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Assessment of the Effects of Radiation Exposure to Human Sensitive Organs Due to Quarry Mining in Kokona, Nasarawa and Toto of Nasarawa State Nigeria

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Abstract: The interaction of radiation with matter, ether from external (i.e. external sources) or from internal pollution of the body by toxic substances, can pose biological hazard which may show the clinical symptoms later. This study aimed at assessing the Effects of Radiation Exposure to Human Sensitive Organs due to quarry mining in Kokona, Nasarawa and Toto of Nasarawa State Nigeria. Finding of this study have revealed that the mean annual effective dose rate for Kokona, Nasarawa and Toto are 0.0274, 0.0166 and 0.0227 mSv/y respectively. The mean excess lifetime cancer risk (ELCR) for Kokona, Nasarawa and Toto are 0.0960×10^{-3}, 0.058×10^{-3} and 0.0795×10^{-3}. The mean Effective Dose Rate to Organs (D_{organ}), for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body in Kokona, Nasarawa and Toto are 0.0176, 0.0107 and 0.0145, 0.0159, 0.0097 and 0.0132, 0.0190, 0.0115 and 0.0157, 0.0225, 0.0136 and 0.0186, 0.017, 0.0103 and 0.0141, 0.0126, 0.0077 and 0.0105, and 0.0186, 0.0113 and 0.0155 mSv/yr respectively. It can be concluded that the background radiation in different quarry mining sites of Kokona, Nasarawa and Toto of Nasarawa State is not an issue of health concern except on seventy years of exposure. It is therefore, advised that, government should stop the illegal mining and introduce mechanize mining for easy control of the health effects. Also, it is recommended that water and soil sample be taking for elemental analysis to ascertain the effect of the mining activity in these areas through ingestion, since it has no much effects on the populace of the area through inhalation according to this research.

Keywords: Radionuclides; Mining; D_{organ}; Radiation; Effective Dose; Excess Lifetime Cancer Risk.

1 Introduction

The interaction of radiation with matter, ether from external (i.e. external sources) or from internal pollution of the body by toxic substances, can pose biological hazard which may show the clinical symptoms later. The nature and extent of these symptoms and the time they take to appear is a function of the amount of radiation absorbed and the rate at which it is received. Radiation Safety is bothered about cellular effects, which may damage the chromosomes and their components (e.g., genes, DNA, etc.). Radiation association with the body produces micro sub-cellular-level effects that may course cellular responses and, in the accumulation, may produce macro observable health effects on some organs or tissues. Irradiation of tissue sets a series of intracellular biochemical events into motion that start with ionization of a molecule, and may lead to cellular injury. This may, in turn, lead to further injury to the organ and to the organism. Some factors can modify the response of a living organism to a given radiation dose. Factors associated with the dose include the dose rate, the energy and type of radiation (Depending on the quantity of ionization deposited along a unit length of track of radiation, LET), and the temporal pattern of the exposure. The DNA is considered to be the main target molecule for radiation toxicity. Molecular effects, which includes effect to the DNA, can occur in any of two ways from an exposure to radiation. Firstly, radiation can associate directly with the DNA, causing a single or double-strand DNA breaks or bonding base pairs. Secondly, radiations can associate directly with other neighboring molecules within or outside of the cell, such as water, to produce free radicals and active oxygen species. These reactive molecules, in turn, associates with the DNA and/or other molecules within the cell (membranes, mitochondria, lipids, proteins, etc.) to produce a wide range of health implication

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at the cellular and tissue levels of the organism [1-5]. Cellular/Organ Radio sensitivity [6-8]. The health consequences of radiation exposure depend on also some biological factors which include species, age, sex, the portion of the body tissues exposed, different radio sensitivity, and repair mechanisms. According to the Law of Bergonie and Tribondeau, the sensitivity of cell lines is directly proportional to their mitotic rate and inversely proportional to the degree of differentiation [9-14]. Cellular changes in susceptible cell types may result in cell death; extensive cell death may produce irreversible damage to an organ or tissue, or may result in the death of the individual. If the cells are adequately repaired and relatively normal function is restored, the subtler DNA alterations may also be expressed at a later time as mutations and/or tumors [12-15].

This study tends to unveil the various factors that leads to the variation in radiation effects in Kokona, Nasarawa and Toto as well as the hazards of man's continual exposure to radiation through different radiation emitting source and possible protection and control measures to its exposure. This study aimed at assessing the Effects of Radiation Exposure to Human Sensitive Organs due to quarry mining in Kokona, Nasarawa and Toto of Nasarawa State Nigeria.

2 Materials and Methods

2.1 Materials

The materials used to execute this research work are;

The inspector Alert Nuclear Radiation Monitor with the serial number 35440, made in USA by ion spectra (International Med. Com. Inc) using alkaline battery 0f 9.0volts, a scientific calculator, personal computer (laptop), pen and exercise book.

2.2 Method

The methods of radiation measurement used in this research work was by using radiation monitor with in-build Geiger Muller tube operating in the Dose Rate mode to determine the background ionizing radiation level from the selected Quarry Mining Sites across Kokona, Nasarawa and Toto of Nasarawa State. The Geiger Muller tube generates a pulse of electrical current each time radiation passes through the tube which cause ionization. Each pulse is electrically detected and registered as a count mSv/hr, but CPM, been the most direct and appropriate method of measuring alpha and beta activity was chosen as the correct mode. The inspector Alert was held above the ground level (1m above). The device was turn on and measurements were taken after a deep sound that indicates the statistical validity of the readings on the liquid crystal display (LCD) of the monitor.

2.2.1 Study Area

Kokona is a Local Government Area in Nasarawa State, Nigeria. Its headquarters are in the town of Garaku. It has an area of 1,844 km^2 and a population of 109,749 at the 2006 census. The postal code of the area is 961.

Nasarawa is a Local Government Area in Nasarawa State, Nigeria. Its headquarters are in the town of Nasarawa, located at 8°32'N 7°42'E, with a population of 30,949 (as of 2016). The local government area has an area of 5,704 km^2 and a population of 189,835 at the 2006 census. The postal code of the area is 962.

Toto is a Local Government Area in Nasarawa State, Nigeria. Its headquarters is in the town of Toto. Toto covers an area of 2,903 km^2 and a population of 119,077 at the 2006 census. The postal code of the area is 962.

The map of Nasarawa State showing Kokona, Nasarawa and Toto Local Government Areas and the map of Kokona, Nasarawa and Toto Local Government Areas showing the data points are shown respectively in Figures 1 and 2. The geographical coordinates of the data points are tabulated in Table 1.

Table 1: The Geographical Coordinates of the Data Points

S/N	Sample Point	E (Coordinate)	N (Coordinate)
1	Kokona 1	7° 58' 8.4"	9° 2' 42"
2	Kokona 2	8° 5' 38.4"	8° 54' 25.2"
3	Kokona 3	8° 6' 36"	8° 42' 50.4"
4	Nasarawa 1	7° 34' 44.4"	8° 41' 49.2"
5	Nasarawa 2	8° 6' 54"	8° 25' 8.4"
6	Nasarawa 3	7° 32' 56.4"	8° 15' 18"
7	Toto 1	7° 25' 4.8"	8° 26' 49.2"
8	Toto 2	7° 17' 20.4"	8° 9' 10.8"
9	Toto 3	7° 0' 3.6"	8° 1' 19.2"

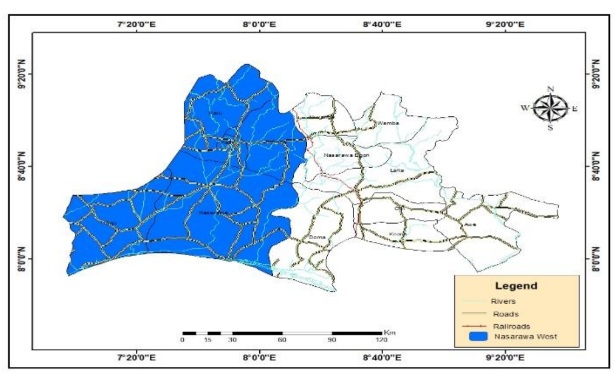

Fig.1: Map of Nasarawa State Showing Nasarawa West Senatorial District.

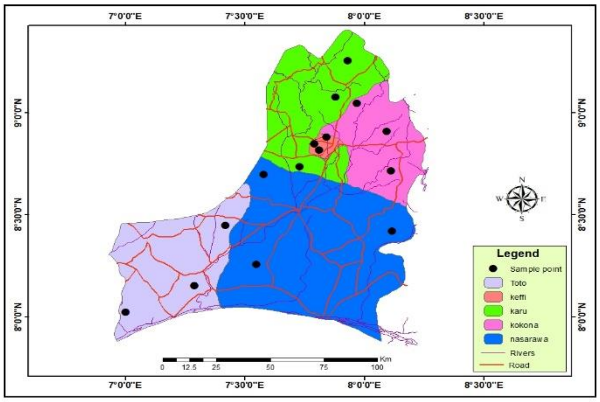

Fig. 2: Map of Nasarawa West Showing Data Point.

2.2.2 Method Data Collection and Measurement

The instrument used was Inspector Alert Meter. This detector is a relatively economical meter frequently used to perform surveys of very low radiation fields. It can measure variations in background dose rate. The measuring range is 0 to 5000 µR/hr. (For µSv/h, use Model 19 Series 8, P/N: 48-2582.) The cast aluminum instrument housing with a separate battery compartment and accompanying metal handle offer an industrial robustness and quality that promote long lasting protection.

The meter was held one meter above the ground to reflect abdominal level of human readings in count per minute. Readings were taken three times in µR/hr after which the average reading was calculated for each of the camp work visited. The analytical procedure was conducted for five days, in Plateau State.

2.2.3 Method of Data Analysis

[20] Recommended indoor occupancy factors of 0.8. This occupancy factor is the proportion of the total time during which an individual is exposed to a radiation field. Eight thousand seven hundred and sixty hours per year (8760hr/yr) were used. Equation (1) converts from Gamma Activity in milli Röentgen per hour to Exposure Dose Rate in micro – Sievert per hour, equation (2) converts the Exposure Dose Rate in micro – Sievert per hour to Annual Effective Dose Rate in milli Sievert per year, equation (3) evaluates the Excess Lifetime Cancer Risk, while equation (4) evaluates the Annual Effective Dose Rate to organs.

$$10mR/hr(GA) = 1\mu Sv/hr(EDR) \quad (1)$$

$$AEDR mSv/yr = [(EDR)\mu Sv/hr \times 8760hr/yr \times 0.8] \div 1000 \quad (2)$$

$$ELCR = AEDR \times DL \times RF \quad (3)$$

$$D_{organ} = AEDR \times F \quad (4)$$

3 Results and Discussion

3.1 Results

Gamma activity level was obtained from the field, after which equations (1) – (4) were used to evaluate the Exposure Dose Rate (EDR), Annual Effective Dose Rate (AEDR), Excess Lifetime Cancer Risk (ELCR) and Effective Dose to different organs of the body (D_{organ}) and are presented in Table 2, 3, 4 and 5.

Table 2: Exposure Levels and Related Radiological Health Indices in Kokona, Nasarawa and Toto.

Sample Points	Gamma Activity (mR/hr)	Exposure Dose Rate (µSv/hr)	Effective Dose Rate (mSv/yr)	Excess Lifetime Cancer Risk
Kok 1	0.032	0.0032	0.0224	0.0785
	0.015	0.0015	0.0105	0.0368
	0.057	0.0057	0.0399	0.1398
	0.028	0.0028	0.0196	0.0687
Mean	**0.033**	**0.0033**	**0.0231**	**0.0809**
Kok 2	0.020	0.0020	0.0140	0.0491
	0.021	0.0021	0.0147	0.0515
	0.024	0.0024	0.0168	0.0589
	0.020	0.0020	0.0140	0.0491
Mean	**0.021**	**0.0022**	**0.0149**	**0.0521**
Kok 3	0.122	0.0122	0.0855	0.2992
	0.065	0.0065	0.0456	0.1594
	0.037	0.0037	0.0259	0.0908
	0.029	0.0029	0.0203	0.0711
Mean	**0.063**	**0.0063**	**0.0443**	**0.1551**
Nas 1	0.025	0.0025	0.0175	0.0613
	0.025	0.0025	0.0175	0.0613
	0.022	0.0022	0.0154	0.0540
	0.023	0.0023	0.0161	0.0564
Mean	**0.024**	**0.0024**	**0.0166**	**0.0583**
Nas 2	0.028	0.0028	0.0196	0.0687
	0.021	0.0021	0.0147	0.0515
	0.023	0.0023	0.0161	0.0564
	0.025	0.0025	0.0175	0.0613
Mean	**0.024**	**0.0024**	**0.0170**	**0.0595**
Nas 3	0.012	0.0012	0.0084	0.0294
	0.021	0.0021	0.0147	0.0515
	0.037	0.0037	0.0259	0.0908

	0.023	0.0023	0.0161	0.0564
Mean	**0.023**	**0.0023**	**0.0163**	**0.0570**
Toto 1	0.042	0.0042	0.0294	0.1030
	0.075	0.0075	0.0526	0.1840
	0.017	0.0017	0.0119	0.0417
	0.048	0.0048	0.0336	0.1177
Mean	**0.046**	**0.0046**	**0.0319**	**0.1116**
Toto 2	0.042	0.0042	0.0294	0.1030
	0.025	0.0025	0.0175	0.0613
	0.021	0.0021	0.0147	0.0515
	0.025	0.0025	0.0175	0.0613
Mean	**0.028**	**0.0028**	**0.0198**	**0.0693**
Toto 3	0.023	0.0023	0.0161	0.0564
	0.026	0.0026	0.0182	0.0638
	0.021	0.0021	0.0147	0.0515
	0.024	0.0024	0.0168	0.0589
Mean	**0.024**	**0.0024**	**0.0165**	**0.0576**

Table 2 presented the raw data obtained for gamma activity level at different mining points of Kokona, Nasarawa and Toto of Nasarawa State, which was later summarized in Table 3 for further interpretation and analysis.

Table 3: Summary of Exposure Levels and Related Radiological Health Indices in Kokona, Nasarawa and Toto

Sample Points	Gamma Activity (mR/hr)	Exposure Dose Rate (µSv/hr)	Effective Dose Rate (mSv/yr)	Excess Lifetime Cancer Risk
Kok 1	0.033	0.0033	0.0231	0.0809
Kok 2	0.021	0.0022	0.0149	0.0521
Kok 3	0.063	0.0063	0.0443	0.1551
Mean	**0.039**	**0.0039**	**0.0274**	**0.0960**
Nas 1	0.024	0.0024	0.0166	0.0583
Nas 2	0.024	0.0024	0.0170	0.0595
Nas 3	0.023	0.0023	0.0163	0.0570
Mean	**0.024**	**0.0024**	**0.0166**	**0.0580**
Toto 1	0.046	0.0046	0.0319	0.1116
Toto 2	0.028	0.0028	0.0198	0.0693
Toto 3	0.024	0.0024	0.0165	0.0576
Mean	**0.033**	**0.0033**	**0.0227**	**0.0795**

Table 3 presented the summary of the raw data obtained for gamma activity level at different points of Kokona, Nasarawa and Toto and the calculated values for exposure dose rate, effective dose rate and excess lifetime cancer risk.

Based on the data presented, Kokona has the mean gamma activity of 0.039 mR/hr with kokona 3 having the highest value of 0.063 mR/hr followed by kokona 1 with 0.033 mR/hr then kokona 2 having the lowest value of 0.021 mR/hr. Nasarawa has the mean gamma activity of 0.024 mR/hr with Nasarawa 1 and Nasarawa 2 having the highest value of 0.024 mR/hr then Nasarawa 3 having the lowest value of 0.023 mR/hr. Toto has the mean gamma activity of 0.033 mR/hr with Toto 1 having the highest value of 0.046 mR/hr followed by Toto 2 with 0.028 mR/hr then Toto 3 having the lowest value of 0.024 mR/hr.

On exposure dose rate, Kokona has the mean exposure dose rate of 0.0039 µSv/hr with kokona 3 having the highest value of 0.0063 µSv/hr followed by kokona 1 with 0.0033 µSv/hr then kokona 2 having the lowest value of 0.0022 µSv/hr. Nasarawa has the mean exposure dose rate of 0.0024 µSv/hr with Nasarawa 1 and Nasarawa 2 having the highest value of 0.0024 µSv/hr then Nasarawa 3 having the lowest value of 0.0023 µSv/hr. Toto has the mean exposure dose rate of 0.0033 µSv/hr with Toto 1 having the highest value of 0.0046 µSv/hr followed by Toto 2 with 0.0028 µSv/hr then Toto 3 having the lowest value of 0.0024 µSv/hr.

On effective dose rate, Kokona has the mean effective dose rate of 0.0274 mSv/yr with Kokona 3 having the highest value of 0.0443 mSv/yr followed by Kokona 1 with 0.0231 mSv/yr then Kokona 2 having the lowest value of 0.0149 mSv/yr. Nasarawa has the mean effective dose rate of 0.0166 mSv/yr with Nasarawa 2 having the highest value of 0.0170 mSv/yr followed by Nasarawa 1 with 0.0166 mSv/yr then Nasarawa 3 having the lowest value of 0.0163 mSv/yr. Toto has the mean effective dose rate of 0.0227 mSv/yr with Toto 1 having the highest value of 0.0319 mSv/yr followed by Toto 2 with 0.0198 mSv/yr then Toto 3 having the lowest value of 0.0165 mSv/yr.

On excess lifetime cancer risk, Kokona has the mean excess lifetime cancer risk of 0.096 $x10^{-3}$, with Kokona 3 having the highest value of 0.1551 $x10^{-3}$ followed by Kokona 1 with 0.0809 $x10^{-3}$ then Kokona 2 having the lowest value of 0.0521 $x10^{-3}$. Nasarawa has the mean excess lifetime cancer risk of 0.058 $x10^{-3}$ with Nasarawa 2 having the highest value of 0.0595 $x10^{-3}$ followed by Nasarawa 1 with 0.0583 $x10^{-3}$ then Nasarawa 1 having the lowest value of 0.057 $x10^{-3}$. Toto has the mean excess lifetime cancer risk of 0.0795 $x10^{-3}$, with Toto 1 having the highest value of 0.1116 $x10^{-3}$ followed by Toto 2 with 0.0693 $x10^{-3}$ then Toto 3 having the lowest value of 0.0576 $x10^{-3}$.

Table 4 shows that the estimated mean D_{organ} values for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body due to radiation exposure and inhalation in different mining points of Kokona, Nasarawa and Toto of Nasarawa state which was later summarized in Table 5 for further interpretation and analysis.

Table 4: Dose to different organs of the body in Kokona, Nasarawa and Toto.

S/ P	Effective Dose Rate to Sensitive Organs						
Kk 1	Lungs	Ovaries	Bone Marrows	Testes	Kidney	Liver	Whole Body
	0.0144	0.0130	0.0155	0.0184	0.0139	0.0103	0.0152
	0.0067	0.0061	0.0073	0.0086	0.0065	0.0048	0.0071
	0.0256	0.0232	0.0276	0.0328	0.0248	0.0184	0.0272
	0.0126	0.0114	0.0135	0.016	0.0122	0.0090	0.0133
Kk 2	**0.0148**	**0.0134**	**0.0160**	**0.0190**	**0.0143**	**0.0106**	**0.0157**
	0.0090	0.0081	0.0097	0.0115	0.0087	0.0064	0.0095
	0.0094	0.0085	0.0102	0.0121	0.0091	0.0068	0.0100
	0.0108	0.0098	0.0116	0.0138	0.0104	0.0077	0.0114
	0.0090	0.0081	0.0097	0.0115	0.0087	0.0064	0.0095
Kk 3	**0.0095**	**0.0086**	**0.0103**	**0.0122**	**0.0092**	**0.0069**	**0.0101**
	0.0547	0.0496	0.0590	0.0701	0.0530	0.0393	0.0581
	0.0292	0.0264	0.0314	0.0374	0.0282	0.0210	0.0310
	0.0166	0.0150	0.0179	0.0213	0.0161	0.0119	0.0176
	0.0130	0.0118	0.0140	0.0167	0.0126	0.0093	0.0138
Ns 1	**0.0284**	**0.0257**	**0.0306**	**0.0363**	**0.0275**	**0.0204**	**0.0301**
	0.0112	0.0101	0.0121	0.0144	0.0109	0.0081	0.0119
	0.0112	0.0102	0.0121	0.0144	0.0109	0.0081	0.0119
	0.0099	0.0089	0.0106	0.0126	0.0096	0.0071	0.0105
	0.0103	0.0093	0.0111	0.0132	0.0100	0.0074	0.0110
Ns 2	**0.0107**	**0.0097**	**0.0115**	**0.0136**	**0.0103**	**0.0077**	**0.0113**
	0.0126	0.0114	0.0135	0.0161	0.0122	0.0090	0.0133
	0.0094	0.0085	0.0102	0.0121	0.0091	0.0068	0.0100
	0.0103	0.0093	0.0111	0.0132	0.0100	0.0074	0.0110
	0.0112	0.0102	0.0121	0.0144	0.0109	0.0081	0.0119
Ns 3	**0.0109**	**0.0099**	**0.0117**	**0.0139**	**0.0105**	**0.0078**	**0.0116**
	0.0054	0.0049	0.0058	0.0069	0.0052	0.0039	0.0057
	0.0094	0.0085	0.0102	0.0121	0.0091	0.0068	0.0100
	0.01659	0.0150	0.0179	0.0213	0.0161	0.0119	0.0176
	0.0103	0.0093	0.0111	0.0132	0.0100	0.0074	0.0110
Tt 1	**0.0104**	**0.0095**	**0.0112**	**0.0134**	**0.0101**	**0.0075**	**0.0111**
	0.0188	0.0171	0.0203	0.0241	0.0182	0.0135	0.0200
	0.0336	0.0305	0.0363	0.0431	0.0326	0.0242	0.0357
	0.0076	0.0069	0.0082	0.0098	0.0074	0.0055	0.0081
	0.0215	0.0195	0.0232	0.0276	0.0209	0.0155	0.0229
Tt 2	**0.0204**	**0.0185**	**0.0220**	**0.0261**	**0.0198**	**0.0147**	**0.0217**
	0.0188	0.0171	0.0203	0.0241	0.0182	0.0135	0.0200
	0.0112	0.0102	0.0121	0.0144	0.0109	0.0081	0.0119

	0.0094	0.0085	0.0102	0.0121	0.0091	0.0068	0.0100
	0.0112	0.0102	0.0121	0.0144	0.0109	0.0081	0.0119
Tt 3	**0.0127**	**0.0115**	**0.0137**	**0.0162**	**0.0123**	**0.0091**	**0.0135**
	0.0103	0.0093	0.0111	0.0132	0.0100	0.0074	0.0110
	0.0117	0.0106	0.0126	0.0149	0.0113	0.0084	0.0124
	0.0094	0.0085	0.0102	0.0121	0.0091	0.0068	0.0100
	0.0108	0.0098	0.0116	0.0138	0.0104	0.0077	0.0114
	0.0105	**0.0096**	**0.0114**	**0.0135**	**0.0102**	**0.0076**	**0.0112**

Table 5: Summary of Dose to different organs of the body in Kokona, Nasarawa and Toto.

S/P	Effective Dose Rate to Sensitive Organs						
	Lungs	Ovaries	Bone Marrows	Testes	Kidney	Liver	Whole Body
Kk 1	0.0148	0.0134	0.0160	0.0190	0.0143	0.0106	0.0157
Kk 2	0.0095	0.0086	0.0103	0.0122	0.0092	0.0069	0.0101
Kk 3	0.0284	0.0257	0.0306	0.0363	0.0275	0.0204	0.0301
Mean	**0.0176**	**0.0159**	**0.0190**	**0.0225**	**0.017**	**0.0126**	**0.0186**
Ns 1	0.0107	0.0097	0.0115	0.0136	0.0103	0.0077	0.0113
Ns 2	0.0109	0.0099	0.0117	0.0139	0.0105	0.0078	0.0116
Ns 3	0.0104	0.0095	0.0112	0.0134	0.0101	0.0075	0.0111
Mean	**0.0107**	**0.0097**	**0.0115**	**0.0136**	**0.0103**	**0.0077**	**0.0113**
Tt 1	0.0204	0.0185	0.0220	0.0261	0.0198	0.0147	0.0217
Tt 2	0.0127	0.0115	0.0137	0.0162	0.0123	0.0091	0.0135
Tt 3	0.0105	0.0096	0.0114	0.0135	0.0102	0.0076	0.0112
Mean	**0.0145**	**0.0132**	**0.0157**	**0.0186**	**0.0141**	**0.0105**	**0.0155**

0.0176, 0.0107 and 0.0145, 0.0159, 0.0097 and 0.0132, 0.0190, 0.0115 and 0.0157, 0.0225, 0.0136 and 0.0186, 0.017, 0.0103 and 0.0141, 0.0126, 0.0077 and 0.0105, and 0.0186, 0.0113 and 0.0155 respectively.

Table 5 presented the summary of the evaluated results for D_{organ} values for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body due to radiation exposure and inhalation in different mining points of Kokona, Nasarawa and Toto of Nasarawa State.

Based on the data presented, Kokona has the mean effective dose to lungs of 0.0176 mSv/yr with Kokona 3 having the highest value of 0.0284 mSv/yr followed by Kokona 1 with 0.0148 mSv/yr then Kokona 2 having the lowest value of 0.0094 mSv/yr. Nasarawa has the mean effective dose to lungs of 0.0107 mSv/yr with Nasarawa 2 having the highest value of 0.0109 mSv/yr followed by Nasarawa 1 with 0.0107 mSv/yr then Nasarawa 3 having the lowest value of 0.0104 mSv/yr. Toto has the mean effective dose to lungs of 0.0145 mSv/yr with Toto 1 having the highest value of 0.0204 mSv/yr followed by Toto 2 with 0.0127 mSv/yr then Toto 3 having the lowest value of 0.0105 mSv/yr.

On effective dose to ovaries, Kokona has the mean effective dose to ovaries of 0.0159 mSv/yr with Kokona 3 having the highest value of 0.0257 mSv/yr followed by Kokona 1 with 0.0134 mSv/yr then Kokona 2 having the lowest value of 0.0086 mSv/yr. Nasarawa has the mean effective dose to ovaries of 0.0097 mSv/yr with Nasarawa 2 having the highest value of 0.0099 mSv/yr followed by Nasarawa 1 with 0.0097 mSv/yr then Nasarawa 3 having the lowest value of 0.0095 mSv/yr. Toto has the mean effective dose to ovaries of 0.0132 mSv/yr with Toto 1 having the highest value of 0.0185 mSv/yr followed by Toto 2 with 0.0115 mSv/yr then Toto 3 having the lowest value of 0.0096 mSv/yr.

On effective dose to bone marrow, Kokona has the mean effective dose to bone marrow of 0.019 mSv/yr with Kokona 3 having the highest value of 0.0306 mSv/yr followed by Kokona 1 with 0.016 mSv/yr then Kokona 2 having the lowest value of 0.0103 mSv/yr. Nasarawa has the mean effective dose to bone marrow of 0.0115 mSv/yr with Nasarawa 2 having the highest value of 0.0117 mSv/yr followed by Nasarawa 1 with 0.0115 mSv/yr then Nasarawa 3 having the lowest value of 0.0112 mSv/yr. Toto has the mean effective dose to bone marrow of 0.0157 mSv/yr with Toto 1 having the highest value of 0.022 mSv/yr followed by Toto 2 with 0.0137 mSv/yr then Toto 3 having the lowest value of 0.0114 mSv/yr.

On effective dose to testes, Kokona has the mean effective dose to testes of 0.0225 mSv/yr with Kokona 3 having the highest value of 0.0363 mSv/yr followed by Kokona 1 with 0.019 mSv/yr then Kokona 2 having the lowest value of 0.0122 mSv/yr. Nasarawa has the mean effective dose to testes of 0.0136 mSv/yr with Nasarawa 2 having the highest value of 0.0139 mSv/yr followed by Nasarawa 1 with 0.0136 mSv/yr then Nasarawa 3 having the lowest value of 0.0134 mSv/yr. Toto has the mean effective dose to testes of 0.0186 mSv/yr with Toto 1 having the highest value of 0.0261 mSv/yr followed by Toto 2 with 0.0162 mSv/yr then Toto 3 having the lowest value of 0.0135 mSv/yr.

On effective dose to Kidney, Kokona has the mean effective dose to Kidney of 0.017 mSv/yr with Kokona 3 having the highest value of 0.0275 mSv/yr followed by Kokona 1 with 0.0143 mSv/yr then Kokona 2 having the lowest value of 0.0092 mSv/yr. Nasarawa has the mean effective dose to Kidney of 0.0103 mSv/yr with Nasarawa 2 having the highest value of 0.0105 mSv/yr followed by Nasarawa 1 with 0.0103 mSv/yr then Nasarawa 3 having the lowest value of 0.0101 mSv/yr. Toto has the mean effective dose to Kidney of 0.0141 mSv/yr with Toto 1 having the highest value of 0.0198 mSv/yr followed by Toto 2 with 0.0123 mSv/yr then Toto 3 having the lowest value of 0.0102 mSv/yr.

On effective dose to liver, Kokona has the mean effective dose to liver of 0.0126 mSv/yr with Kokona 3 having the highest value of 0.0204 mSv/yr followed by Kokona 1 with 0.0106 mSv/yr then Kokona 2 having the lowest value of 0.0069 mSv/yr. Nasarawa has the mean effective dose to liver of 0.0077 mSv/yr with Nasarawa 2 having the highest value of 0.0078 mSv/yr followed by Nasarawa 1 with 0.0077 mSv/yr then Nasarawa 3 having the lowest value of 0.0075 mSv/yr. Toto has the mean effective dose to liver of 0.0105 mSv/yr with Toto 1 having the highest value of 0.0147 mSv/yr followed by Toto 2 with 0.0091 mSv/yr then Toto 3 having the lowest value of 0.0076 mSv/yr.

On effective dose to whole body, Kokona has the mean effective dose to whole body of 0.0186 mSv/yr with Kokona 3 having the highest value of 0.0301 mSv/yr followed by Kokona 1 with 0.0157 mSv/yr then Kokona 2 having the lowest value of 0.0101 mSv/yr. Nasarawa has the mean effective dose to whole body of 0.0113 mSv/yr with Nasarawa 2 having the highest value of 0.0116 mSv/yr followed by Nasarawa 1 with 0.0113 mSv/yr then Nasarawa 3 having the lowest value of 0.0111 mSv/yr. Toto has the mean effective dose to whole body of 0.0155 mSv/yr with Toto 1 having the highest value of 0.0217 mSv/yr followed by Toto 2 with 0.0135 mSv/yr then Toto 3 having the lowest value of 0.0112 mSv/yr.

3.2 Result Analysis

3.2.1 Comparison of Results with United Nation Scientific Committee on Effect of Atomic Radiation

In this section, the results presented in Table 3 and Table 5 is used to plot charts in order to compare the results of the present study with UNSCEAR and presented in figure 3 and 4.

3.2.1.1 Comparison of Annual Effective Dose Rate with United Nation Scientific Committee on Effect of Atomic Radiation

The data presented in Table 3 was used to plot a chart in order to compare the result of annual effective dose rate with UNSCEAR. This chart is presented in Figure 3.

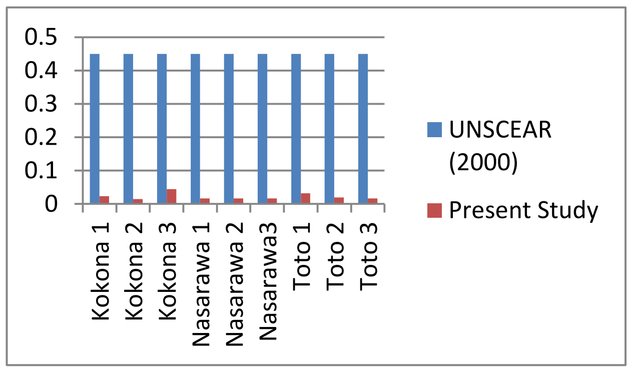

Fig.3: Comparison of Annual Effective Dose Rate with UNSCEAR

On comparison of Annual Effective Dose Rate with UNSCEAR, it is observed that the Effective Dose for all the areas is found to be low.

3.2.1.2 Comparison of Excess Lifetime Cancer Risk with United Nation Scientific Committee on Effect of Atomic Radiation.

The data presented in Table 3 was used to plot a chart in order to compare the result of excess lifetime cancer risk with UNSCEAR. This chart is presented in Figure 4.

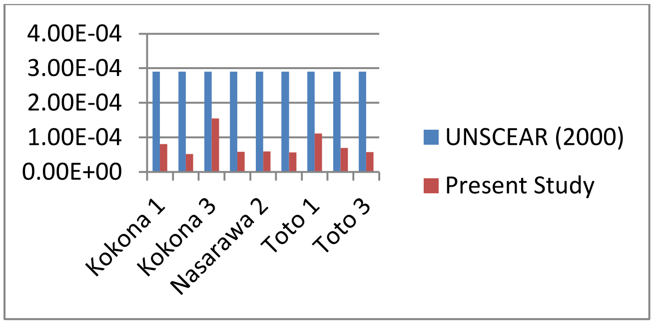

Fig. 4: Comparison of Excess Lifetime Cancer Risk with UNSCEAR.

On comparison of Excess Lifetime Cancer Risk with UNSCEAR, it is observed that the Excess Lifetime Cancer Risk was found to be low.

3.2.1.3 Comparison of Dose to different organs of the body with United Nation Scientific Committee on Effect of Atomic Radiation.

The data presented in Table 5 was used to plot a chart in order to compare the result of Effective Dose to different organs of the body with UNSCEAR. This chart is presented in Figure 5.

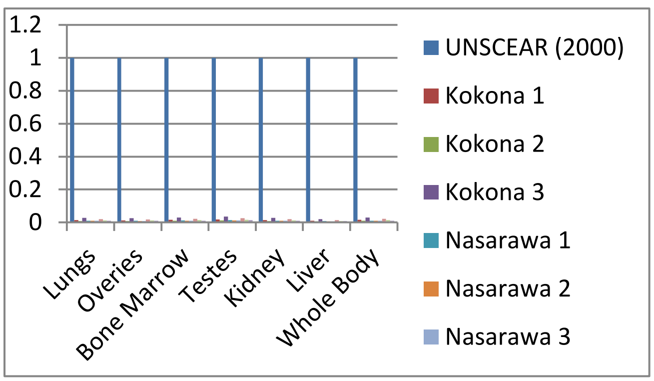

Fig. 5: Comparison of Effective Dose Rate to Various Organs (D_{organ}) with UNSCEAR

On comparison of Effective Dose Rate to various Organs (D_{organ}) with UNSCEAR, it is observed that the D_{organ} was found to be lower compare to UNSCEAR as presented in Figure 5.

4 Discussion

On annual effective dose rate, finding of this study have revealed that the mean annual effective dose rate for Kokona, Nasarawa and Toto are 0.0274, 0.0166 and 0.0227 mSv/y respectively, which are lower the value of effective dose of 0.45 mSv/yr as recommended by UNSCEAR and may not cause radiological hazard to the public and workers unless on excessive exposure. This finding on comparison of Annual Effective Dose Rate (AEDR) is in line with the finding of [13, 14]. But not in line with the findings of [15] who investigated the indoor and outdoor ionizing radiation level at Kwali General Hospital, Abuja Nigeria using a well calibrated Geiger Muller counter and found the average annual effective dose rate as 0.750± 0.020 mSv/yr and 0.189±0.005 mSv/yr for indoor and outdoor measurements respectively. Also not in line with the findings of [16] who assessed the background ionizing radiations at Biochemistry, Chemistry, Microbiology and physics laboratories of Plateau State University Bokkos using Gamma-scout Radiometer and found the mean annual effective dose rate of the laboratories for indoor and outdoor to be 1.54 mSv/yr and 0.44 mSv/yr respectively.

On comparison of excess lifetime cancer risk, finding of this study have revealed that the mean excess lifetime cancer risk (ELCR) for Kokona, Nasarawa and Toto are 0.0960 × 10-3, 0.058 × 10-3 and 0.0795 × 10-3 which are lower than the value of excess lifetime cancer risk (ELCR) of 2.9 × 10-3 as recommended by UNSCEAR and may not cause radiological hazard to the public and workers. This finding is in line with the finding of [13, 14]. But not in line with the findings of [15] who investigated the indoor and outdoor ionizing radiation level at Kwali General Hospital, Abuja Nigeria using a well calibrated Geiger Muller counter and found the average excess lifetime cancer risk as 2.63 × 10-3and 0.66 × 10-3 for indoor and outdoor measurements respectively. Also not in line with the findings of [16] who assessed the background ionizing radiations at Biochemistry, Chemistry, Microbiology and physics laboratories of Plateau State University Bokkos using Gamma-scout Radiometer and found the mean excess lifetime cancer risk of the laboratories for indoor and outdoor background radiation level to be 1.54 mSv/yr and 0.44 mSv/yr respectively.

On comparison of Effective Dose Rate to Organs (Dorgan) values for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body, finding of this study have revealed that the mean Dorgan values for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body for Kokona, Nasarawa and Toto are 0.0176, 0.0107 and 0.0145, 0.0159, 0.0097 and 0.0132, 0.0190, 0.0115 and 0.0157, 0.0225, 0.0136 and 0.0186, 0.017, 0.0103 and 0.0141, 0.0126, 0.0077 and 0.0105, and 0.0186, 0.0113 and 0.0155 mSv/yr respectively, which is lower than the value of effective dose to sensitive organs recommended by the international tolerable limits of 1.0 mSv annually which further stress that the radiation levels do not constitute any immediate health effect on residents of the area. This finding is in line with the finding of [12, 13, 14, 15, and 16].

5 Conclusions

This tends to unveil the dangerous effect of radiation exposure on human organs as a result of quarry mining taking place in some part of Kokona, Nasarawa and Toto of Nasarawa State. Data in milli Roentgen per hour (mR/hr) were converted to exposure dose rate in micro Sivert per hour (µSv/hr), from exposure dose rate in micro Sivert per hour (µSv/hr) to Annual Effective Dose Rate in milli Sivert per year (mSv/yr), from Annual Effective Dose Rate in milli Sivert per year(mSv/yr) to Excess Lifetime Cancer Risk and also lastly, from Annual Effective Dose Rate in milli Sivert per year (mSv/yr) to Annual Effective Dose Rate to Organs in milli Sivert per year (mSv/yr). From the findings presented, it can be concluded that the background radiation in different mining sites of Kokona, Nasarawa and Toto of Nasarawa State is not an issue of health concern except when accumulated by the public over a long period of time which may cause cancer to the members of public on getting themselves approximately seventy years of exposure. It is therefore, advised or recommended that the government stop all the illegal miners from mining and introduce mechanize mining for easy control of the health effects. Also, it is recommended that water and soil sample be taking for elemental analysis to ascertain the effect of the mining activity in these areas through ingestion, since it has no much effect on the populace of the area through inhalation according to this research.

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