

Research Article

Metals Transfer from Soil to Plants and Water across Nasarawa Town, Nasarawa Local Government Area, Nasarawa State, Nigeria

*U. Rilwan¹, J. Waida², M. Musa³, Andrew Adamu¹ and S. I. Ikpughul¹

¹Department of Physics, Nigerian Army University, Biu, Borno State, Nigeria

²Department of Physics, Borno State University, Maiduguri, Borno State, Nigeria

³Department of Physics, Modibbo Adama University, Yola, Adamawa State, Nigeria

*Corresponding author: rilwan.usman@naub.edu.ng, doi.org/10.55639/607.4454

ARTICLE INFO:

Keyword:

Heavy metal,
Toxicity,
Soil-plant,
Soil-water
Transfer factor

ABSTRACT

In Nasarawa, mining has been going on for the last 50 years, and the vegetables we ate have trapped metals. This research aims to show how much of these metals are transferred from soil to water and different kinds of food crops in Nasarawa. The findings showed that, at all places, the Transfer Factor for various trace elements in soil-water dropped in the following order: Zn (0.76) > Pb (0.75) > Fe (0.66) > Mn (0.59) > Cu (0.51) > Ni (0.49). The overall Transfer Factor (soil-edible plants) for several trace elements is in the following order: Pb (0.60) > Zn (0.54) > Zn (0.49) > Ni (0.39) > Cu (0.38) > Mn (0.22). Because of this, the nearby flora and water are regarded as safe for use in food by the general public, even though the transfer coefficients of a trace element in the majority of the heavy metals (Zn, Fe, Cu, and Pb) are greater than 0.50, which suggests that there may be a higher likelihood that anthropogenic activities have contaminated the plant or water. Additionally, heavy metal levels in the environment must be regularly checked to prevent rapid accumulation over time.

Corresponding author: U. Rilwan, Email: rilwan.usman@naub.edu.ng

Department of Physics, Nigerian Army University, Biu, Borno State, Nigeria

INTRODUCTION

Due to residential or occupational exposure, over 35 metals are of concern to us, 23 of which are heavy metals (Rilwan *et al.*, 2021). The environment and nutrition frequently include these heavy metals. While they are necessary for tiny doses for maintaining health, greater levels can be poisonous or hazardous (Joseph *et al.*, 2022). In addition to reducing energy levels, heavy metal toxicity can harm vital organs like the kidney, liver, lungs, brain, and blood. Long-term exposure can cause slowly developing physical, skeletal, and neurological degenerative processes that resemble illnesses such as muscular dystrophy, Parkinson's disease, Alzheimer's disease, and multiple sclerosis (Waida *et al.*, 2022).

Lead and its compounds have accumulated in the environment, including the air, the water, and the soil, as a result of human activities such as mining, manufacturing, and burning fossil fuels (Abdu, *et al.*, 2022). Batteries, cosmetics, and metal products including pipes, solder, and bullets are all made with lead. Because lead is extremely dangerous, its use in many items, including paints, gasoline, etc., has significantly decreased in modern times (Mundi *et al.*, 2019).

Most aerobic organisms depend on iron-mediated processes for their respiration. It can catalyze reactions that result in the production of radicals, which can harm biomolecules, cells, tissues, and the entire organism if it is not properly insulated (Usman *et al.*, 2020a). Paediatricians have historically been primarily interested in the subject of iron toxicity. Due to their high exposure to iron-containing products, children are especially vulnerable to iron poisoning (Abdu, *et al.*, 2022a). In developed and meat-eating nations, excessive iron intake is a severe issue that raises the risk of cancer (Waida *et al.*, 2022a).

Only very small amounts of the chemical nickel are present in the environment (Abdu,

et al., 2022). The usage of nickel as a component of steel and other metal products is its most popular use (Galadima *et al.*, 2022). Nickel naturally occurs in trace levels in food. Since plants are known to acquire nickel, the uptake of nickel by vegetables will be inevitable. Nickel is more readily absorbed through the lungs of smokers. Finally, detergents include nickel. Nickel can enter the human body through the air we breathe, the water we drink, the food we eat, and cigarette smoke. Nickel exposure may also occur from skin contact with soil or water that has nickel contamination (Waida *et al.*, 2022).

A transition metal called zinc is typically found in nature in its divalent state. It is regarded as a crucial mineral because it is required for the creation of hundreds of enzymes all over the body. In enzymatic processes involving DNA expression, membrane stability, vitamin A metabolism, and the gustatory and olfactory systems, it functions as a cofactor. Zinc is found in a variety of environmental sources; therefore, exposure and toxicity are very common (Usman *et al.*, 2020).

Although copper is a necessary nutrient for people, animals, and plants, excessive exposure to it can be harmful to people's health. In the US, leaching of copper from plumbing into tap water is a common source of copper exposure in addition to diet and supplements (Bello *et al.*, 2021).

This work intends to unveil the extent to which Zn, Fe, Cu, Ni, Mn and Pb transfers from soil to water and various species of food crops in Nasarawa to ensure the safety of food and also to maintain the specific safety limits of the effective doses. This work will also provide basic data for the metallic judgment of potential heavy metals release, and for setting up a radiation control of foodstuffs to support the Nigerian Nuclear Regulatory Authority

(NNRA) in their food policy, administration and regulatory functions.

MATERIALS AND METHODS

Materials

Items like a hand trowel, plastic containers, gloves, polyethene sampling vials, a GPS meter, masking tape, a permanent marker, a notebook, and X-ray fluorescence (XRF) spectrometer apparatus were the tools utilized to conduct this study.

Method

Study Area

Table 1: Coordinates of the Sample Points

Location Code	GPS Coordinate	
	North	East
Nasarawa P01	8 ⁰ 32'33.26	7 ⁰ 42'29.28
Nasarawa P02	8 ⁰ 32'37.54	7 ⁰ 42'15.16
Nasarawa P03	8 ⁰ 32'04.44	7 ⁰ 43'17.40

The town of Nasarawa, which is the administrative centre of the Local Government Area (Nasarawa) in the Nigerian state of Nasarawa, is situated at 8°32'N 7°42'E and has a population of 30,949 people (as of 2016). In the local government area, which covers 5,704 km², 189,835 people were living there as of the 2006 census. The region's postal code is 962 (Rilwan *et al.*, 2021a).

The sample locations shown in Table 1 were later utilized to create the map of the research region that is shown in Figure 1.

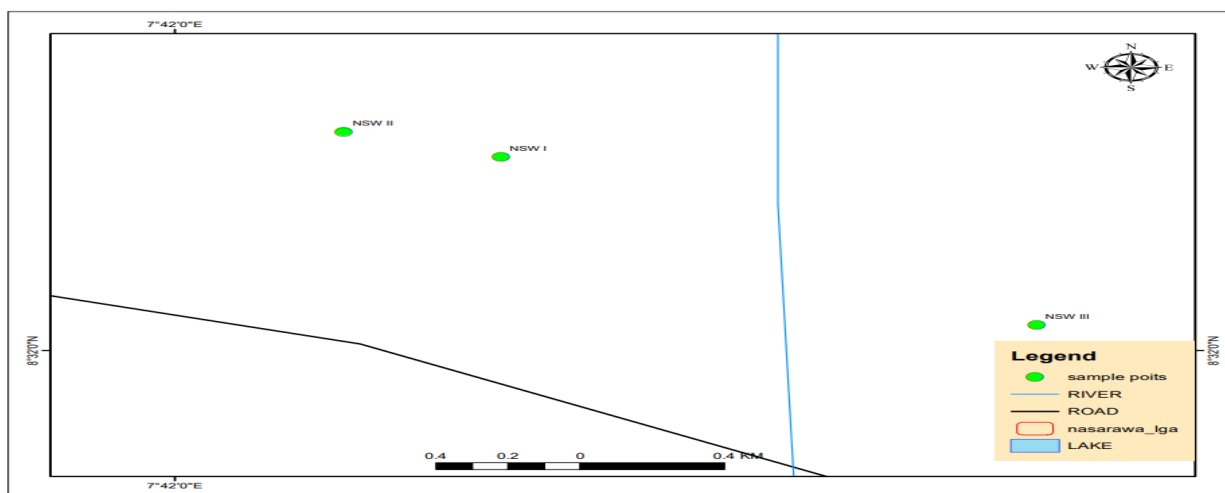


Figure 1: Map Showing the Area under Study

Sample Gathering

Three (3) soil samples, three (3) edible plant samples, and three (3) water samples were chosen from various farmlands in Nasarawa town using a random sampling technique. In this study, a total of 9 samples were examined. Using coring equipment, three soil samples were taken from farmlands in Nasarawa town at a depth of 5 cm. To avoid cross-

contamination, 4 kg of moist samples were collected and put right away into a zip-lock plastic bag made of high-density polyethene. Three plant samples were taken from the Nasarawa town farmlands. To avoid cross-contamination, the samples were put right away into a high-density polyethene zip-top bag. Every sample was identified by a special number (Sample ID). Three water samples

were taken from streams in the Nasarawa town farmlands. To prevent cross-contamination, the samples were put into plastic containers and tightly covered. For traceability, each sample had a label that read a special identifying code (sample ID) (Rilwan *et al.*, 2021).

Preparation of Sample

For analysis, just the edible portion of the plant sample was employed. Three times, ultrapure water was used to wash the plant samples. The plant samples were weighed after the water had evaporated, 48 hours of oven drying at 65 °C, followed by another weight and powder grinding. On a wet-weight basis, the heavy metal concentrations in the plant's edible parts were calculated. A sample of the edible plant was collected for XRF analysis. Natural air drying was used to achieve constant weight for all soil samples. To analyze the pH, organic matter (OM), and heavy metal concentrations, in a mortar and pestle, the dry soil samples were first homogenized before being passed through standard sieves measuring 0.9 mm, 0.3 mm, and 0.15 mm, respectively. The loss on ignition method was used to calculate the OM contents of soil samples, and the solid-to-water ratio was found to be 1:2.5. A sample of

the soil was collected for XRF examination. Two (2) drops of concentrated HNO₃ were used to acidify water samples for the analysis of heavy metals, and two (2) millilitres (ml) each of Winkler A and Winkler B were used to fix samples for the determination of dissolved oxygen. On the field, several operations were performed. The following day, all samples were transported to the lab in ice chests. XRF analysis was performed on the sample of digested water (Yahaya *et al.*, 2022).

Approach to Data Analysis

Element concentrations were examined using the X-Ray Florescence Spectrometric Analysis system at the Centre for Dryland Agriculture Bayero University, Kano. The results were applied to evaluate the soil-plant and soil-water transfer parameters (Abdu *et al.*, 2022).

Transfers factor

To determine the degree of risk and associated danger caused by wastewater irrigation and the subsequent buildup of heavy metals in the edible portion of the test plant, soil and water, the transfers factor (TF) was determined. Rilwan *et al.* (2021) and WHO (2017) state that the link that gives the ratio of soil to plant and soil to water transfers is;

$$TF_{\text{soil-plant}} = \frac{C_{\text{plant}}}{C_{\text{soil}}} \text{ and } TF_{\text{soil-water}} = \frac{C_{\text{water}}}{C_{\text{soil}}} \quad 1$$

The ratio "> 1" indicates that metal deposition in plant or water is greater compared to that in soil (Rilwan *et al.*, 2021). The likelihood of a metal being

contaminated by human activity is higher in a plant if the metal's transfer coefficient is higher than 0.50 (Tyovenda *et al.*, 2018).

RESULTS AND DISCUSSION**Results****Table 2:** Heavy Metal Concentration in Soil, Water and Plant

Sample Type	Sample Code	Zn	Fe	Cu	Pb	Ni	Mn
Soil	P01	0.42	0.05	0.05	0.09	0.007	0.293
	P02	0.45	0.07	0.05	0.08	0.004	0.341
	P03	0.36	0.06	0.03	0.05	0.022	0.213
	Mean	0.41	0.06	0.04	0.07	0.011	0.282
Water	P01	0.31	0.03	0.03	0.08	0.005	0.182
	P02	0.36	0.05	0.03	0.06	0.001	0.23
	P03	0.27	0.04	0.01	0.03	0.011	0.102
	Mean	0.31	0.04	0.02	0.06	0.006	0.171
Edible Plants	P01	0.22	0.02	0.02	0.07	0.004	0.071
	P02	0.27	0.04	0.02	0.05	0.002	0.121
	P03	0.18	0.03	0.01	0.02	0.002	0.011
	Mean	0.22	0.03	0.02	0.05	0.003	0.068

S/P = Sample Point; P = Points; Cr = Chromium; Cd = Cadmium; As = Arsenic; Pb = Lead; Ni = Nickel.

Table 3: Soil to Water and Soil to Edible Plants Transfer Factor.

Sample Type	Sample Code	Zn	Fe	Cu	Pb	Ni	Mn
Soil-Water	P01	0.74	0.60	0.60	0.89	0.71	0.62
	P02	0.80	0.71	0.60	0.75	0.25	0.67
	P03	0.75	0.67	0.33	0.60	0.50	0.48
	Mean	0.76	0.66	0.51	0.75	0.49	0.59
Soil-Edible Plants	P01	0.52	0.40	0.40	0.78	0.57	0.24
	P02	0.60	0.57	0.40	0.63	0.50	0.35
	P03	0.50	0.50	0.33	0.40	0.09	0.05
	Mean	0.54	0.49	0.38	0.60	0.39	0.22
	Waida <i>et al.</i> , (2022)	0.53	0.5	0.37	0.61	0.38	0.23
	Abbas <i>et al.</i> , (2017)	0.55	0.48	0.39	0.59	0.4	0.21

S/P = Sample Point; P = Points; Cr = Chromium; Cd = Cadmium; As = Arsenic; Pb = Lead; Ni = Nickel.

It was also observed from Table 3 that the soil- water transfer factors for Zn, Fe, Cu, Pb, Ni and Mn have the total values of 0.76, 0.66, 0.51, 0.75, 0.49 and 0.59 respectively, while soil-edible plant transfer factor for Zn, Fe, Cu, Pb, Ni and Mn has the total of 0.54, 0.49, 0.38, 0.60, 0.39 and 0.22 respectively. These results

are consistent with the findings of Waida *et al.* (2022) and Abbas et al (2017).

When it comes to the soil-water plant transfer factor, Zn (0.76) is trending higher than Pb (0.75), Fe (0.66), Mn (0.59), Cu (0.51) and Ni (0.49).

The decreasing pattern of transfer factor for soil-edible plants is Pb (0.60), Zn (0.54), Fe (0.49), Ni (0.39), Cu (0.39) and Mn (0.22).

Results Evaluation

Charts were created using the data from Table 3 to compare the findings of the current study with those of the World Health Organization (WHO), as shown in Figures 2 and 3.

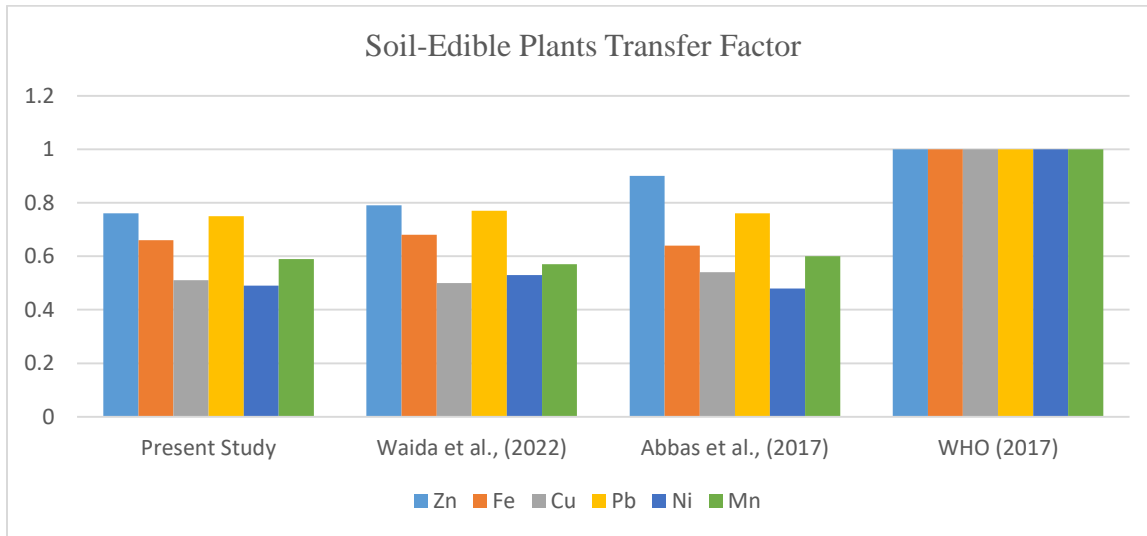


Figure 2: Chart of Soil-Water Transfer Factor with World Health Organization

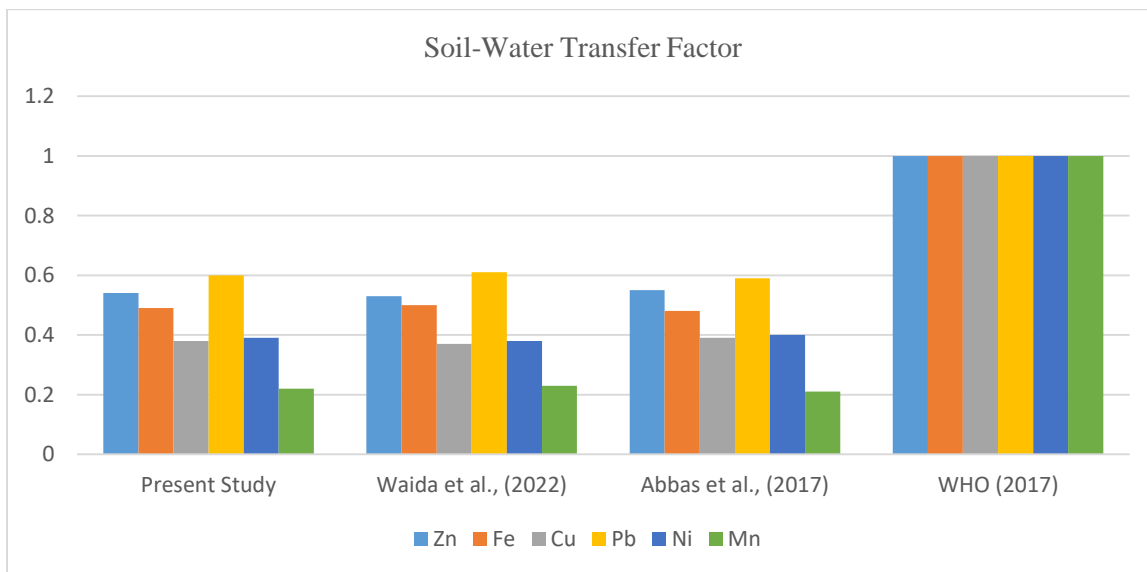


Figure 3: Chart of Soil-Edible Plants Transfer Factor with World Health Organization

Based on the findings shown in Figures 2 and 3, the soil-water and soil-edible transfer factors appear to be consistent with earlier studies by Waida *et al.* (2022) and Abbas *et al.*

(2017) and are all lower than the World Health Organization-recommended limits of unity for all the heavy metals in all the study locations.

DISCUSSION

The concentration of an element in plants solely depends on their level of relative exposure to polluted soil. The soil-water and soil-edible plant Transfer Factors (TF) for different heavy metals in this study demonstrated that the TF values for all the locations were within the acceptable range.

According to sample points, the total Transfer Factor (TF) for several trace elements in soil-edible plants dropped in the following order: Zn (0.76) > Pb (0.75) > Fe (0.66) > Mn (0.59) > Cu (0.51) > Ni (0.49).

Also, based on sample points, the total Transfer Factor (TF) for several trace elements in soil-water fell in the following order: Pb (0.60), Zn (0.54), Zn (0.49), Ni (0.39), Cu (0.38), and Mn (Mn) (0.22).

These results are lower than the suggested limits of unity established by the World Health Organization for all the heavy metals in all the study areas, and they are consistent with earlier research by Waida *et al.* (2022) and Abbas *et al.* (2017).

CONCLUSION

In Nasarawa, samples of soil, water, and plants were examined for the presence of heavy metals. The soil-plant and soil-water transfer factors were also examined. Although the transfer coefficients of a trace element in the majority of the heavy metals (Zn, Fe, Cu, and Pb) are greater than 0.50, which suggests that the plant or water may have a greater chance of the heavy metals being contaminated by anthropogenic activities, minimum transfer factors (soil-plant and soil-water) in this study were observed (> 1), which implies no more heavy metal build-up in plant or water parts than in soil. Therefore, it can be said that the research area's soil, edible plants and water are safe for use by the general public, albeit it is advised that heavy metal levels be checked frequently.

ACKNOWLEDGEMENT

The initial author expressed gratitude to the other authors for their constructive comments, which improved and brought freshness to the work.

Competing Interests

There is no conflict of interest, according to the authors.

REFERENCES

- Abbas Abdullahi Auta, Umar Ibrahim, Abdullahi Abubakar Mundi, Idris Mohammed Mustapha and Musa Usman Sarki (2019). Assessment of Heavy Metals Concentration in Swampy Agricultural Soil of Nasarawa West, Nigeria. *Asian Journal of Advanced Research and Reports*, 3(1), 1-9.
- Abdu, N.M., Aznan, F.I., and Nura, N.G. (2022). Annual effective dose associated with radioactivity in drinking water from tin mining areas in north-western Nigeria. *Journal of Radiation research and applied Sciences*. 15(3), 96-102.
- Abdu, N.M., Aznan, F.I., and Nura, N.G. (2022). Radiological mapping of tin mining areas in Doguwa Kano State, Nigeria. *Environmental Forensics*, 12(2): 1-14.
- Abdullahi Abubakar Mundi, Umar Ibrahim and Idris Mohammed Mustapha (2019). Contamination and Pollution Risk Assessment of Heavy Metals in Rice Samples (*Oryza sativa*) from Nasarawa West, Nigeria. *Asian Journal of Advanced Research and Reports*, 3(4), 1-8.

- Bello Aisha Ademoh, Usman Rilwan, Musa Yusuf (2021). Assessment on Radiation Hazard Indices from Selected Dumpsites in Lafia Metropolis, Nasarawa State, Nigeria. *Journal of Oncology Research*. 4(1), 20-26.
- Galadima, O. O., Ayagi, M. D., Rebecca, R., Rilwan, U., and Dauda, M. A (2022). Analysis and Assessment of Gross Alpha and Beta in Drinking Water of Some Selected Areas of Gashua, Yobe State, Nigeria. *Advances in Theoretical and Computational Physics*. 5(3), 485-491.
- Idris Yahaya, Abdullahi Abubakar Mundi, Idris Mohammed Mustapha, Jibrin Isah and Musa Mohammed (2022). Evaluation of Concentration of Copper, Lead, and Zinc in Different Brands of Cigarette Sold in Keffi Main Market of Nasarawa State, Nigeria. *Asian Journal of Advanced Research and Reports*, 4(4), 1-7.
- Rilwan Usman, A. M. Kamal A. Mamman, M. M. Idris, A. Ubaidullah, O.G. Okara and E.I Ugwu (2021). Health Implication of the Accumulation of Heavy Metals Concentration in Ara and Laminga Water Sources of Nasarawa Local Government Area in Nasarawa State, Nigeria. *NAUB Journal of Science and Technology (NAUBJOST)*, 1(1), 101-106.
- Rilwan Usman, Aliyu Muhammad Kama, Emmanuel I. Ugwu1, Idris M. Mustapha, Adamu Mamman, and Abdulrahman Hudu (2021a). Assessment and Analysis of the Presence of Heavy Metals in Water in Ara and Laminga of Nasarawa State, Nigeria: Health Implication on the Populace. *The Pacific Journal of Science and Technology*. 22(2), 240-246.
- Soja Reuben Joseph, Lucas Williams Lumbi, Umar Ibrahim, Samson Dauda Yusuf, Abdullahi Abubakar Mundi, Idris Mustapha Muhammad, Mercy Nandutu, Segna Launini Bello, Dalhatu Faruk Yartsakuwa and Ignatuis Oche Oduh (2022). Estimation of Public Radiological Dose from Mining Activities in some Selected Cities in Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, 8(1a), 22-35.
- Tyovenda, A.A., Ikpughul, S.I. and Sombo, T. (2018). Assessment of Heavy Metal Pollution of Water, Sediments and Algae in River Benue at Jimeta-Yola, Adamawa State, Nigeria. *Nigerian Annals of Pure and Applied Sciences Federal University of Agriculture, Makurdi-Benue State*, Maiden Edition, 186-195.
- Usman Rilwan, Auta Abdullahi Abbas, Shu'aib Muhammad and Hassan Abdullahi Abdullahi (2020). Heavy Metal Contamination and It's Cancer Risk in Swampy Agricultural Soils across Karu, Nasarawa West, Nigeria. *International Research Journal of Oncology*. 3(2), 1-12.
- Usman Rilwan, Bello Aisha A., Mathew Alpha and Abdullahi Hassan Abdullahi (2020a). "Identification of Heavy Metals in Agricultural Soils of Karu, Nasarawa, Nigeria". *Nigerian Journal of Physics*. 29(2), 96-101.
- Waida, J., Rilwan, U., Ikpughul, S.I. and Madaki, K. S. (2022). Transfer of ^{40}K , ^{226}Ra and ^{232}Th from Soil to Water and Edible Plants and Associated Radiological Effects in Barkin Ladi and Mangu, Plateau State, Nigeria. *Journal of Chemical Research Advances*, 3(2), 29-35.
- Waida, J., Rilwan, U., Jafar, M., Alkasim, A and Yuguda, H. (2022a). Contamination Factor of Radioactive Trace Elements (^{40}K , ^{226}Ra and ^{232}Th) due to Mining Activities in Barkin Ladi and Mangu, Plateau State, Nigeria. *Water, Energy, Food and Environment Journal*, 3(1), 1-12.
- WHO (2017). *Trace elements in human nutrition: Manganese. Report of a WHO expert committee*. Geneva, World Health Organization, pp. 34-36 (Technical Report Series No. 532).