Journal of Oncology Research
https://ojs.bilpublishing.com/index.php/jor

ARTICLE

Health Effects of Radiation Exposure to Human Sensitive Organs across Some Selected Mining Sites of Plateau State, Nigeria

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ARTICLE INFO

Article history
Received: 22 February 2022
Revised: 18 July 2022
Accepted: 28 July 2022
Published Online: 10 August 2022

Keywords:
Radionuclides
Mining
D_{organ}
Radiation
Effective dose
Excess lifetime cancer risk

ABSTRACT

The association of radiation with matter, being it from external means (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 are a function of the amount of radiation absorbed and the rate at which it is received. This study aimed at assessing the health effects of radiation exposure to human sensitive organs across some selected mining sites of Plateau State Nigeria. Finding of this study have revealed that the mean D_{organ} values for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body for different mining points of Plateau State are 0.29 mSv/y, 0.26 mSv/y, 0.31 mSv/y, 0.36 mSv/y, 0.28 mSv/y, 0.21 mSv/y and 0.30 mSv/y respectively. From the findings presented, it can be concluded that the background radiation in Plateau State is not an issue of health concern in regards to sensitive organs and may not course immediate health effect except when accumulated over long period of time which may cause cancer to the indoor members on approximately seventy years of exposure.

1. Introduction

The association of radiation with matter, being it from external means (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 cause 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

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DOI: https://doi.org/10.30564/jor.v4i2.4469

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 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 will find solution to question like; the various factors that leads to the variation in radiation effects in Plateau State, 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 health effects of radiation exposure to human sensitive organs across some selected mining sites of Plateau State Nigeria.

2. Materials and Method

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 9.0 volts, a scientific calculator, personal computer (laptop), pen and exercise book.

2.2 Method

The methods of radiation measurement used in this research work were by using radiation monitor with inbuild Geiger Muller tube operating in the Dose Rate mode to determine the background ionizing radiation level from the selected mining sites of Plateau 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 , 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 (1 m 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

Plateau is the twelfth-largest state in Nigeria. Approximately in the centre of the country, it is geographically unique in Nigeria due to its boundaries of elevated hills surrounding the Jos Plateau which is its capital, and the entire plateau itself [16].

Plateau State is celebrated as "The Home of Peace and Tourism". With natural formations of rocks, hills and waterfalls, it derives its name from the Jos Plateau and has a population of around 3.5 million people. Plateau State is located at North Central Zone out of the six geopolitical zones of Nigeria. With an area of 26,899 square kilometers, the State has an estimated population of about three million people. It is located between latitude 08°24'N and longitude 008°32' and 010°38' east [17-19].

The map of Nigeria showing Plateau State, the map of Plateau State showing the mining Local Governments and map of mining Local Government showing the sample points are shown respectively in Figures 1, 2 and 3. The geographical coordinates of the data points are tabulated in Table 1.

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 accom-

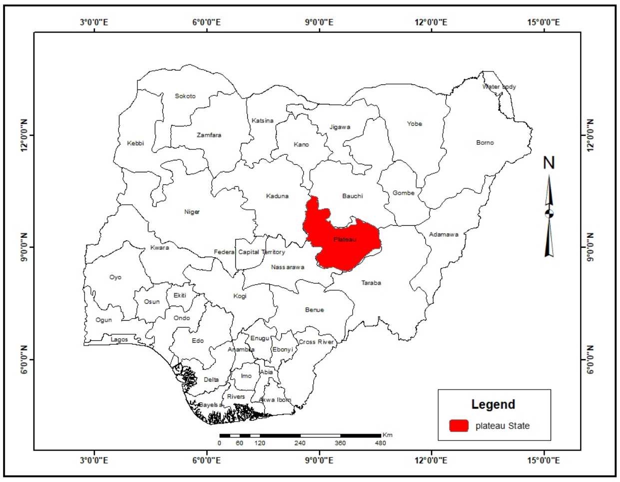

Figure 1. Map of Nigeria Showing Plateau State

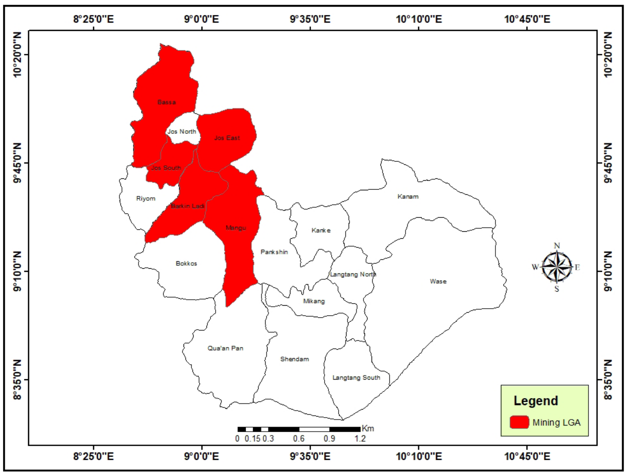

Figure 2. Map of Plateau State Showing Mining Local Government Areas

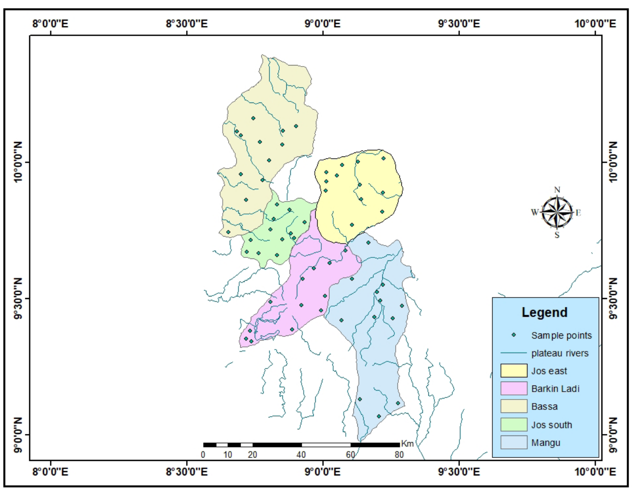

Figure 3. Map of Mining Local Government Areas Showing Data Points

Table 1. Geographical Coordinates of the Data Points

Village	Sample Points	Geographical Coordinates	
		East	North
Bassa	PT01	8°44'34.8"	10°09'39.6"
	PT02	8°40'58.8"	10°06'50.4"
	PT03	8°41'49.5"	10°06'00.00"
	PT04	8° 46' 4.8"	10° 4' 30"
	PT05	8° 51' 7.2"	10° 6' 57.6"
	PT06	8° 54' 3.6"	10° 7' 55.2"
	PT07	8° 50' 56.4"	10° 3' 57.6"
	PT08	8° 48' 3.6"	10° 0' 32.4"
	PT09	8° 41' 52.8"	9° 57' 21.6"
	PT10	8° 46' 37.2"	9° 56' 2.4"
	PT11	8° 43' 4.8"	9° 51' 46.8"
	PT12	8° 39' 3.6"	9° 44' 42"
Jos South	PT01	8° 49' 48"	9° 50' 42"
	PT02	8° 52' 33.6"	9° 49' 37.2"
	PT03	8° 49' 4.8"	9° 47' 34.8"
	PT04	8° 55' 55.2"	9° 46' 51.6"
	PT05	8° 48' 21.6"	9° 45' 10.8"
	PT06	8° 52' 48"	9° 44' 24"
	PT07	8° 53' 34.8"	9° 43' 22.8"
	PT08	8° 51'	9° 43' 1.2"
	PT09	8° 44' 2.4"	9° 42' 54"
	PT10	8° 43' 8.4"	9° 40' 19.2"
	PT11	8° 45' 46.8"	9° 40' 1.2"
	PT12	8° 49' 51.6"	9° 39' 32.4"
Barkin Ladi	PT01	9° 4' 55.2"	9° 40' 33.6"
	PT02	9° 1' 30"	9° 37' 55.2"
	PT03	8° 58' 1.2"	9° 36' 39.6"
	PT04	8° 55' 26.4"	9° 34' 19.2"
	PT05	9° 0' 25.2"	9° 30' 36"
	PT06	8° 59' 31.2"	9° 27' 25.2"
	PT07	8° 55' 8.4"	9° 28' 33.6"
	PT08	8° 48' 25.2"	9° 29' 20.4"
	PT09	8° 53' 13.2"	9° 23' 13.2"
	PT10	8° 43' 55.2"	9° 22' 55.2"
	PT11	8° 42' 57.6"	9° 21' 10.8"
	PT12	8° 44' 13.2"	9° 20' 34.8"
Mangu	PT01	9° 9' 57.6"	9° 42' 21.6"
	PT02	9° 6' 21.6"	9° 34' 19.2"
	PT03	9° 13' 8.4"	9° 33'
	PT04	9° 11' 52.8"	9° 31' 30"
	PT05	9° 12' 36"	9° 29' 34.8"
	PT06	9° 17' 20.4"	9° 28' 22.8"
	PT07	9° 15' 21.6"	9° 25' 40.8"
	PT08	9° 11' 20.4"	9° 25' 58.8"
	PT09	9° 4' 1.2"	9° 25' 12"
	PT10	9° 8' 6"	9° 7' 55.2"
	PT11	9° 16' 30"	9° 6' 57.6"
	PT12	9° 12' 18"	9° 4' 1.2"
Jos East	PT01	9° 13' 22.8"	10° 0' 57.6"
	PT02	9° 7' 37.2"	10° 0' 7.2"
	PT03	9° 4' 8.4"	9° 59' 24"
	PT04	9° 0' 46.8"	9° 57' 50.4"
	PT05	9° 3'00.00"	9° 57' 3.6"
	PT06	9° 0' 46.8"	9° 55' 51.6"
	PT07	9° 0' 28.8"	9° 53' 45.6"
	PT08	9° 8' 2.4"	9° 55' 8.4"
	PT09	9° 13' 8.4"	9° 53' 20.4"
	PT10	9° 8' 24"	9° 51' 57.6"
	PT11	9° 13' 1.2"	9° 49' 4.8"
	PT12	9° 6' 21.6"	9° 46' 12"

panying 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

UNCEAR [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 (8760 hr/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.

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

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

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

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

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 Tables 2, 3, 4 and 5.

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

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

Based on the data presented, exposure levels and related radiological health indices appear to be similar for all villages except that of Barkin Ladi and Jos East which appear slightly different.

Table 2. Exposure Levels and Related Radiological Health Indices in Plateau State

Village	Sample Points	Gamma Activity (mR/hr)	Exposure Dose Rate (μSv/hr)	Effective Dose Rate (mSv/yr)	Excess Lifetime Cancer Risk
Bassa	PT01	0.64	0.064	0.45	1.6
	PT02	0.60	0.060	0.42	1.5
	PT03	0.61	0.061	0.43	1.5
	PT04	0.65	0.065	0.46	1.6
	PT05	0.62	0.062	0.43	1.5
	PT06	0.60	0.060	0.42	1.5
	PT07	0.63	0.063	0.44	1.5
	PT08	0.68	0.068	0.48	1.7
	PT09	0.64	0.064	0.45	1.6
	PT10	0.67	0.067	0.47	1.6
	PT11	0.62	0.062	0.43	1.5
	PT12	0.66	0.066	0.46	1.6
Mean		**0.64**	**0.064**	**0.45**	**1.6**
Jos South	PT01	0.66	0.066	0.46	1.6
	PT02	0.67	0.067	0.47	1.6
	PT03	0.67	0.067	0.47	1.6
	PT04	0.64	0.064	0.45	1.6
	PT05	0.68	0.068	0.48	1.7
	PT06	0.63	0.063	0.44	1.5
	PT07	0.60	0.060	0.42	1.5
	PT08	0.62	0.062	0.43	1.5
	PT09	0.65	0.065	0.46	1.6
	PT10	0.61	0.061	0.43	1.5
	PT11	0.60	0.060	0.42	1.5
	PT12	0.64	0.064	0.45	1.6
Mean		**0.64**	**0.064**	**0.45**	**1.6**
Barkin Ladi	PT01	0.63	0.063	0.44	1.5
	PT02	0.68	0.068	0.48	1.7
	PT03	0.64	0.064	0.45	1.6
	PT04	0.67	0.067	0.47	1.6
	PT05	0.62	0.062	0.43	1.5
	PT06	0.66	0.066	0.46	1.6
	PT07	0.64	0.064	0.45	1.6
	PT08	0.60	0.060	0.42	1.5
	PT09	0.61	0.061	0.43	1.5
	PT10	0.65	0.065	0.46	1.6
	PT11	0.62	0.062	0.43	1.5
	PT12	0.60	0.060	0.42	1.5

Table 2 continued

Village	Sample Points	Gamma Activity (mR/hr)	Exposure Dose Rate (μSv/hr)	Effective Dose Rate (mSv/yr)	Excess Life-time Cancer Risk
Mean		**0.63**	**0.063**	**0.44**	**1.5**
Mangu	PT01	0.64	0.064	0.45	1.6
	PT02	0.68	0.068	0.48	1.7
	PT03	0.63	0.063	0.44	1.5
	PT04	0.60	0.060	0.42	1.5
	PT05	0.62	0.062	0.43	1.5
	PT06	0.65	0.065	0.46	1.6
	PT07	0.61	0.061	0.43	1.5
	PT08	0.60	0.060	0.42	1.5
	PT09	0.64	0.064	0.45	1.6
	PT10	0.66	0.066	0.46	1.6
	PT11	0.67	0.067	0.47	1.6
	PT12	0.67	0.067	0.47	1.6
Mean		**0.64**	**0.064**	**0.45**	**1.6**
Jos East	PT01	0.64	0.064	0.45	1.6
	PT02	0.60	0.060	0.42	1.5
	PT03	0.61	0.061	0.43	1.5
	PT04	0.65	0.065	0.46	1.6
	PT05	0.62	0.062	0.43	1.5
	PT06	0.60	0.060	0.42	1.5
	PT07	0.64	0.064	0.45	1.6
	PT08	0.68	0.068	0.48	1.7
	PT09	0.63	0.063	0.44	1.5
	PT10	0.60	0.060	0.42	1.5
	PT11	0.62	0.062	0.43	1.5
	PT12	0.65	0.065	0.46	1.6
Mean		**0.63**	**0.063**	**0.44**	**1.5**

Table 3. Summary of Exposure Levels and Related Radiological Health Indices in Plateau State

Village	Gamma Activity (mR/hr)	Exposure Dose Rate (μSv/hr)	Effective Dose Rate (mSv/yr)	Excess Lifetime Cancer Risk
Bassa	0.64	0.064	0.45	1.6
Jos South	0.64	0.064	0.45	1.6
BarkinLadi	0.63	0.063	0.44	1.5
Mangu	0.64	0.064	0.45	1.6
Jos East	0.63	0.063	0.44	1.5
Mean	**0.64**	**0.064**	**0.45**	**1.6**

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 Plateau State, which was later summarized in Table 5 for further interpretation and analysis.

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 Plateau State.

Based on the data presented, the effective dose to different organs of the body in Plateau State appears to be similar for all villages except that of Liver in Jos East which appear slightly different.

3.2 Result Analysis

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

Table 4. Dose to different organs of the body in Plateau State

Village	Sample Points	Effective Dose Rate to Sensitive Organs						
		Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
Bassa	PT01	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT02	0.27	0.24	0.29	0.34	0.26	0.19	0.29
	PT03	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT04	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT05	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT06	0.29	0.24	0.29	0.34	0.26	0.19	0.29
	PT07	0.28	0.26	0.30	0.36	0.27	0.20	0.30
	PT08	0.31	0.29	0.33	0.39	0.30	0.22	0.33
	PT09	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT10	0.30	0.27	0.32	0.39	0.29	0.22	0.32
	PT11	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT12	0.29	0.27	0.32	0.38	0.29	0.21	0.31
Mean		**0.29**	**0.26**	**0.31**	**0.36**	**0.28**	**0.21**	**0.30**
Jos South	PT01	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT02	0.28	0.25	0.30	0.35	0.27	0.20	0.29

Table 4 continued

Village	Sample Points	Effective Dose Rate to Sensitive Organs						
		Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
	PT03	0.30	0.27	0.32	0.39	0.29	0.22	0.32
	PT04	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT05	0.31	0.29	0.33	0.39	0.30	0.22	0.33
	PT06	0.28	0.26	0.30	0.36	0.27	0.20	0.30
	PT07	0.29	0.24	0.29	0.34	0.26	0.19	0.29
	PT08	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT09	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT10	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT11	0.27	0.24	0.29	0.34	0.26	0.19	0.29
	PT12	0.29	0.26	0.31	0.37	0.28	0.21	0.31
Mean		**0.29**	**0.26**	**0.31**	**0.36**	**0.28**	**0.21**	**0.30**
Barkin Ladi	PT01	0.28	0.26	0.30	0.36	0.27	0.20	0.30
	PT02	0.31	0.29	0.33	0.39	0.30	0.22	0.33
	PT03	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT04	0.30	0.27	0.32	0.39	0.29	0.22	0.32
	PT05	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT06	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT07	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT08	0.27	0.24	0.29	0.34	0.26	0.19	0.29
	PT09	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT10	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT11	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT12	0.29	0.24	0.29	0.34	0.26	0.19	0.29
Mean		**0.29**	**0.26**	**0.31**	**0.36**	**0.28**	**0.21**	**0.30**
Mangu	PT01	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT02	0.31	0.29	0.33	0.39	0.30	0.22	0.33
	PT03	0.28	0.26	0.30	0.36	0.27	0.20	0.30
	PT04	0.29	0.24	0.29	0.34	0.26	0.19	0.29
	PT05	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT06	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT07	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT08	0.27	0.24	0.29	0.34	0.26	0.19	0.29
	PT09	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT10	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT11	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT12	0.30	0.27	0.32	0.39	0.29	0.22	0.32
Mean		**0.29**	**0.26**	**0.31**	**0.36**	**0.28**	**0.21**	**0.30**
Jos East	PT01	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT02	0.27	0.24	0.29	0.34	0.26	0.19	0.29
	PT03	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT04	0.29	0.27	0.32	0.38	0.29	0.21	0.31
	PT05	0.28	0.25	0.30	0.35	0.27	0.20	0.29
	PT06	0.29	0.24	0.29	0.34	0.26	0.19	0.29
	PT07	0.29	0.26	0.31	0.37	0.28	0.21	0.31
	PT08	0.31	0.29	0.33	0.39	0.30	0.22	0.33
	PT09	0.28	0.26	0.30	0.36	0.27	0.20	0.30
	PT10	0.29	0.24	0.29	0.34	0.26	0.19	0.29
	PT11	0.28	0.25	0.30	0.35	0.27	0.20	0.29
Mean		**0.29**	**0.26**	**0.31**	**0.36**	**0.28**	**0.20**	**0.30**
	PT12	0.29	0.27	0.32	0.38	0.29	0.21	0.31

Table 5. Summary of Dose to different organs of the body in Plateau State

Village	Effective Dose Rate to Sensitive Organs						
	Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
Bassa	0.29	0.26	0.31	0.36	0.28	0.21	0.30
Jos South	0.29	0.26	0.31	0.36	0.28	0.21	0.30
Barkin Ladi	0.29	0.26	0.31	0.36	0.28	0.21	0.30
Mangu	0.29	0.26	0.31	0.36	0.28	0.21	0.30
Jos East	0.29	0.26	0.31	0.36	0.28	0.20	0.30
Mean	**0.29**	**0.26**	**0.31**	**0.36**	**0.28**	**0.21**	**0.30**

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

The data presented in Table 3 were used to plot a chart in order to compare the result of annual effective dose rate with UNSCEAR. This chart is presented in Figure 4.

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.

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

The data presented in Table 3 were used to plot a chart in order to compare the result of excess lifetime cancer risk with UNSCEAR. This chart is presented in Figure 5.

On comparison of excess lifetime cancer risk with UNSCEAR, it is observed that the excess lifetime cancer risk was found to be high.

3.2.3 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 charts are presented in Figures 6 to 10.

On comparison of Effective Dose Rate to Organs (D_{organ}) with UNSCEAR, it is observed that the D_{organ} was found to be lower compare to UNSCEAR for all villages presented in Figures 6 to 10.

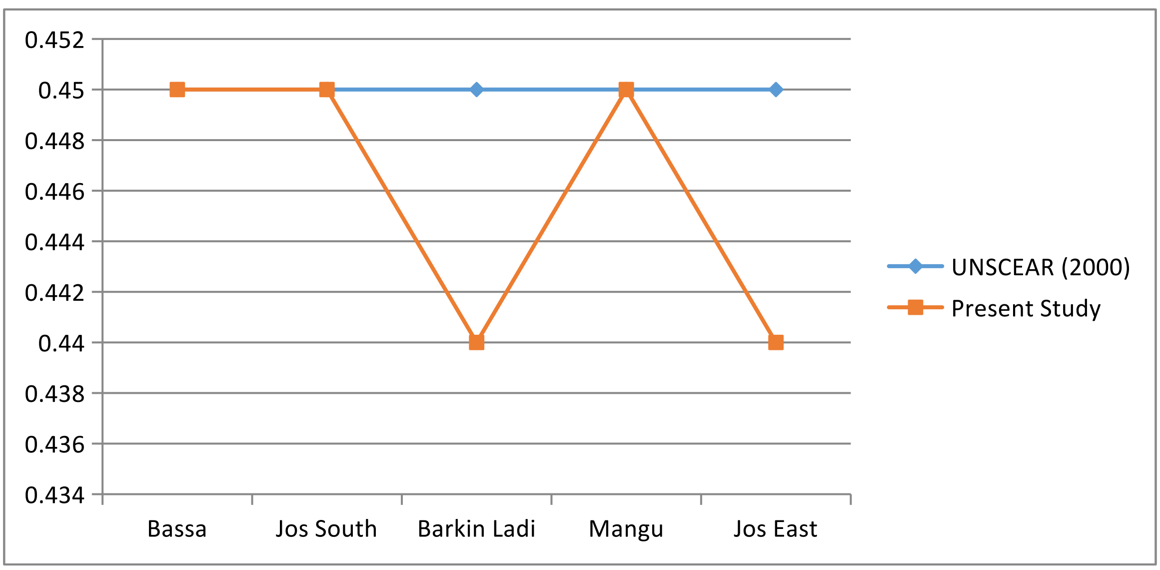

Figure 4. Comparison of Annual Effective Dose Rate with UNSCEAR

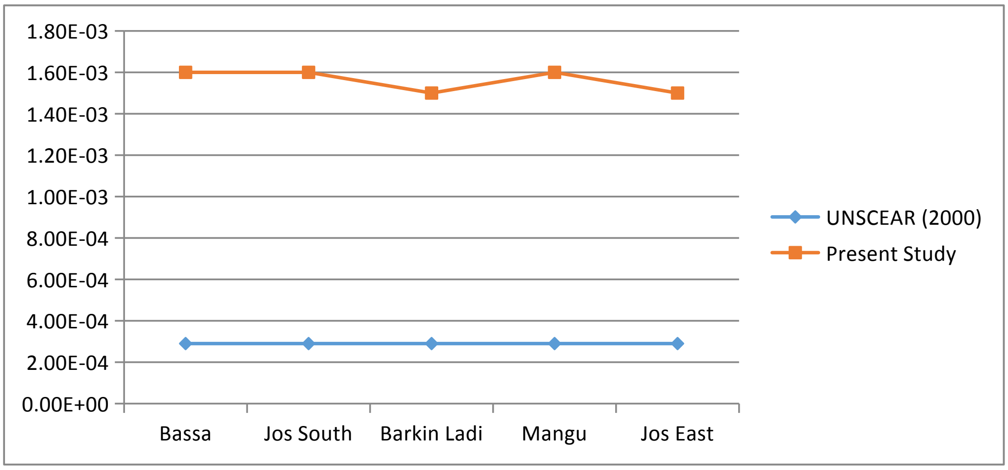

Figure 5. Comparison of Excess Lifetime Cancer Risk with UNSCEAR

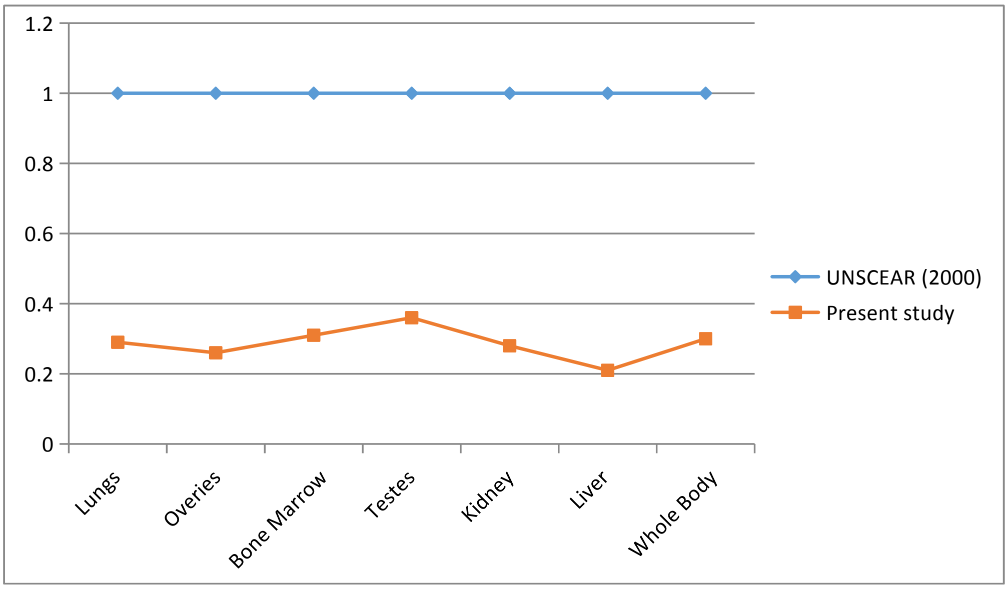

Figure 6. Comparison of Effective Dose Rate to Organs (D_{organ}) for Bassa with UNSCEAR

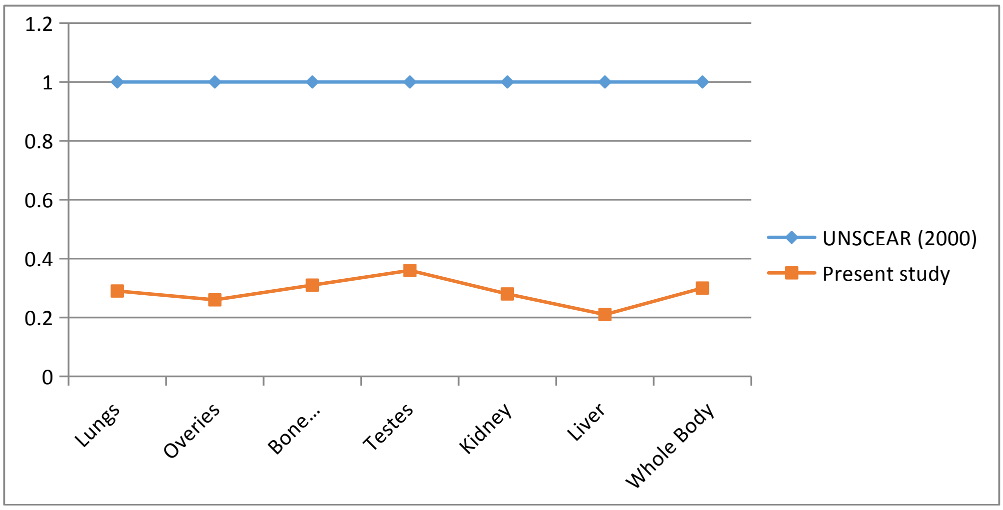

Figure 7. Comparison of Effective Dose Rate to Organs (D_{organ}) for Jos South with UNSCEAR

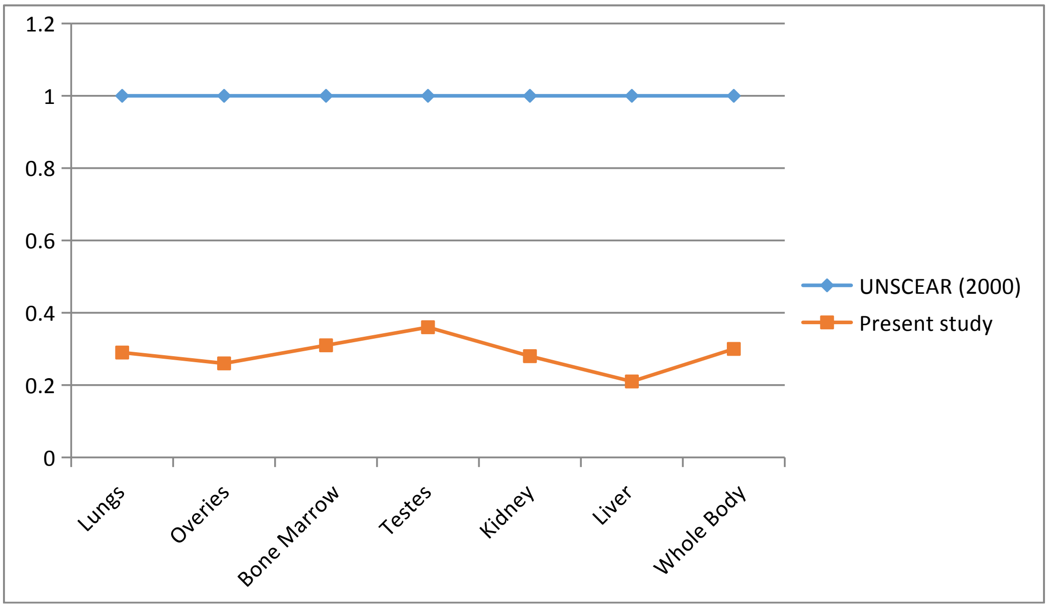

Figure 8. Comparison of Effective Dose Rate to Organs (D_{organ}) for Barkin Ladi with UNSCEAR

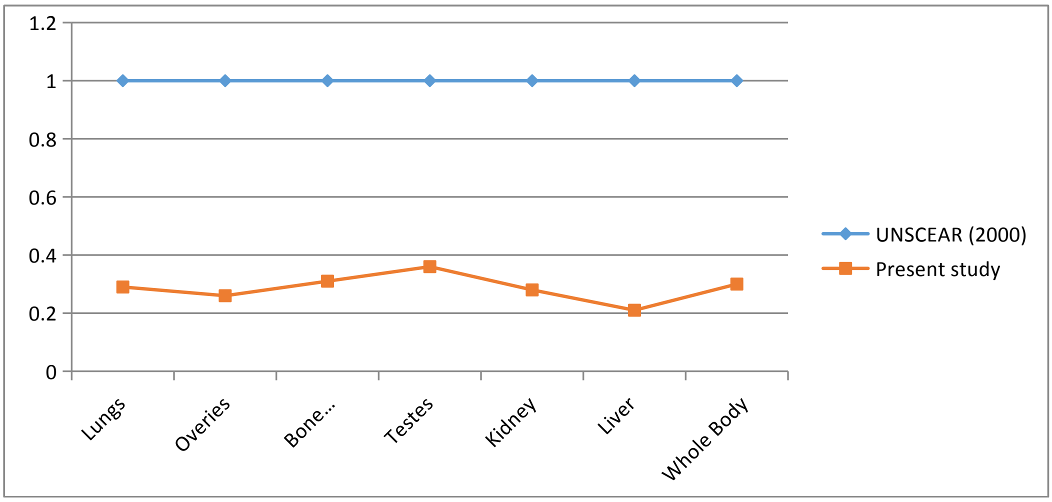

Figure 9. Comparison of Effective Dose Rate to Organs (D_{organ}) for Mangu with UNSCEAR

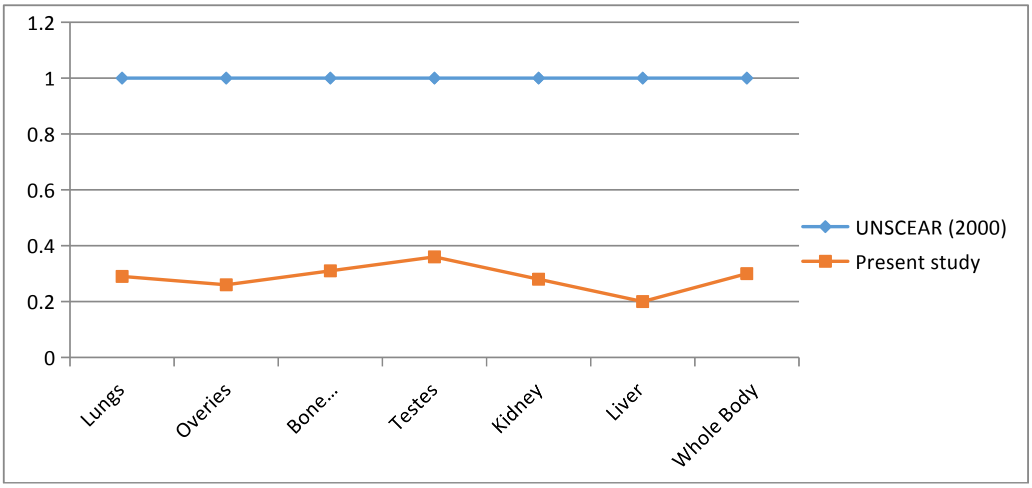

Figure 10. Comparison of Effective Dose Rate to Organs (D_{organ}) for Jos East with UNSCEAR

4. Discussion

On annual effective dose rate, finding of this study have revealed that the mean annual effective dose rate for different mining points of Plateau State are 0.45 mSv/y which is equal to the value of effective dose recommended by UNSCEAR and may cause radiological hazard to the public and workers on excessive exposure. This finding on comparison of Annual Effective Dose Rate (AEDR) is in line with the finding [13,14]. But not in line with the findings [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 [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 different mining points of Plateau State are 1.6×10^{-3} which is higher than the value of excess lifetime cancer risk (ELCR) recommended by UNSCEAR and may cause radiological hazard to the public and workers. This finding is in line with the finding [13,14]. But not in line with the findings [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 $2.63 \times 10^{-3}$and 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 (D_{organ}) 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 different mining points of Plateau State are 0.29 mSv/y, 0.26 mSv/y, 0.31 mSv/y, 0.36 mSv/y, 0.28 mSv/y, 0.21 mSv/y and 0.30 mSv/y respectively, which is higher than the value of effective dose to 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 [12-16].

5. Conclusions

This tends to unveil the effect of exposure to radiation on human organs as a result of illegal mining taking place in some part of Plateau 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 Plateau 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.

Conflict of Interest

There is no conflict of interest.

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