mSv/yr) =Dose rate (nGy/hr) x 8760h x 0.2 x 0.7 Sv/Gy x 10^{-6} (1)
Where:
0.7Sv/Gy is the conversion coefficient from absorbed dose in air.
0.2 is the occupancy factor proposed by UNCEAR.

RESULTS AND DISCUSSION

Radiation exposure was measured five (5) times in each location using an inspector alert meter, it was summed up and the average was recorded. The readings were taken in count per minute and were converted to radiation dose rate in µSv/h and nGy/h. In order to ascertain the radiation hazard indices, the annual effective dose rate of each area was evaluated using the radiation dose rate per area in nGy/h. This study revealed the environmental background radiation doses of Azara town which ranges from 0.50±0.19 µSv/hr to 0.90±0.67 µSv/hr and the average outdoor gamma dose rate in the environment is 0.66±0.31µSv/hr. The annual effective dose rate ranges from 0.60mSv/yr to 1.10mSv/yr with an average of 0.81mSv/yr see table 1 for details.

The results in table1, established the presence of ionizing radiation in the environment of Azara town. This study of radiation exposure in the environment is intended to evaluate whether the levels of exposure are sufficiently high to the extent that radiological health effect may result and such areas may require the implementation of regulatory control.

The variation in the results can be attributed to many factors like the temperature, altitude, number of buildings, population, location of the area, distance away from the mining sites and human activities.

The estimated values of effective dose in Azara is higher compare to 0.26mSv/yr obtained by Agba *et al*. (2006), for the Preliminary investigation of the ambient radiation levels of mining sites in Benue State, Nigeria. It is also higher compare to 0.25 mSv/yr obtained by Sadiq and Agba (2012), in the measurement of indoor and outdoor ambient radiation levels in Keffi, Nigeria.

About 90% of the evaluated effective doses within Azara town were lower than 1 mSv/yr which is the public exposure limit according to UNSCEAR and therefore may not attract regulatory controls, but 10% of the evaluated effective doses are higher than 1 mSv/yr which require that the area should be marked as control area.

CONCLUSION

Any mining activity or mineral processing operation has the potential to increase the radiation dose received by individuals owing to the fact that minerals and raw materials contains radionuclides of natural or terrestrial origin. Background radiation levels are higher in some areas in Azara town because of the following activities:

- Mining materials being transported from the mining sites to the town by erosion.
- Tailings dumped around the mining industries were transferred to town and used as building materials.
- Miners stored mined products in their homes before processing.
- Indiscriminate dumped of mine wastes.
- Wind blow from the mining area to the neighboring town.

The result above shows that public radiation exposure in Gindin Rimi is higher with an annual effective dose of about 1.10mSv/yr which is above ICRP standard. This implies that if measures were not taken, the inhabitants of the area may later experienced stochastic effect due to long time exposure of low level of ionizing radiation.

Table 1. Average background Radiation and Annual Effective Dose in 10 areas of Azara town.

S/n	Measured area (Angwa)	Elevation (m)	Coordinates		Count per minute (CPM)	Dose Rate (µSv/h)	Dose Rate (nGy/h)	Annual Effective Dose Rate (mSv/y)
			Longitude	Latitude				
1.	Buga	119	N08^{O}21’53.3”	E009^{O}14’54.9”	66	0.66±0.30	660	0.81
2.	Kofar Fada	125	N08^{O}21’55.5”	E009^{O}14’58.3”	76	0.76±0.35	760	0.93
3.	Lungu	125	N08^{O}21’57.1”	E009^{O}15’01.6”	64	0.64±0.37	640	0.79
4.	Birni	110	N08^{O}22’07.6”	E009^{O}14’58.1”	55	0.55±0.29	550	0.67
5.	Gindin Rimi	121	N08^{O}21’43.1”	E009^{O}14’59.3”	90	0.90±0.67	900	1.10
6.	Tudun wada	121	N08^{O}21’44.6”	E009^{O}15’14.8”	70	0.70±0.19	700	0.86
7.	Gobirawa	124	N08^{O}21’33.7”	E009^{O}14’50.7”	66	0.66±0.25	660	0.81
8.	Motor garage	122	N08^{O}21’36.8”	E009^{O}14’39.7”	62	0.62±0.19	620	0.76
9.	Wadata	120	N08^{O}21’44.1”	E009^{O}14’51.1”	50	0.50±0.19	500	0.61
10.	Waje	115	N08^{O}21’52.0”	E009^{O}14’53.8”	60	0.60±0.29	600	0.74
						0.66±0.30		**0.81**

RECOMMENDATIONS

In view of the findings in this research, the following recommendations are hereby made:

- Activities of both miners and the general public should always be monitored.
- The Nasarawa State Government should as a matter of priority ensure the safety of the people of Azara town by intervening through public awareness campaign and also by introducing a safety measures in order to control public exposure arising from mining activities.
- The Local, State and the Federal Government should involve institutions of higher learning, research institutes or centers and experts in radiation protection in finding the solutions of radiation exposure due to human activities.

AKNOWLEDGEMENT

Our gratitude goes to the emir of Azara Dr. Alh. Kabiru Musa without him, this survey would not have been possible.

REFERENCES

Agba,E.H., Onjefu,S.A. & Ugwuanyi, J.U. (2006). Preliminary investigation of the ambient radiation levels of mining sites in Benue State, Nigeria. Nigerian J. Physics.18:219–22.

Akinloye, M.K. & Olomo,, J.B. (2002). Radioactivity in Opa dam partII: Fish and sediment radionuclides contents. Nigeria. Nigerian J. Physics.14:113–6.

Akpabio, G.T. & Ituen, E.E. (2006). Comparative effect of radioactivity on roots in coastal and hinterland locations in Akwa Ibom State, Nigeria. Nigerian J. Physics. 18:117–26.

Canoba, A.C. (2012). NORM Survey in Argentina, ICRP Publication 123.

Bennett, B.G., (1997). Exposure to Natural Radiation Worldwide. In: Proceedings of the Fourth International Conference on High Levels of Natural Radiation: Radiation Doses and Health Effects, Beijing, China, 1996, Elsevier, Tokyo, pp. 15–23.

Bhaumik, B.K., Bhattacharya, T., Acharyulu, A.A.P.S.R., Srinivas, D. & Sandilya M.K., (2004). Principles of Radiometry in Radioactive Metal Exploration. Physics Lab, Eastern Region, AMD Complex, Jamshedpur, India, p. 292.

Jibiri, I.I. & Farai, I.P. (1999). Radioactivity levels of some Nigerian rock samples. Nigerian J. Physics. 11:22–5.

NCRP, (1987). Exposure of the population of the United States and Canada from natural background radiation. Report No. 94. National Council on Radiation Protection and Measurements, Bethesda, Maryland.

NRC, (2003). How Does Radiation Affect the Public? http://www.nrc.gov/what-we-do/radiation/affect.html.

Olomo, J.B., Akinoloye, M.K. & Balogun, F.A. (1994). Distribution of gamma-emitting natural radionuclides in solids and water around nuclear research establishment, Ile-Ife, Nigeria. Nuclear Instruments Methods. 353:553–7.

UNSCEAR, (1993). Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effect of Atomic Radiation, United Nations, New York.

UNSCEAR, (2000). Exposure from natural radiation sources. United Nations Scientific Committee on the effects of Atomic Radiation. Report to general assembly. Annex B, exposure from natural radiation sources. United Nations, New York.

UNSCEAR (2000). Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation, Report to general assembly. Annex B, exposure from natural radiation sources. United Nations, New York.

Uwah, E.J. & Akpan, I.O. (2005). Radiation monitoring along the creeks of Calabar river and its environs. Global J. Pure Appl Sci. 11:137–40.

Uwah, E.J & Inyang, S.O. (1998). Studies of environmental radioactivity levels in Calabar. Global J. Pure Appl. Sci. 4:187–90.