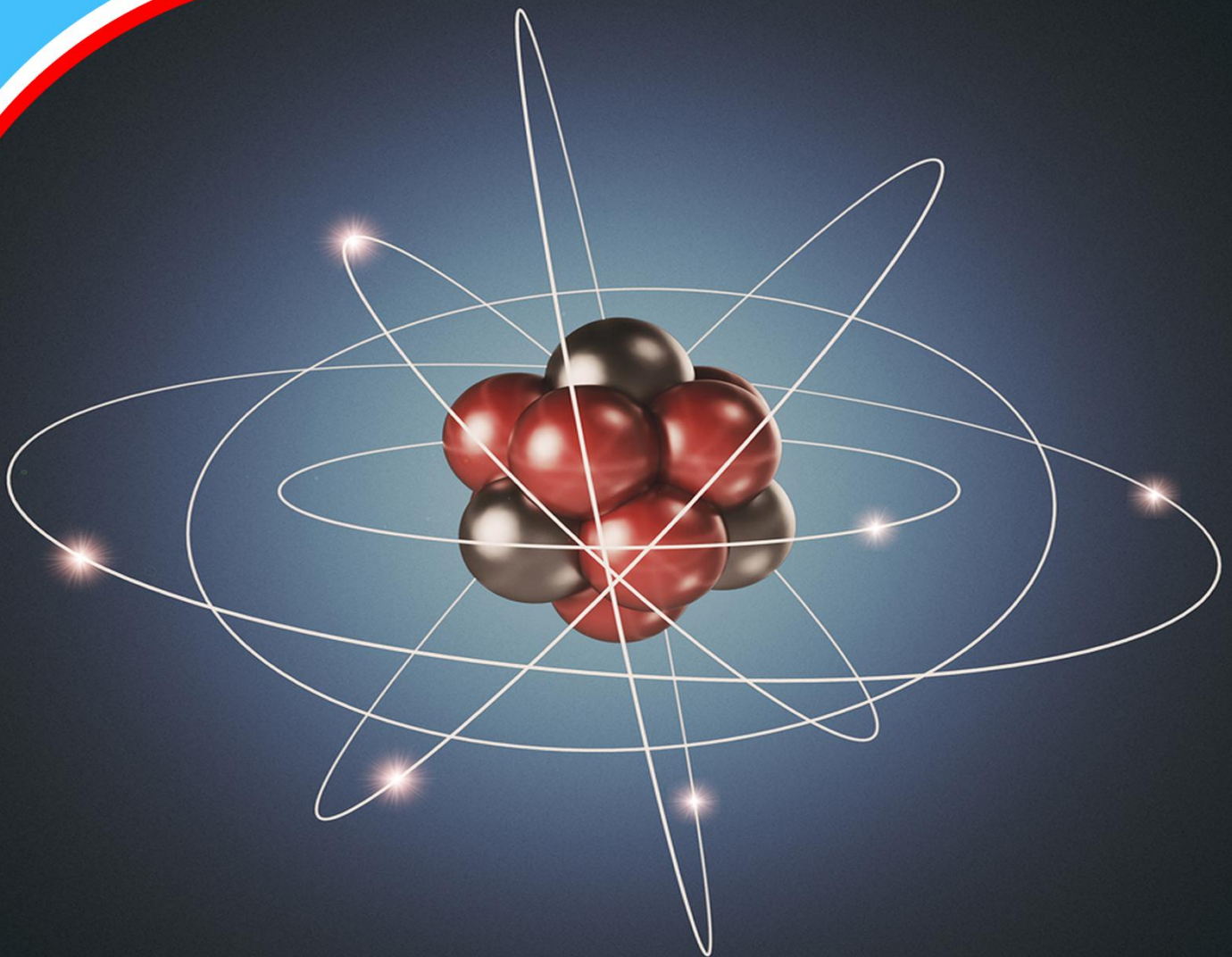


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**ASSESSMENT OF GROSS ALPHA, GROSS BETA  
RADIOACTIVITY AND HEAVY METALS CONCENTRATION IN  
SOIL SAMPLES IN WUKARI, TARABA STATE**

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### Abstract

This study is aimed at assessment of gross alpha, gross beta radioactivity and heavy metals concentration in soil samples. It involves ten (10) different locations in Wukari, Taraba state. The analyses included gross alpha and beta radioactivity using MPC-2000-DP and the measurement of heavy metals concentration using Atomic Absorption Spectroscopy (AAS). The results obtained showed that the gross alpha activities ranged from  $(0.0027 \pm 0.0003 - 0.0177 \pm 0.0001)$  Bq/g while the gross beta ranged from  $(0.0125 \pm 0.0020 - 0.2379 \pm 0.0012)$  Bq/g. The present study indicates that the nature of soil in the study area has a very low level radiation. Measured values of gross alpha contamination in soil samples collected from different locations in the study area were found below the permissible range of WHO. The total heavy metals Cu, Pb, Zn, Co, Fe were evaluated in the soil samples. Based on the findings concentrations of these soils were analyzed showed significantly higher concentrations which follow the order  $Pb > Fe > Cu > Co > Zn$ , comparing with WHO standards guidelines, the results revealed that food samples planted on this soil could be disastrous to human health.

**Keywords:** *Gross alpha, gross beta radioactivity, heavy metals concentration Atomic Absorption Spectroscopy (AAS), and MPC -2000-dp*

## INTRODUCTION

Radioactivity contamination of the environment is an increase in the natural background radiation arising out of human activities involving the use of naturally occurring or artificially produced radioactive substance (Petel,1980). Such contamination could be occasional, accidental or continuous.

The gross alpha radioactivity concentration in soil samples is defined as the total radioactivity of all alpha emitters (including  $^{226}\text{Ra}$ ). Values of gross alpha radioactivity in soil samples depend on the geological characteristic, mineral content and activities in the area. The gross beta radioactivity in soil is due to natural long-lived isotopes  $^{40}\text{K}$ ,  $^{210}\text{Pb}$ ,  $^{228}\text{Ra}$  excluding  $^3\text{H}$ ,  $^{14}\text{C}$  and other weak beta emitters. (Ferdous, 2012). Heavy metals are characterized by their rather high atomic mass and their high density. Although typically occurring in rather low concentration, they can be found all through the crust of our planet. The presence of heavy metals particularly (Pb, Cu and Zn) in soil and surface water affects fertility and nutrient status when it's above permissible limits. Soil is the upper layer of earth in which plant grow, a black or dark brown material typically consisting of mixture of organic remains, clay and rock particles.

Heavy metals are soil's pollutant. The biological and biochemical properties are affected by the presence of heavy metals. Heavy metals indirectly affects the enzymatic activities by shifting microbial communities (Shun-hong *et al*, 2009). According to (Chen *et al*, 2010) heavy metals affects the bacterial community tolerance in soil. Cd is more toxic in enzymes in the soil system, it has greater effect than Pb because of its mobility and affinities (Singh *et al*, 2011).

The intake of heavy metals by plant and subsequent absorption by humans pledge a potential threat to the life and health of humans and plants (Sprynskyy *et al*, 2007). The absorption and accumulation in plants depends on the physiochemical properties of the soil. The target organs of various heavy metals in humans include Cd, it is targeted to the placenta, kidney, liver, brain and bones (Cai *et al*, 2007). Zn is considered to be less toxic depending on the severity of exposure, the symptoms or effects includes muscular weakness, vomiting and nausea (Chen *et al*, 2010). High amount of exposures to Cu and Pb can result to dysfunction of liver and kidney (Odum *et al*, 2000)

Soil acts as source of transfers of radionuclides through the food chain depending on their chemical properties and the uptake process by the roots of plants and animals (Jabbar, 2010); hence, it is the basic indicator of the radiological status of the environment. The major potential hazard from the natural radiation is from either direct or indirect exposure to soil which lead to direct or indirect contamination of uranium series radionuclides. Use of fertilizers and naturally occurring radionuclides leads to elevation of uranium series nuclides in soil. Naturally occurring radionuclides of thorium and uranium are the significant contributors of ingestion dose and are present in the biotic system of plants and animals.

Radioactivity is common in the rocks and soil that makes up our planet, in water and oceans and even in our building materials. Soil acts as a source of transfers of radionuclides through the food chain depending on their chemical properties and the uptake process by the roots to plants and animals (A. Jabbar, 2015); hence, it is the indicator of the radiological status of the environment.

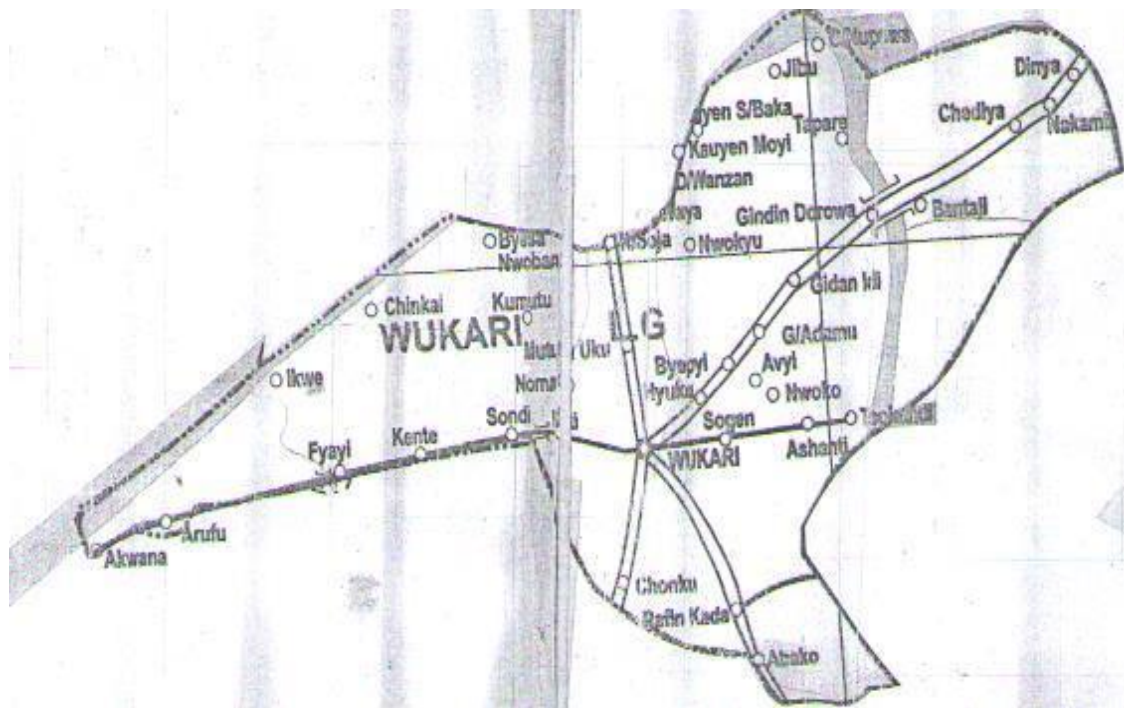
Often in radioactivity research, attentions are mostly given to gamma emitters detection and quantification even in an environment where it is possible to have alpha and beta emitters (Gu and Yaprak, 2010, Lu et al., 2012, Mehade Hassan et al.,2014). While it is true those gamma rays have the highest penetrating power when compared to alpha and beta particles within the body either through inhalation or ingestion are far more detrimental because of their ionizing power.

The activities of humans such as drilling, mining, transportation and burning of fossils fuels have raised the concentration of naturally occurring radioactive materials in the environment (Avwiri & Ebeniro, 1998; Foland, Kirland & Vinnikoov, 1995; Pujol & Sanchez –Cabeza, 2000). Also the dumping of large amount of waste materials in sites without adequate soil protection measures results in surface soil and ground water pollution (Eikelboom et al., 2001, Namasivayam et al., 2001). Radioactive wastes when being released due to the continuous smelting and re-cycling of metalliferous ores and scrap metals, some of which have been contaminated with radioactive materials from their sources; waste are particulate in nature and because they are air borne may be dispersed into the communities surroundings where they may eventually settle in farmlands, farm crops and in communities sources of water and are as well inhaled continuously. Crops grown in such communities could absorb these radioactive elements either from the soil or through their leaves.

When these contaminated crops are eventually consumed, radioactive elements get into the body and could reach hazardous levels depending on the type of radioactive elements present in the soil. This, no doubt is a problem to the communities in the immediate environs of Wukari metropolis.

### **Study Area**

Wukari is a Local Government Area in Taraba State, Nigeria. Its headquarters are in the town of Wukari on the A4 highway. With coordinates  $7^{\circ}51'N$   $9^{\circ}47'E$ , with total area of  $4,308\text{km}^2$  and a population of 241,546 at the 2006 census. The people are predominantly farmers, who farm crops and tubers. Therefore this research is aimed at assessing the effect of gross alpha, gross beta radioactivity and heavy metals concentration in soil sample of Wukari metropolis.



**Figure 1:** Map of the study area (Source: Aremu *et al*, 2017)

## MATERIALS AND METHODS

The field data collection was carried in Wukari, Taraba State. The procedure used for this work was stratified random and grid sampling, the soil samples was collected from different location with a pipe of mean height of 9.234cm and a mean radius of 2.43cm, The collected samples were properly labeled. At every location, the surface radiation dose was measured at the surface and 1 meter above the surface using a Gamma Scout (W/alert version) radiation meter. An Etrex Garmin Global position system (GPS meter) was used to obtain coordinates and locations of the sampling. Some portion of the soil was collected and taken to the Central Laboratory, Federal University Wukari, Taraba. Were it was crushed and dried at 50°C to remove the moisture of the soil samples. The heavy metal concentration (ppm) was determined using atomic absorption spectrophotometer (UNICAM 929) presented in Table 1. The remaining portion of the soil samples was taken to Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria, where it was analysed with a proportional counter MPC –2000 DP. The counting equipment of MPC-2000DP is automated. The protocol involves entering present time, counting voltage and number of counting per cycles, each sample was counted three times and the mean used in computing the activity. Also to be entered are the counter characteristics (efficiency and background) volume of sample used and sample prepared efficiency. Results are displayed as raw count (count per minute), count rate activity and standard deviation.

**Calibration of Counting Equipment.**

Alpha and Beta Voltage= 1290V Alpha only voltage = 750V Beta efficiency using Sr-90 with reference number 14539 = 87.95%± 0.21% Alpha efficiency using Polonium-239 = 42.06%±0.22% Count time (min) = 60 The background count for alpha and beta were measured to be :Alpha background = 0.53cpm Beta background = 0.50cpm

The count rate of each sample was automatically processed by the computer using the equation Control charts used to maintain instrument stability (MPC 2KV24 instruction manual). As shown below:

$$C_{(\alpha,\beta)} = \frac{R_{(\alpha,\beta)} \times 60}{t} \tag{1}$$

Where  $C_{(\alpha,\beta)}$  = The count rate (cpm) of the alpha or beta particle,

$R_{(\alpha,\beta)}$  = Raw count of the alpha or Beta particle,  $t$  = count time (2700 seconds).

$$\alpha \text{ or } \beta \text{ radioactivity (Bq/g)} = \frac{\alpha \text{ or } \beta \text{ count rate (cpm)} - \text{BkG count rate (cpm)}}{\text{sample eff} \times \text{sample size} \times \text{detector eff}} \times 0.0167 \tag{2}$$

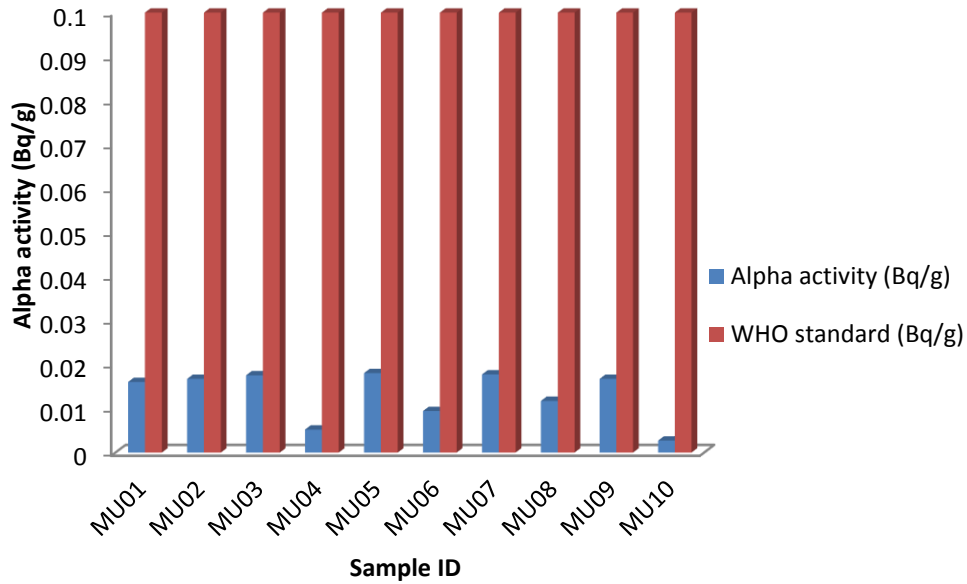
**Table 1:** Concentration of Heavy (Trace) Elements (in ppm) in soil samples.

| S/N | Metal | GF 01       | GF 02       | GF 03       | GF 04       | GF 05       | GF 06       | GF 07       | GF 08       | GF 09       | GF 10       | WHO/FAO Standard (2001) |
|-----|-------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------------------|
| 1   | Pb    | 536.40<br>0 | 550.00<br>0 | 562.00<br>0 | 550.00<br>0 | 536.40<br>0 | 420.00<br>0 | 536.60<br>0 | 525.00<br>0 | 462.50<br>0 | 574.00<br>0 | 50.000                  |
| 2   | Zn    | 57.400      | 62.500      | 76.300      | 87.400      | 73.800      | 67.500      | 62.600      | 55.000      | 62.600      | 67.500      | 300.00                  |
| 3   | Cu    | 139.90<br>0 | 130.00<br>0 | 130.00<br>0 | 105.00<br>0 | 80.000      | 140.00<br>0 | 105.00<br>0 | 105.00<br>0 | 139.90<br>0 | 80.000      | 100.00                  |
| 4   | Fe    | 448.00<br>0 | 458.00<br>0 | 473.00<br>0 | 503.00<br>0 | 449.00<br>0 | 475.00<br>0 | 540.00<br>0 | 405.00<br>0 | 400.00<br>0 | 490.00<br>0 |                         |
| 5   | Co    | 75.000      | 112.00<br>0 | 90.000      | 90.000      | 100.00<br>0 | 128.00<br>0 | 90.000      | 90.000      | 128.00<br>0 | 90.000      |                         |

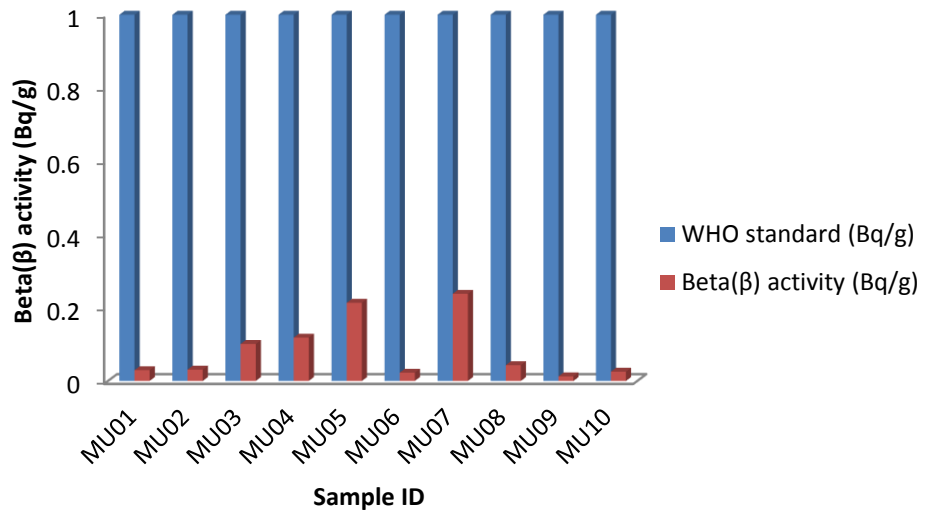
**Table 2:** Gross alpha and beta radioactivity concentration (Bq/g) of soil samples collected in Wukari, Taraba state.

| Sample ID | Sample location                    | Geographical coordinate                              | Alpha activity (Bq/g) | Beta( $\beta$ ) activity (Bq/g) |
|-----------|------------------------------------|--|-----------------------|---------------------------------|
| MU01      | Behind Amson Garden                | 7° 50' 49" <sup>ll</sup><br>9° 48' 12" <sup>ll</sup> | 0.0160±0.0098         | 0.0295±0.0020                   |
| MU02      | Beside MGGSS                       | 7° 51' 23" <sup>ll</sup><br>9° 46' 29" <sup>ll</sup> | 0.0167±0.0012         | 0.0309±0.0012                   |
| MU03      | Opp F.U.W                          | 7° 50' 41" <sup>ll</sup><br>9° 46' 52" <sup>ll</sup> | 0.0175±0.0013         | 0.1010±0.0022                   |
| MU04      | Wapan Aku                          | 7° 51' 44" <sup>ll</sup><br>9° 45' 53" <sup>ll</sup> | 0.0052±0.0005         | 0.1183±0.0011                   |
| MU05      | Beside GSS Wukari Ibi road         | 7° 53' 20" <sup>ll</sup><br>9° 46' 37" <sup>ll</sup> | 0.0180±0.0091         | 0.2136±0.0020                   |
| MU06      | New Site                           | 7° 50' 49" <sup>ll</sup><br>9° 48' 19" <sup>ll</sup> | 0.0094±0.0014         | 0.0226±0.0016                   |
| MU07      | Beside Agatha lodge opp F.U.W      | 7° 50' 22" <sup>ll</sup><br>9° 46' 54" <sup>ll</sup> | 0.0177±0.0001         | 0.2379±0.0012                   |
| MU08      | Wapan Ngaku beside Cherubin Church | 7° 51' 48" <sup>ll</sup><br>9° 46' 03" <sup>ll</sup> | 0.0117±0.0087         | 0.0431±0.0023                   |
| MU09      | Opp Amson Garden                   | 7° 50' 50" <sup>ll</sup><br>9° 48' 17" <sup>ll</sup> | 0.0167±0.0002         | 0.0125±0.0020                   |
| MU10      | Behind GSS                         | 7° 53' 19" <sup>ll</sup><br>9° 46' 37" <sup>ll</sup> | 0.0027±0.0003         | 0.0254±0.0016                   |

Where MU01= Behind Amson Garden ,MU02- Behind MGGSS, MU03- Opp FUW, MU04- Wapan Ngaku Area, MU05- Behind GSS Ibi, MU06- New site, MU07- Behind Agatha Lodge, MU08- Wapan ngaku Church, MU09- Opp Amson Garden ,MU10- Behind GSS

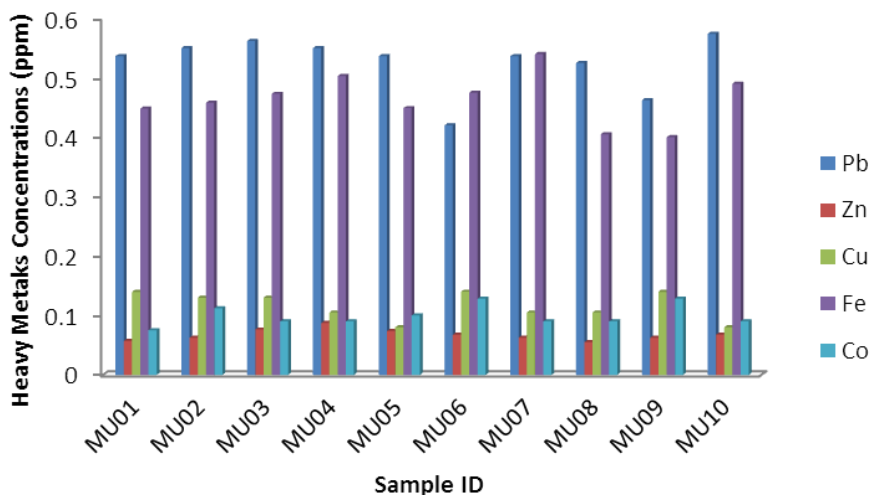


**Figure 2:** Comparison of alpha activity concentration in soil samples for all zones with WHO (2003) standard





**Figure 3: Comparison of Beta activity concentration in soil samples of Wukari with WHO (2003) standard.**



**Figure 4: Heavy metal activity concentration in soil samples of Wukari**

## CONCLUSION

The study measured the gross alpha and beta activity concentrations in soil samples in Wukari Local Government Area of Taraba State. The average alpha activity concentration obtained were all lesser than the WHO (2003) recommended safe limit (0.1 Bq/g) and that of beta activities were all below recommended safe limit by WHO, 2003 recommended safe unit of 1.0Bq/g. Finally, all the results obtained revealed that the commonly consumed food crops / stuffs surveyed are safe for consumption without posing any immediate radiological threat to the public. However, inhabitants are cautioned against excessive exposure to avoid further accumulative dose of these radiations. However, the concentration of Copper from various sites ranged from 80mg/kg-140mg/kg. The arithmetic mean of copper is 115.48mg/kg which was above the WHO/FAO (2001) permissible Unit. The concentration of Zinc from various sites ranged from 55mg/kg- 87.40mg/kg. The arithmetic mean of copper is 67.26mg/kg which was above the WHO/FAO (2001) permissible Unit of 300mg/kg. Also, the concentration of lead from various sites ranged from 420mg/kg-562mg/kg. The arithmetic mean of copper is 525.24mg/kg which was above the WHO/FAO (2001) permissible Unit of 50mg/kg.

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