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Assessment of Gamma Radiation Dose Rate Associated With Artisanal Goldmine Sites at Northern Zamfara State, Nigeria

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Abstract

This study assessed the gamma radiation dose rate associated with artisanal goldmine at Northern Zamfara State, Nigeria. Measurements of gamma radiation dose rates in the area was carried out using a portable survey meter, Inspector Alert and the coordinates of each point was recorded using a global positioning system. A total number of 166 average measurements were taken with the survey meter held at 1 m above the ground, with at least five readings taken at each location in order to minimize error. The mean GDR rate of the study area was found to be 32 nGy h-1 which is less than the world average value of 59 nGy h-1. Kaura Namoda local government area has the highest mean value of GDR rate of 38 nGy h-1, while Bakura local government area has the lowest mean value of GDR rate of 28 nGy h-1. Radiological health hazards; outdoor annual effective dose rate, lifetime dose and excess lifetime cancer risk were computed as 0.04 mSv y-1, 2.8 mSv, and 1.38 × 10-4 respectively. In general, it can be concluded that the artisanal mining activities doesn't pose any significant effect within the study area.

Keywords: *GDR; Inspector alert; Zamfara; Radiological health hazards.*

1. Introduction

Terrestrial gamma radiation (GDR) is a major source of human exposure to ionizing radiation (UNSCEAR, 2000). Ionizing radiations can have serious effect on the biological system through interaction with the cellular composition of the organism.

A thorough investigation showed that people of Zamfara State engaged in illegal gold mining as a means of their livelihood. They extract and process it themselves through unsafe and unregulated means (Medecins Sans Frontieres, 2012). This may result in contamination and pollution of soil and air of the area, which is an issue that need a great attention because it can cause serious health hazard.

An increase in active artisanal mining activities in the area led into people digging up rocks by hand, breaking them into pebbles using hammers, grinding the broken pebbles to sand with flour mills, and extracting gold from the sand which could further enhanced the background radiation level in the area thereby exposing the environment and its inhabitant to radiation (Medecins Sans Frontieres, 2012). Several related studies has been reported worldwide with none from the study area(Abba, Hassan, Saleh, Aliyu, & Ramli, 2018; Arogunjo, 2007; Chanyotha et al., 2011; Di Paolo et al., 2013; Garba, Ramli, Saleh, Sanusi, & Gabdo, 2014; Saleh et al.; Scovell et al., 2018). This necessitate the need for a detailed radiological studies in order to assess the radiological status of the area which might have further been enhanced by the illegal mining activities reported to

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have become rampant in the area, which could further have been the reason behind the high mortality rate recorded in the area beyond the reported lead contamination.

This study aimed at providing a first-hand information on the radiological status of the area which was dilapidated by the illegal mining activities, by measuring the Terrestrial Gamma Radiation Dose which will indicate the level of enhancement above the background level if any, and this will lead into a details radiological studies if necessary.

2. Experimental

Study Area

The study area is located between longitude 50 00′ 00″E to 7o 15′ 00″E and latitude 120 00′ 00″N to 13o 15′ 00″N, with a population of 1,509,741 (NPC, 2006). It covered Maradun, Bakura, Talata Mafara, Shinkafi, Zurmi, Kaura Namoda and Birnin-Magaji local government areas of Northern Zamfara State, with total population of 1.5 million [10]. The area is characterized by granites, gneisses, migmatites, phyllites, quartzites, meta-conglomerates (NGSA, 2013).

Measurement of Gamma Radiation Dose (GDR)

166 GDR were measured using a portable handheld survey meter (Inspector AlertTM) positioned 1 m above the ground across the seven local government areas within the study area (Fig. 1) with at least three reading at each point. The coordinate of each location was recorded using a Global Positioning System, Garmin (GPS Map78).

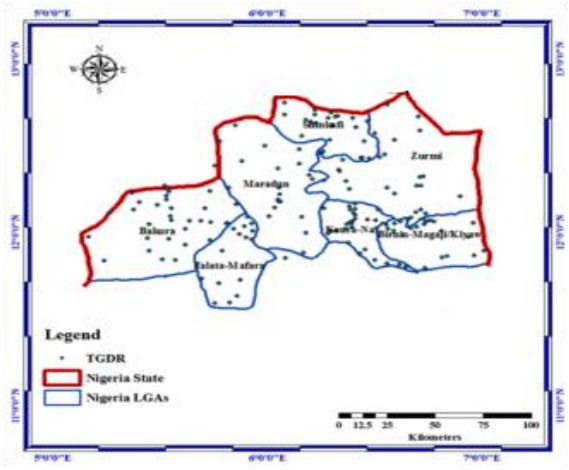

Figure 1: GDR survey points

3. Results and Discussion

The measured GDR rates in the study area were found to range between 20 nGy h^{-1} to 61 nGy h^{-1}, with an average value of 32 nGy h^{-1} (Table 1) which is less than the world average value of 59 nGy h^{-1}(UNSCEAR, 2000; Garba et al., 2016).Kaura Namoda local government recorded the highest average value of GDR rate 38 nGy h^{-1}, followed by Birnin Magaji with mean value 34 nGy h^{-1}, and next is Zurmi local government with mean value 33 nGy h^{-1}.

Table 1. Mean GDR in each of LGA

LGA	Terrestrial Gamma Radiation (nGy h^{-1})				
	Mean	95% CI for Mean		Min	Max
		LB	UB		
Shinkafi	30±1	28	32	21	37
Zurmi	33±2	29	38	20	61
Kaura Namoda	38±2	35	42	27	60
Birnin Magaji	34±1	32	37	24	56
Maradun	29±1	27	31	21	40
Talata Mafara	30±2	26	34	21	50
Bakura	28±1	26	31	20	44
Northern Zamfara	**32±1**	**31**	**33**	**20**	**61**

The higher values of GDR observed in those areas could be attributed to the Old Granite land formation covering about 70% land mass of the three local governments. Bakura LGA has the lowest mean GDR with a value of 28 nGy h^{-1}, followed by Maradun with 29 nGy h^{-1}, and then Shinkafi with a value 30 nGy h^{-1}. These lower values of GDR in those areas are traced to the Gondomar/Illo geological formation covering about 90% land mass of the three local governments. It consists of basal conglomerates, gravels with sand, variegated clays, and interbedded clays and grits (Obaje, 2009), formed fromorganic deposit.

Radiological Mapping

A radiological map of Northern Zamfara, State (Fig. 2) shows that about 70% land mass occupied by Zurmi, Kaura Namoda and Birnin Magaji local governments have TGR rates ranged from 34 nGy h^{-1} to 61 nGy h^{-1}, and the areas were mostly dominated by the Old Granite land formation which was reported to be associated with igneous rocks, such as granites, granodiorites, monzorites and charnockites which are enriched by rocks of moderate to high radioactive materials (UNSCEAR, 2000).

While the remaining 30% land mass of the same three local governments are exposure to TGR rates ranged from 25 nGy h^{-1} to 34 nGy h^{-1}. However, about 90% land mass of Shinkafi, Maradun, Talata Mafara, and Bakura are exposure to TGR rates ranged from 20 nGyh^{-1} to 34 nGy h^{-1}. The map correlates with the result presented in Table 1.

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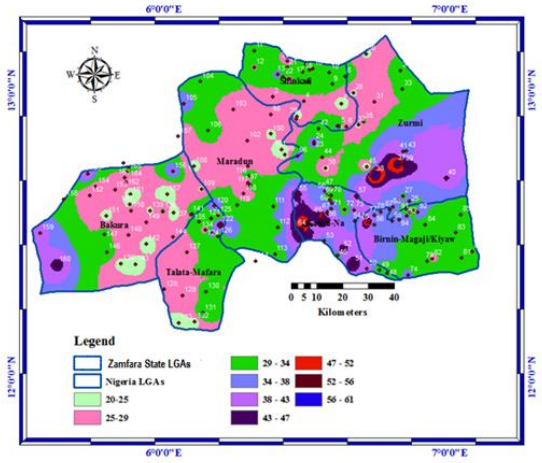

Figure 2: Radiological Map of the Study Area

Radiological Hazard Indices

Radiological health hazards indices comprising of outdoor annual effective dose rate, mean population weighted dose rate, lifetime dose and excess lifetime cancer risk were computed using (1-4) and were found to be 0.04 mSv y^{-1}, 2.8 mSv, and 1.38×10^{-4} respectively.

H_R (mSv y^{-1}) = GDR x 8760 hy^{-1} x O x C x 10^{-6} (1)

where O is the outdoor occupancy factor assumed to be 0.2, and C is the conversion coefficient (0.7 mSv nGy^{-1}). The calculated value is 0.04 mSv y^{-1} and is less than the world average value of 0.07 mSv y^{-1}.

$LD = H_R \times D_L$ (2)

where D_L is the average life expectancy assumed to be 70 years according to [1]. The estimated value is 2.8 mSv.

$ELCR = H_R \times DL \times RF$ (3)

where RF is the risk factor that is fatal cancer risk per Sievert, assumed to be 0.05 Sv^{-1} in this work according to ICRP-106. It was found to be 1.4×10^{-4} for the study area.

$Dw = (\sum DP)/(\sum P)$ (4)

where D and P are the mean dose rate and population respectively for each local government of Northern Zamfara State as summarized in the table 3. The calculated value for this parameter is 32 nGy h^{-1}.

LGA	Mean TGRD (nGy h^{-1})	Population (NPC 2006)
Bakura	28	187,141
Birnin Magaji	34	184,083
Kaura Namoda	38	285,363
Maradun	29	207,563
Shinkafi	30	135, 964
Talata Mafara	30	215,650
Zurmi	33	293,977

4. Conclusion

The gamma radiation dose rates associated with artisanal goldmines at Northern Zamfara State, Nigeria was assessed. The measured GDR was measured based on the geological formations of the area and it has indicated that the areas mostly dominated by the Old Granite land formation found mostly around Zurmi, Kaura Namoda and Birnin Magaji local government areas have GDR rates ranged from 34 nGy h^{-1} to 61 nGy h^{-1} which covered about 70% of the total land mass of the study area. Based on the assessed radiological hazard indices it can generally be concluded that the artisanal mining activities doesn't pose any significant radiological risk to the population but despite this a strict measure should be put in place in order to closely be monitoring the levels so as to keep it within normal variability range.

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