Original Research Article

TERESTERIAL BACKGROUND IONIZING RADIATION AROUND LEAD/ZINC MINING SITE IN ISHIAGU, EBONYI STATE.

ABSTRACT

The determination of the background ionizing radiation around Lead/Zinc mining sites at Ishiagu, Ebonyi State was carried out using appropriate equipment. The background ionizing radiation of the environment was determined by measuring the radiation exposure rates using Radalert-200 and Geographical Positioning System (GPS). Radiological health parameters and effective dose to different organs of the body was estimated. The average exposure rate of 0.017mR/h measured was relatively higher than the world acceptable value of $0.013mRh^{-1}$. All the radiological risk parameters estimated are relatively high. The result of this work shows that the mining activities have enhanced the radiation level of Ishiagu and health status of the populace.

Keywords: Radalert-200, Geographical Positioning System (GPS), gamma dose rate

1. INTRODUCTION

Everywhere in the world, man is exposed to radiation from different sources including rocks, soil and solar system. This radiation may also be man-made especially in medical imaging and radiotherapy, security screening equipment and smoke detectors [8]. Mining sites and its environs where heavy metal ores are extracted and may be processed are not left out in radiation effect.

Everything that exist around us and have any form of impact on us is our environment. They include air, water and soil. The environment is a combined environmental system and an unfriendly effect on one part will obviously have an impact on other parts. When harmful substances are introduced into the system and the environment becomes polluted, it affects man and his environment adversely [1]. Naturally Occurring Radioactive Materials (NORMs) occur in soil, sediment, water, plants, animals, human, coal, lignite, petroleum, phosphate ores, geothermal wastes, waste waters in small but varying amounts almost everywhere [11]. Excessive exposure of residents and workers of the nearby communities to ionizing radiation could result to health side effects such as lung cancer, eye cataracts, and skin erythema.

A radionuclide, sometimes called radioactive nuclide or radioisotope or radioactive isotope is an atom which has excess nuclear energy. This makes it very unstable. This excess energy can be emitted from the nucleus as gamma radiation; transferred to one of its electrons to release it as a conversion electron; or used to create and emit a new particle (alpha or beta particle) from the radiation emissions have the ability to free an electron from an atom, the reason they are regarded as ionizing radiation nucleus. Radioactive decay is a process in which radionuclides emit energy in form of radiation. All chemical elements can exist as radionuclides. Even the lightest element, hydrogen, has a well-known radionuclide, tritium. Elements heavier than lead, and the elements technetium and promethium, exist only as radionuclides. (In theory, elements heavier than dysprosium exist only as radionuclides, but the half-life for some such elements (e.g. gold and platinum) are too long to found.

Unplanned exposure to radionuclides generally has a harmful effect on living organisms including humans, although low levels of exposure occur naturally without harm. The degree of harm will depend on the nature and extent of the radiation produced, the amount and nature of exposure (close contact, inhalation or ingestion), and the biochemical properties of the element; with increased risk of cancer the most usual consequence. A gamma ray or gamma radiation (symbol γ), is a penetrating electromagnetic radiation arising from the radioactive decay of atomic nuclei. It consists of the shortest wavelength electromagnetic waves and so imparts the highest photon energy. Gamma rays are ionizing radiation and are thus biologically hazardous. Due to their high penetration power, they can damage bone marrow and internal organs. Unlike alpha and beta rays, they pass easily through the body and thus pose a formidable radiation protection challenge, requiring shielding made from dense materials such as lead or concrete . The continues extraction or mining of lead/zinc in lshiagu exposes the people working in the site and people leaving around the area to great health danger. Evaluation of health related risk from exposure to background ionizing radiation is of immense importance because it will give the radiological status of the area and residents which serves as a radiation safety monitoring tool. The result of this work will also serve as baseline data for the background radiation levels in this area. The absorbed dose, equivalent dose rate, the annual effective dose equivalent rate (AEDE) and the excess life time cancer risk (ELCR) were estimated from the measured gamma exposure rates of the mining community.

2. MATERIALS AND METHODS

2.1 Study Area

This research was carried out in May 2019. Ishiagu village is situated in Ivo LGA of Ebonyi State. It is found between latitude 5°54’ – 5°59’ N and longitudes 7°30’ – 7°35’ E [7]. The area coverage (about 25 sq.km), is located in the south-west part of the Abakaliki Basin, in Eastern part of Nigeria and is comprised of a low-lying sedimentary terrain with some encroachment on different occurrences. Lead/zinc extraction is a major profitable/economic activity of the Ishiagu region of south eastern Nigeria, next to farming. A large portion of land has been used for open pit extraction and get rid of the resultant mine waste. Mining operations in Isiagu, started in 1965 [5].

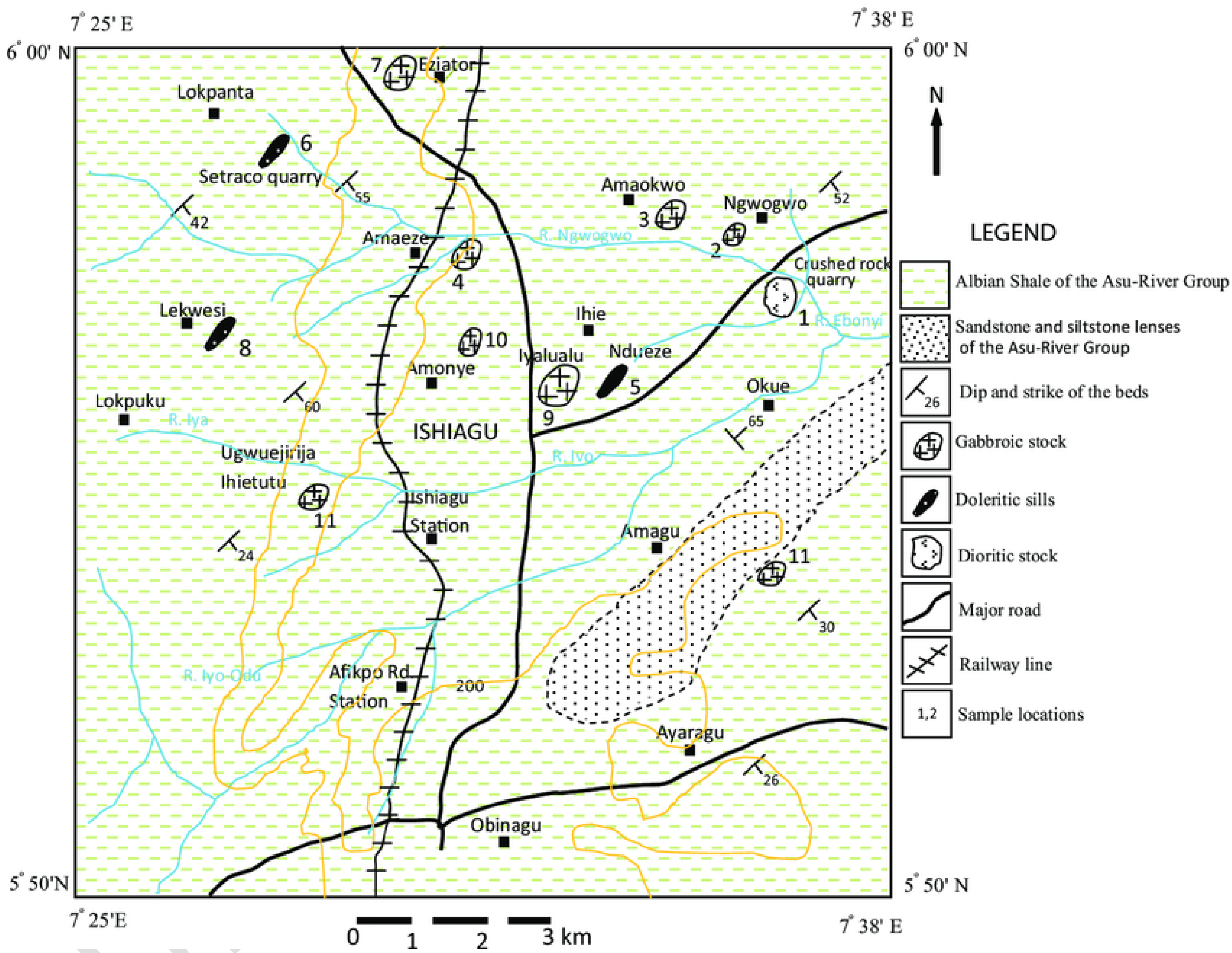

Figure 1: Map of Ishiagu showing sampling points

2.2 Field Measurement

An *in-situ* measurement of the background radiation level was done using Global positioning system (GPS) and a well calibrated radiation meters (Radalert Tm 200 nuclear radiation monitoring meter ,S.E. International Inc, Summer Town, USA) containing a Geiger-Muller tube capable of detecting alpha, beta, gamma and X-rays within the temperature range of – 10^{o}C and 50^{o}C was used to measure radiation levels. The Geiger Muller tube generates a pulse current each time radiation passes through the tube and causes ionization [2]. Each pulse is electronically detected and registered as a count. The radiation meters were calibrated with a 137Cs source of a specific energy and set to measure exposure rate in milli-Roetgen per hour. The readings were taken within the hours of 1300 and 1600 hours because exposure rate meter has a maximum response to environmental radiation within these hours [6]. The tube of the radiation meter was raised to a height of 1.0m above the earth surface with its window facing first the earth surface and then vertically downwards [3]. For each location two measurements spanning over 2 minutes were carried out.

2. Results and Discussion

Equivalent Dose Rate

The equivalent dose rate of the entire body for a year is approximately calculated using the National Council on Radiation Protection and Measurement's recommendation [11].

$$\mathbf{1\ mRh^{-1} = 0.96 \times 24 \times 365\ \ mSvy^{-1}\ \ 100} \qquad \mathbf{(1)}$$

The results of the estimated whole body equivalent dose rate are presented in tables 3.1 to 3.8

Absorbed Dose Rate

The absorbed dose rate is calculated from the exposure rate using the conversion factor [11].

$$\mathbf{1\ \mu Rh^{-1}\ \ = 8.7\ nGyh\text{-}1 = 8.7 \times 10^{-3}\ \ = 76.212\ \mu Gyy^{-1}\ \ (1/8760y)} \qquad \mathbf{(2)}$$

Annual Effective Dose Equivalent (AEDE)

To compute the annual effective dose equivalent (AEDE) absorbed by the people or workers around the study area, the already estimated absorbed dose rate were used. In calculating AEDE, dose conversion factor of 0.7 Sv/Gy and the occupancy factor for outdoor of 0.25 (6 hours out of 24 hours) was used. The occupancy factor for outdoor was determined based upon interaction with peoples of the area. It was discovered that they spent approximately 6 hours in the course of their daily activities within the study environment. The annual effective dose was calculated using the following relation [11].

$$\mathbf{AEDE\ (Outdoor)\ (mSvy^{-1}) = Absorbed\ dose\ rate\ (nGyh^{-1}) \times 8760\mathit{h} \times 0.7Sv/Gy \times 0.25} \qquad \mathbf{(3)}$$

Excess Life Cancer Risk (ELCR)

The possibility of contacting cancer by the mining workers and residents of the study area who spend all their life time in this environment can be approximately obtained using the Excess Lifetime Cancer Risk (ELCR) . The estimation is giving as

$$\mathbf{ELCR = AEDE \times Average\ duration\ of\ life \times Risk\ factor\ (Rf)} \qquad \mathbf{(4)}$$

Where AEDE, DL and RF is the annual effective dose equivalent, duration of life (70 years) and risk factor (Sv^{-1}), fatal cancer risk per sievert. For low dose background radiations which are considered to produce stochastic effects, ICRP 60 uses values of 0.05 for the public [11].

Effective Dose Rate Dorgan in mSvy-1 to Different Organs/ Tissues

The effective dose rate to a particular organ can be calculated using the relations:

$$\mathbf{D_{organ}\,(mSvy^{-1}) = O \times AEDE \times F} \qquad (5)$$

Where AEDE is annual effective dose, O is the occupancy factor 0.8 and F is the conversion factor for organ dose from ingestion[11] The calculated effective dose rates delivered to the different organs are presented in Fig 5

Table 1. Radiation exposure rate measured at Around Mining Pit

S/N	Location	Geographical Positions	Average Exposure rate (mRh^{-1})	Absorbed dose rate ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCRx 10^{-3}
1.	AMP 1	N05^{0}55’46.5 E 007^{0}29’05.0	0.009	78.30	0.12	0.42
2.	AMP 2	N 05^{0}55’45.5 E 007^{0}29’04.5	0.011	95.70	0.15	0.51
3.	AMP 3	N 05^{0}55’44.4 E 007^{0}29’04.5	0.010	87.00	0.13	0.47
4.	AMP 4	N05^{0}55’44.1 E007^{0}29’03.9	0.017	147.90	0.23	0.79
5.	AMP 5	N 05^{0}55’40.2 E 007^{0}29’04.0	0.012	104.40	0.16	0.56
6.	AMP 6	N 05^{0}55’40.8 E 007^{0}29’05.0	0.013	113.10	0.17	0.61
7.	AMP 7	N 05^{0}55’41.4 E 007^{0}29’07.1	0.018	156.60	0.24	0.84
8.	AMP 8	N 05^{0}55’41.4 E 007^{0}29’04.5	0.018	156.60	0.24	0.84
9.	AMP 9	N 05^{0}55’42.8 E 007^{0}29’07.3	0.016	139.20	0.21	0.75
10.	AMP 10	N 05^{0}55’43.7 E 007^{0}29’07.6	0.012	104.40	0.16	0.56
11.	AMP 11	N 05^{0}55’43.3 E 007^{0}29’04.5	0.018	156.60	0.24	0.84
12.	AMP 12	N 05^{0}55’42.6 E 007^{0}29’10.7	0.014	121.80	0.19	0.65
13.	AMP 13	N 05^{0}55’40.5 E 007^{0}29’09.3	0.014	121.80	0.19	0.65
14.	AMP 14	N 05^{0}55’47.4 E 007^{0}29’30.5	0.014	121.80	0.19	0.65

15.	AMP 15	N 05^{0}55’47.1 E 007^{0}29’05.8	0.008	69.60	0.11	0.37
16.	AMP 16	N 05^{0}55’47.7 E 007^{0}29’06.4	0.005	43.50	0.07	0.23
17.	AMP 17	N 05^{0}55’48.3 E 007^{0}29’07.1	0.010	87.00	0.13	0.47
18.	AMP 18	N 05^{0}55’48.8 E 007^{0}29’06.2	0.016	139.20	0.21	0.75
19.	AMP 19	N 05^{0}55’45.9 E 007^{0}29’06.7	0.017	147.90	0.23	0.79
20.	AMP 20	N 05^{0}55’42.2 E 007^{0}29’08.4	0.021	182.70	0.28	0.98
21.	AMP 21	N 05^{0}55’44.6 E 007^{0}29’12.8	0.020	174.00	0.27	0.93
22.	AMP 22	N 05^{0}55’44.0 E 007^{0}29’11.8	0.016	139.20	0.21	0.75
23.	AMP 23	N 05^{0}55’45.2 E 007^{0}29’12.1	0.008	69.60	0.11	0.37
24.	AMP 24	N 05^{0}55’43.6 E 007^{0}29’11.4	0.016	139.20	0.21	0.75
25.	AMP 25	N 05^{0}55’42.4 E 007^{0}29’17.2	0.018	156.60	0.24	0.84
26.	AMP 26	N 05^{0}55’41.8 E 007^{0}29’16.2	0.018	156.60	0.24	0.84
27.	AMP 27	N 05^{0}55’41.5 E 007^{0}29’16.3	0.027	234.90	0.36	1.26
28.	AMP 28	N 05^{0}55’41.4 E 007^{0}29’04.5	0.014	121.80	0.19	0.65
29.	AMP 29	N 05^{0}55’41.6 E 007^{0}29’15.5	0.010	87.00	0.13	0.47
	Mean		0.014±0.005	126±39.75	0.19±0.06	0.68±0.21

AMP = Around Mining Pit
PW = Pit Water
PT = Pit

FLB = Flooded Area Around Mining Pit
LS = Lead Store
BSV = Between Site and Nearby Village
Villa = Nearby Village

Table 2. Radiation exposure rate measured at Pit water

S/N	**Location**	**Geographical Positions**	**Average exposure rate (mRh^{-1})**	**Absorbed dose rate (nGyh^{-1})**	**AEDE (mSvy^{-1})**	**ELCR x 10^{-3}**

1	PW1	N 05^0 55′ 46.2 E007^0 29′ 04.1	0.018	156.6	0.24	0.84
	Mean		0.018±0.005	156.6±0.0	0.24±0.0	0.84±0.0

Table 3. Radiation exposure rate measured at Pit

S/N	Location	Geographical Positions	Average exposure rate (mRh^{-1})	Absorbed dose rate (nGyh^{-1})	AEDE (mSvy^{-1})	ELCR x 10^{-3}
1	PT1	N 05^0 55′ 43.1 E 007 ^{0}29′ 03.4	0.019	165.3	0.25	0.89
2	PT2	N 05^0 55′ 42.8 E 007^0 29′ 04.3	0.015	130.5	0.20	0.70
3	PT3	N 05 ^{0}55′ 41.0 E 007^0 29′ 03.8	0.019	165.3	0.25	0.89
	Mean		0.018±0.002	153.7	0.24	0.82

Table 4. Radiation exposure measured at Lead Store

S/N	Location	Geographical Positions	Average exposure rate (mRh^{-1})	Absorbed dose rate (nGyh^{-1})	AEDE (mSvy^{-1})	ELCR x 10^{-3}
1	LS1	N 05^0 55′ 42.2 E 007^0 29′04.3	0.025	217.5	0.33	1.17
2	LS2	N 05^0 55′ 41.9 E 007^0 29′03.9	0.026	226.2	0.35	1.21
3	LS3	N 05^0 55′ 41.1 E 007^0 29′05.9	0.031	269.7	0.41	1.45
	Mean		0.027± 0.003	237.8±22.83	0.36±0.04	1.28±1.28

Table 5. Radiation exposure measured at Flooded Area Around Mining Pit

S/N	Location	Geographical Positions	Average exposure rate (mRh^{-1})	Absorbed dose rate ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}
1	FLD1	N 05^0 55′ 41.5 E 007^0 29′10.9	0.02	174	0.27	0.93
2	FLD2	N 05^0 55′ 41.5 E 007^0 29′ 12.0	0.017	147.9	0.23	0.79
	Mean		0.019±0.002	160.95±13.05	0.25±0.02	0.86±0.07

Table 6. Radiation exposure measured at Between Site and Nearby Village

S/N	Location	Geographical Positions	Average exposure rate (mRh^{-1})	Absorbed dose rate ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}
1	BSV1	N 05^0 56′ 21.6 E 007^0 30′ 33.0	0.013	113.1	0.17	0.61
2	BSV2	N 05^0 56′ 22.3 E 007^0 30′ 38.3	0.018	156.6	0.24	0.84
3	BSV3	N 05^0 56′ 21.9 E 007^0 30′ 43.4	0.011	95.7	0.15	0.51
4	BSV4	N 05^0 56′ 21.5 E 007^0 30′ 50.8	0.009	78.3	0.12	0.42
	Mean		0.013±0.003	110.925±29.1	0.17±0.04	0.60±0.16

Table 7. Radiation exposure measured at Nearby Village

S/N	Location	Geographical Positions	Average exposure rate (mRh^{-1})	Absorbed dose rate ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}
1	Villa1	N 05^0 57′ 10.5 E 007^0 33′ 23.5	0.004	34.8	0.05	0.19
2	Villa2	N 05^0 57′ 12.1 E 007^0 33′ 20.7	0.009	78.3	0.12	0.42
3	Villa3	N 05^0 57′ 12.1 E 007^0 33′ 17.0	0.009	78.3	0.12	0.42
4	Villa4	N 05^0 57′ 10.7 E 007^0 33′ 15.1	0.011	95.7	0.15	0.51
5	Villa5	N 05^0 57′ 08.5 E 007^0 33′ 14.4	0.016	139.2	0.21	0.75
6	Villa6	N 05^0 57′ 07.0 E 007^0 33′ 11.8	0.017	147.9	0.23	0.79
7	Villa7	N 05^0 57′ 07.2 E 007^0 33′ 08.7	0.006	52.2	0.08	0.28
8	Villa8	N 05^0 57′ 07.3 E 007^0 33′ 06.8	0.011	95.7	0.15	0.51
9	Villa9	N 05^0 57′ 07.9 E 007^0 33′ 04.6	0.010	87	0.13	0.47
	Mean		0.010±0.004	89.9±34.31	0.14±0.05	0.48±0.18

Table 8. Mean exposure rate measured and their radiation parameters

S/N	Location	Average exposure rate (mRh^{-1})	Absorbed dose rate ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR x 10^{-3}
1	AMP	0.014	126.00	0.19	0.68
2	PW	0.018	156.60	0.24	0.84
3	PT	0.018	153.70	0.24	0.82
4	LS	0.027	237.80	0.36	1.28
5	FLD	0.019	160.95	0.25	0.86
6	BSV	0.013	110.93	0.17	0.60
7	VILLA	0.010	89.90	0.14	0.48
	Mean	0.017	147.98	0.23	0.79
	World Average	0.013	89.00	0.48	0.29

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Villa = Nearby Village

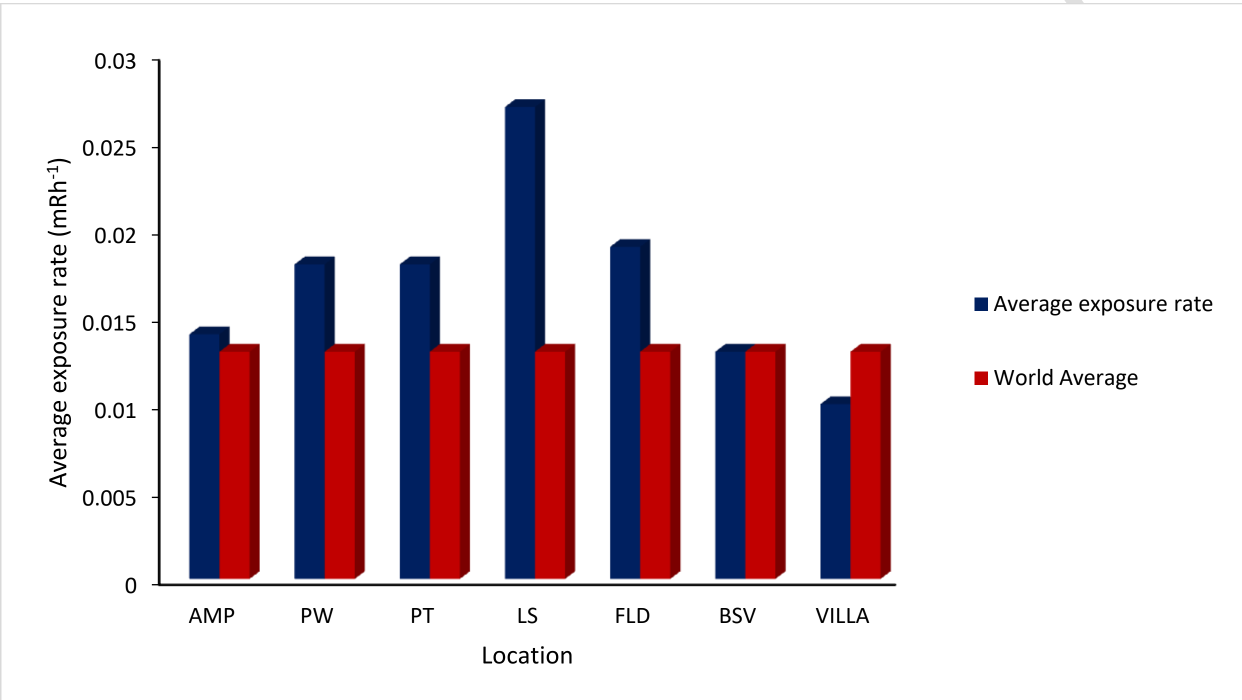

Fig 2. Comparison of measured exposure rate with world average

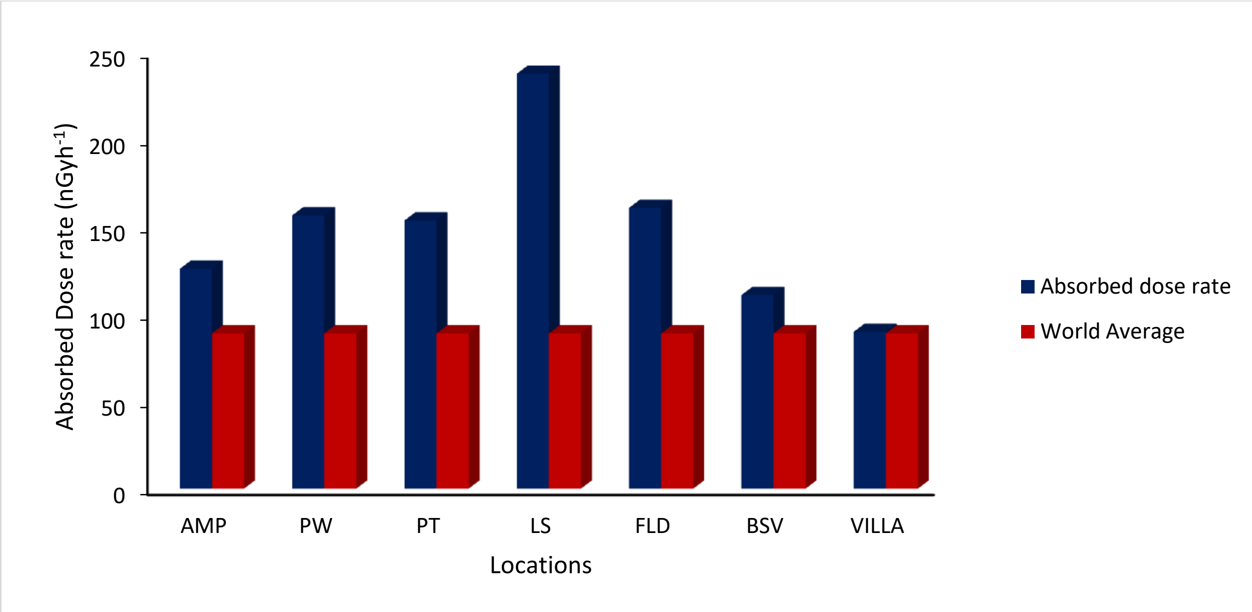

Fig 3. Comparison of absorbed dose rate with world average

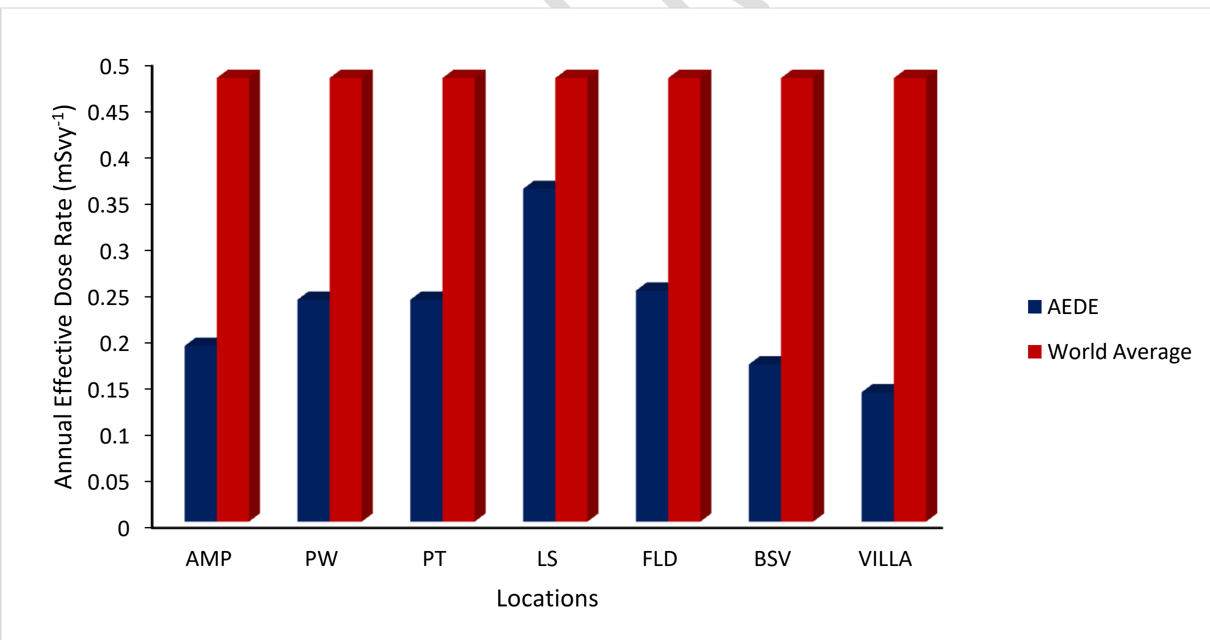

Fig 4. Comparison of AEDE with world average

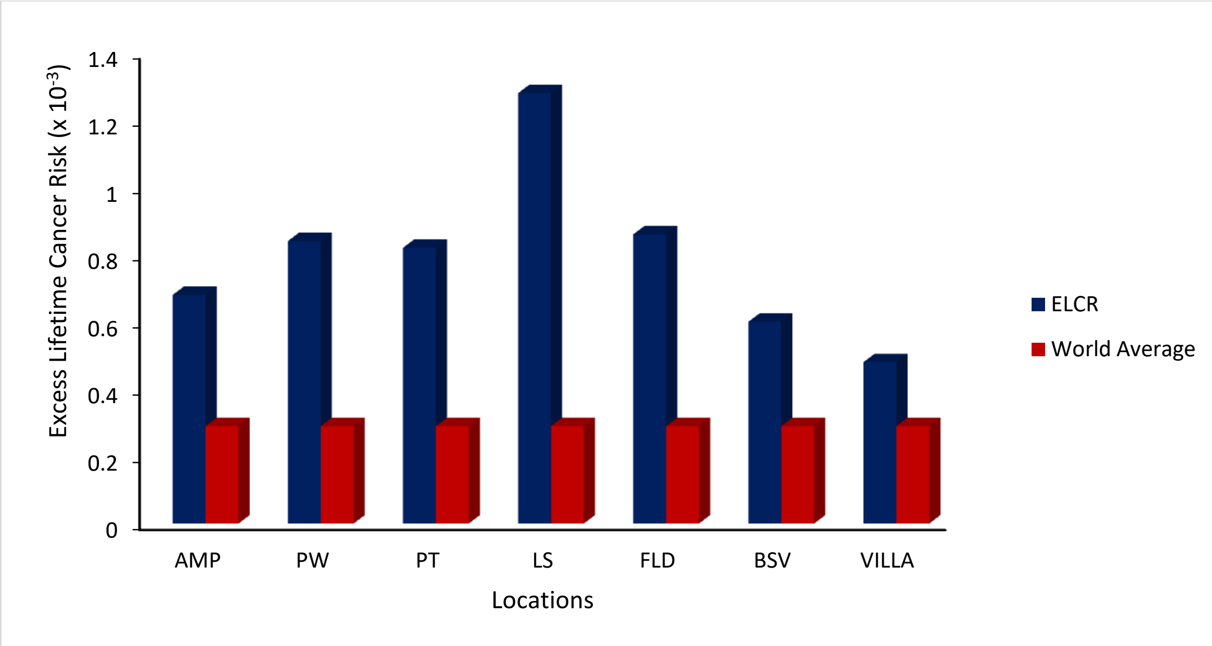

Fig 5. Comparison of ELCR with world average

Table 9. Effective dose rate to different organs

Locations	Lungs	Ovaries	Bone Marrow	Testes	Kidneys	Liver	Whole Body
AMP 1	0.06	0.06	0.07	0.08	0.06	0.04	0.07
2	0.08	0.07	0.08	0.10	0.07	0.05	0.08
3	0.07	0.06	0.07	0.09	0.07	0.05	0.07
4	0.12	0.11	0.13	0.15	0.11	0.08	0.12
5	0.08	0.07	0.09	0.10	0.08	0.06	0.09
6	0.09	0.08	0.10	0.11	0.09	0.06	0.09
7	0.12	0.11	0.13	0.16	0.12	0.09	0.13
8	0.12	0.11	0.13	0.16	0.12	0.09	0.13
9	0.11	0.10	0.12	0.14	0.11	0.08	0.12
10	0.08	0.07	0.09	0.10	0.08	0.06	0.09
11	0.12	0.11	0.13	0.16	0.12	0.09	0.13
12	0.10	0.09	0.10	0.12	0.09	0.07	0.10
13	0.10	0.09	0.10	0.12	0.09	0.07	0.10
14	0.10	0.09	0.10	0.12	0.09	0.07	0.10
15	0.05	0.05	0.06	0.07	0.05	0.04	0.06
16	0.03	0.03	0.04	0.04	0.03	0.02	0.04
17	0.07	0.06	0.07	0.09	0.07	0.05	0.07
18	0.11	0.10	0.12	0.14	0.11	0.08	0.12

19	0.12	0.11	0.13	0.15	0.11	0.08	0.12
20	0.14	0.13	0.15	0.18	0.14	0.10	0.15
21	0.14	0.12	0.15	0.17	0.13	0.10	0.15
22	0.11	0.10	0.12	0.14	0.11	0.08	0.12
23	0.05	0.05	0.06	0.07	0.05	0.04	0.06
24	0.11	0.10	0.12	0.14	0.11	0.08	0.12
25	0.12	0.11	0.13	0.16	0.12	0.09	0.13
26	0.12	0.11	0.13	0.16	0.12	0.09	0.13
27	0.18	0.17	0.20	0.24	0.18	0.13	0.20
28	0.10	0.09	0.10	0.12	0.09	0.07	0.10
29	0.07	0.06	0.07	0.09	0.07	0.05	0.07
PW 1	0.12	0.11	0.13	0.16	0.12	0.09	0.13
PT 1	0.13	0.12	0.14	0.17	0.13	0.09	0.14
2	0.10	0.09	0.11	0.13	0.10	0.07	0.11
3	0.13	0.12	0.14	0.17	0.13	0.09	0.14
LS 1	0.17	0.15	0.18	0.22	0.17	0.12	0.18
2	0.18	0.16	0.19	0.23	0.17	0.13	0.19
3	0.21	0.19	0.23	0.27	0.21	0.15	0.22
FLD 1	0.14	0.12	0.15	0.17	0.13	0.10	0.15
2	0.12	0.11	0.13	0.15	0.11	0.08	0.12
BSV 1	0.09	0.08	0.10	0.11	0.09	0.06	0.09
2	0.12	0.11	0.13	0.16	0.12	0.09	0.13
3	0.08	0.07	0.08	0.10	0.07	0.05	0.08
4	0.06	0.06	0.07	0.08	0.06	0.04	0.07
VILLA 1	0.03	0.02	0.03	0.03	0.03	0.02	0.03
2	0.06	0.06	0.07	0.08	0.06	0.04	0.07
3	0.06	0.06	0.07	0.08	0.06	0.04	0.07
4	0.08	0.07	0.08	0.10	0.07	0.05	0.08
5	0.11	0.10	0.12	0.14	0.11	0.08	0.12
6	0.12	0.11	0.13	0.15	0.11	0.08	0.12
7	0.04	0.04	0.04	0.05	0.04	0.03	0.04
8	0.08	0.07	0.08	0.10	0.07	0.05	0.08
9	0.07	0.06	0.07	0.09	0.07	0.05	0.07
Mean	0.10	0.09	0.11	0.13	0.10	0.07	0.11

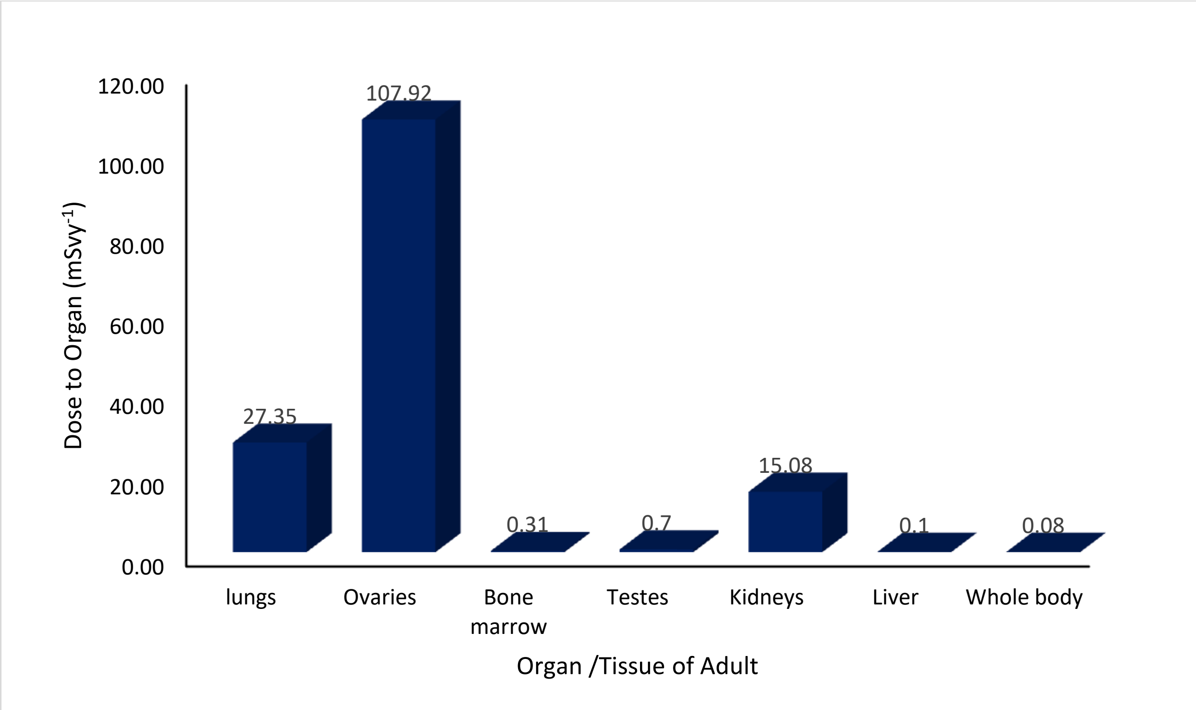

Fig. 6. Effective dose rate to different organs / tissues

Tables 1 to 7 showed the background ionizing radiation rate and equivalent dose rate level of Lead mining site in Ishiagu, Ivo LGA of Ebonyi State, Nigeria. Table 8 showed that the average background ionization radiation exposure dose rate ranged from minimum value of 0.010 ±0.004mR/hr at the nearby village settlement (VILLA) to maximum value of 0.027±0.003 mR/hr at Lead storage house (LS). The mean values of 0.017 obtained from all the locations when compared with the world average value of 0.013mR/hr [12] are slightly greater than the standard world average. The mean exposure rate of 0.014,0.018,0.018,0.019,0.027 in AMP, PW, PT, FLD, LS respectively are slightly greater than the world average of 0.013 except in BSV (0.013) equivalent to world average and in VILLA (0.010). The high mean values of measured background ionizing radiation in the location can be attributed to the lead mining activities and exploitation activities currently going on in the area. It also indicates the possible presence of radioactive isotopes in the solid mineral being excavated.

The absorbed dose measured ranged from 89.90 $nGyh^{-1}$ to 237.80 $nGyhr^{-1}$ with mean value of 147.98 $nGyh^{-1}$ which is higher than the world weighted average of 89.00 $nGyh^{-1}$. The location that recorded the highest exposure rate, absorbed dose, annual effective dose and excess lifetime cancer risk, is lead house (LS) which houses a lot of raw lead solid mineral. The continuous land excavation in search of solid mineral may account to high radiation level recorded in the area.

The annual effective dose (AEDE) measured ranged from 0.14 to 0.36mSv/yr with mean value of 0.23$mSvy^{-1}$. This is lower than the world weight value of 0.48$mSvy^{-1}$ [12]. The ECLR measured ranged from 0.48 to 1.28 x 10^{-3} with mean value of 0.79 x 10^{-3} which is higher when compared with the world standard value of 0.29 x 10^{-3}. The values of the radiation hazard parameters were highest for LS followed by FLD, PW, PT, AMP, BSV and VILLA in that order which implies that exposure rate in the village settlement is the lowest, this may be due to far distance between the mining area and village. The level of exposure recorded in the VILLA may be connected to lead business by some villagers who store lead substance in their homes for trade.

The excess lifetime cancer risk estimated from the annual effective dose in all the location exceeded the world weighted average of 0.29 x 10^{-3}. Therefore, the probability of developing extra cancer due to exposure to natural radioactivity in this area is significant. This suggest further studies of other environmental media such as soil, water and crops from the area of study.

These results can be liken to the work of [8], here the background ionizing radiation level is greater than the world standard value from four mining sites in Benue state of Nigeria. Others areas of study that were found that their BIR is greater than the approved world standards from Alizaga stone quarry site in Nasarawa state of Nigeria, [10] from eight solid mineral sites in Enugu state which was 38% higher due to possible presence of radioisotopes in the solid minerals.

However, the result is different from the one obtained by [4] where the BIR is slightly less than the world standard value.

CONCLUSION

The background ionization radiation of the Ishiagu mining site showed that it is relatively above the standard limit and hence the area of study has been relatively degraded radiologically. The average value of BIR is 0.017 mR/hr which exceeds the WHO average value of 0.013 mR/hr. Hence it is recommended that companies in the study area should put in place means of reducing their radionuclide inputs in their daily production activities The background ionizing radiation in lead mining site, Ishiagu area of Ebonyi State is high.

.The average exposure rate in the site 0.017mR/hr is greater than the world mean value of 0.013mR/hr .The mean absorbed dose rate of 147.98 nGy/hr is greater than the universal standard value of 89 nGy/hr.

The annual effective dose equivalent of 0.23mSv/y is lower than its equivalent world standard value equivalent of 0.48 mSv/y

The excess life cancer risk is high as seen on table 8.

The mean effective dose to different organs due to background ionizing radiation is below the world standard.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation

but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

1. Avwiri, G. O., Osimobi, J.C. & Agbalagba, E.O. (2013). Evaluation of natural occurring radionuclide variation with Lithology depth profile of Udi and Ezeagu Local Government Areas of Enugu State, Nigeria. *International Journal of Engineering and Applied Sciences. 4 (3), 234-239.*

2. Avwiri, G.O., Osimobi,J.C. and Agbalagba,E.O.(2012). Evaluation of radiation hazard indices and excess lifetime cancer risk due to natural radioactivity in soil profile of Udi and Ezeagu Local Government Areas of Enugu State, Nigeria. *Compr. J. Environ. Earth Sci.,:* 1-10.

3. Avwiri, G.O., Tchokossa, P. and Mokobia, C.E. (2007). Natural radionuclide in bore-hole water in Port Harcourt, Rivers State, Nigeria, *Radiation Protection Dosimetry*, 123 (4) 509 – 514.

4 Ayua, T., Tyovenda, A., Igyuse I. & Ejegwoyo, O. (2017). Determination of ionization radiation exposure levels within four local mining sites selected from Sarduana L.G.A of Taraba state, Nigeria. *International Journal of Physics,5 (5), 157-161.*

5 Eze, H. N. & Chukwu, E (2011). Small scale mining and heavy metals pollution of agricultural soil: the case of Ishiagu mining district, southeastern Nigeria. *Journal of Geology and Mining Research* 3(4), 87-104

6 Louis, E.A., Etuk, E.S. and Essien U. (2005). Environmental Radioactivity level in Ikot Ekpene, Nigeria, Nigeria. *Journal of Space research*; 1:80-87.

7 Mbah, V., Onwuemesi, A., Aniwetalu, E. (2015). Exploration of Lead-Zinc mineralization using very low frequency electromagnetic (VLF-EM) in Ishiagu, Ebonyi State. *Journal of Geology and Geosciences*. 4(4),2329-6755

8. Olariwaju, A. I. & Avwiri, G. O. (2017). Assessment of the radiation hazard indices from terrestrial radiation in mining sites in Benue state, Nigeria. 18(1), 1-10.

9. Ononugbo, C. P. & Komolafe, E. (2016). Radiation dosimetry of some selected industrial sites at Onne oil and gas free trade zone, Rivers state, Nigeria. *Journal of Environmental Science and Engineering Technology.* 4(1),2-9

10. Osimobi, J., Agbalagba E., Avwiri, G. & Ononugbo, C. (2015). GIS mapping and background ionizing radiation (BIR) assessment of solid mineral mining sites in Enugu state Nigeria. *Open Access Library Journal 2, 1-9.*

11. Ovuomarie – Kelvin, S. I., Ononugbo, C. P. & Avwiri, G. O. (2018). Evaluation of health risks from exposure to low levels of ionizing radiation in some oil spilled communities of Rivers state, Nigeria. *Journal of scientific research and reports.* 19(5), 1-11

12. UNSCEAR, (2000). United Nation Scientific Committee on the Effects of Atomic Radiation Volume (1).