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Evaluation of Pesticide Residues in Fruits, Vegetables and Farmland Soil, and Their Health Implications Among Some Selected L.G.A in Niger State

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ABSTRACT: *The study evaluated pesticide residues in fruits, vegetables, and soil and their health risk implications in three Local Government Areas of Niger State. Thirty samples were collected from different farmland soils in Badeggi, Kuta, and Masuga irrigation farms. The QuEChERS method was used for GC/MS analysis. The health risk indices of pesticide residues were evaluated using the guidelines recommended by the United States Environmental Protection Agency (USEPA). Concentrations of organochlorine pesticide residues in fruits and vegetables showed endosulfan II was significantly higher in all the samples analyzed, banana had the highest concentration of 0.655mg/kg, and cashew with the lowest concentration of 0.029mg/kg. The results also showed the presence of heptachlor epoxide in all the samples analyzed, guava had the highest concentration of 0.260mg/kg and lowest in watermelon with 0.035mg/kg both are above CODEX permissible limits of 0.02 mg/kg. Similarly, endosulfan I was as well higher than the CODEX permissible limits of 0.02mg/kg in four of the samples analyzed with 0.044mg/kg in spinach and 0.003mg/kg in cashew as highest and lowest respectively. Concentrations of b-cypermethrin residue in onions (0.306mg/kg), carrots (0.298mg/kg) and tomatoes (0.036mg/kg) were higher than the CODEX permissible limits of 0.02mg/kg. Relatedly, delta-BHC residue in banana (0.340 mg/kg) and spinach (0.233 mg/kg) were also higher than the CODEX permissible limits of 0.02mg/kg. However, residue concentrations of z-cypermethrin in five of the samples analyzed were below the CODEX permissible limits of 0.02mg/kg, except cashew with 0.033mg/kg which is higher than the CODEX permissible limit of 0.02mg/kg. The pesticides detected are insecticides with broad-spectrum. Pesticides residues contents in clay soil from the study areas were higher than the CODEX permissible limits of 0.02mg/kg in five samples analyzed with 0.670mg/kg and 0.001mg/kg as the highest and lowest respectively. Only two of the pesticides residue that were above the CODEX permissible limits of 0.02mg/kg in loamy soil with 0.20mg/kg and 0.001mg/kg as highest and lowest respectively. However, none of the pesticide residues detected above the CODEX permissible limits of 0.02mg/kg in sandy soil. Health risk estimation of organochlorine pesticide residues in guava, tomatoes, spinach, carrots and banana from the study area were more than 1 as recommended by USEPA, which portray a great health risk. However, the study showed no health risk associated with consuming cashew. The study also showed that, pesticides applied to vegetables and fruits in these three LGAs irrigation farmlands pollute soils. Generally, fruits, vegetables and soils from the irrigation farmlands contained residues of different pesticides in varying concentrations. The study* *recommends among others that pesticides banned by the country should be properly checked by the regulatory bodies so as to ensure a complete phase-out of these highly hazardous pesticides, and farmers must ensure a good agricultural practice (GAP) in the application of these pesticides.*

KEYWORDS: pesticide residues**,** fruits, vegetables, farmland soil, and health implications**,** Niger state

INTRODUCTION

The widespread use of pesticides in agriculture has significantly enhanced crop productivity and food security. However, the persistent residues of these chemicals in fruits, vegetables, and farmland soil pose substantial risks to human health and the environment (Ali et al, 2021). In Nigeria, where agricultural practices are pivotal to the economy and livelihood of many, understanding the extent of pesticide contamination is crucial (Suleiman *et al.*, 2021).Organochlorine pesticides (OCPs) are a class of chemicals known for their persistent nature and potential adverse effects on human health and the environment. Studies conducted in various regions of Nigeria have consistently revealed the presence of OCP residues in fruits, vegetables, and farmland soils, raising significant public health and environmental concerns (Oyinloye *et al.*, 2021). Fruits and vegetables in Nigeria have been found to contain residues of various OCPs such as DDT (dichlorodiphenyltrichloroethane), HCH (hexachlorocyclohexane), aldrin, dieldrin, and endosulfan (FAO, 2005). Several studies indicated that the levels of OCP residues in food items often exceed the maximum residue limits (MRLs) set by international bodies such as the Codex Alimentarius Commission and the European Union.

The consumption of contaminated produce poses significant health risks including endocrine disruption, neurotoxicity, and an increased risk of cancers. Long-term exposure to low doses of OCPs can accumulate in the human body, leading to chronic health issues (Oyinloye *et al.*, 2021). Organochlorine pesticides are highly persistent in the environment, leading to long-term contamination of soils. These compounds can remain in soil for decades, continuously posing a risk to crops grown in contaminated areas (Bhandari *et al.*, 2020). The presence of OCPs in soil adversely affects soil microbiota and overall soil health, reducing agricultural productivity and soil fertility over time (Bhandari *et al.*, 2020).

This study focuses on evaluating the presence and concentration of (OCPs) residues in fruits, vegetables, and soil within selected Local Government Areas (L.G.A) in Niger State. Niger State, renowned for its agricultural productivity, presents a critical case for assessing the implications of pesticide usage. The residues of these chemicals can accumulate in the food chain, leading to chronic health issues such as cancer, endocrine disruption, and reproductive problems.
By conducting a comprehensive analysis of pesticide residues, this research aims to identify potential health hazards associated with the consumption of contaminated produce and the exposure of local populations to polluted soils. The findings will provide valuable insights into the

current state of pesticide contamination and inform policy decisions and agricultural practices aimed at safeguarding public health and promoting sustainable farming in Niger State.

MATERIALS AND METHOD

Description and Suitability of the Study Area

These three Local Government Areas LGAs (Katcha, Shiroro and Mariga) are ideal for studying pesticide residues due to their distinct agricultural activities and diverse cultural backgrounds. Each area offers unique insights into the impact of agricultural practices on food safety and environmental health within different ethnic and socioeconomic contexts in Niger State. Commonly grown fruits in the three LGAs are (mangoes, oranges, bananas, guava, pawpaw and cashew), while vegetables are (tomatoes, okra, spinach, amaranthus, pepper, onions and carrots).

Sample Collection

Fruits and Vegetable samples from the three LGAs irrigation farm lands, were collected randomly at three sampling locations: Badeggi, Kuta and Masugu irrigation farm lands of Katcha, Shiroro and Mariga LGAs respectively of Niger State, Nigeria. These settlements have been identified for their engagement in irrigation farming, contributing significantly to agricultural productivity in their respective LGAs. The fruits samples collected included guava, watermelon, pawpaw, banana, and cashew while vegetables samples were tomatoes, okra, spinach, onions, and carrots. The sum of 30 fruits and vegetables were collected from all the three LGAs, ten samples from each LGA. Systematic random samples of three (3) farmlands soil were collected from each of the LGAs representing clay, loamy, and sandy soils, at 0-15cm depth.

Sample Preparation, Preservation and Storage

The samples were wrapped in aluminum foil which is labelled appropriately for further laboratory preparation. The fruits and vegetable samples were washed using distilled water, cut into pieces, homogenized with a home mill fitted with stainless steel knives, and then finely grinded in a high-speed blender. A composite of 50g of each of the homogenized samples were kept in a plastic bag and was transported immediately to the laboratory for refrigeration before analysis.

Fifty grams (50g) of soil samples were sieved through a 2mm sieve and mixed thoroughly into a 250ml Erlenmeyer flask and extracted using the shaking method as per (Ande et al, 2021) in 100ml hexane–acetone (1:1).

Chemicals/Reagent

The chemicals used were analytical grade. All test pesticides' certified reference standards were purchased, and they were all 98% pure. Acetonitrile, Methanol, and Ether purified water, PSA (primary secondary amine) sorbent (Bondesil), Sulfate of sodium, anhydrous Sodium chloride, Acetic acid, Sodium acetate, Magnesium sulfate, methanol, hexane, and triphenyl phosphate.

Solution Preparation

A solvent extract subsample was cleaned up using dSPE, a significant advancement of the QuEChERS method. $MgSO_4$ and solid phase extraction (SPE) adsorbents were prefilled with accurate weights in small polypropylene centrifuge tubes to eliminate excessive water and undesirable impurities from the extracted materials. By precisely measuring 10mg (0.01mg) of each analyte in volumetric flasks, stock solutions were created that had 1000mg/dm^3 of each molecule under investigation, in 10cm^3 of methanol or acetonitrile contained in a beaker. These were stored in dark vials in a refrigerator at 4^0C. Working standards were also prepared by serial dilutions. The final concentration (in acetonitrile) of 5, 10, 20, 30, and 40mg/L for each analyte was prepared.

Experimental Procedure: Sample Preparation and clean up

Homogenized samples (15g) were weighed into a 50cm^3 polytetrafluoroethylene (PTFE) tube and 15cm^3 of acetonitrile containing 1% acetic acid (v/v) was added. Following the addition of 6g of $MgSO_4$ and 2.5g of sodium acetate trihydrate (equal to 1.5g of anhydrous), the sample were vigorously agitated for 4 minutes while remaining in an ice bath. After centrifuging the samples at 4000rpm for 5 minutes, 6cm^3 of the supernatant was transferred to a 15cm^3 PTFE tube, and 900mg $MgSO_4$ was added. 300mg PSA was added. The extract was shaken using a vortex mixer for 20s and centrifuged at 4000rpm again for 5 min, approximately 2cm^3 of the supernatant was taken in a vial. For the GC-MS/Analysis, this extract was dried by evaporation under a stream of nitrogen and then reconstituted in n-hexane in an autosampler tube (Schematic representations of the QuEChERS Method are illustrated in Fig. 1 below.

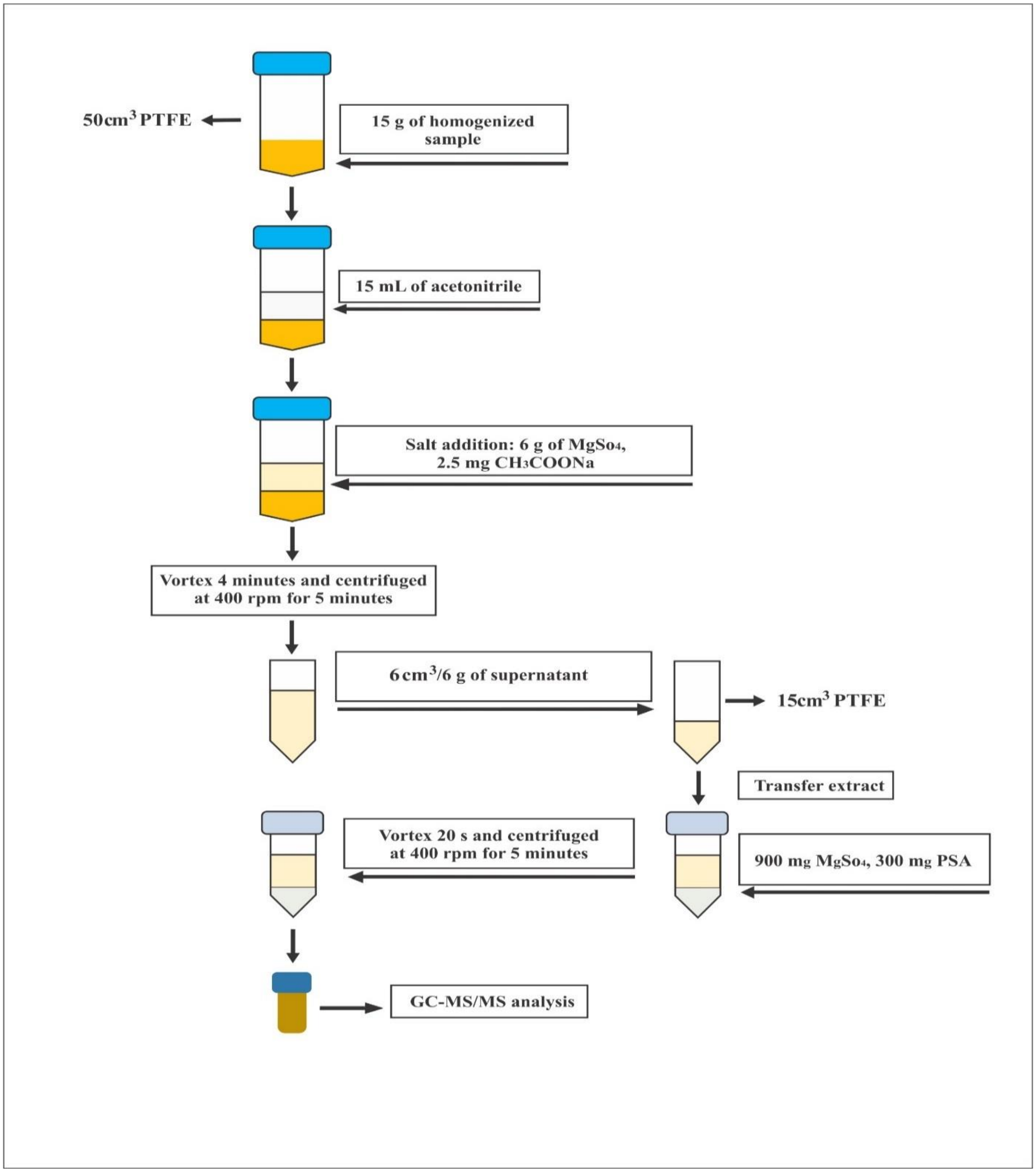

Fig. 1. A conceptual illustration of QuEChER'S Method (Maciej, 2022)

Analytical Method Validation

The process of determining whether a method is appropriate for its intended goal is known as validation. The primary benefit of method validation is that it instills a certain level of trust in both the user and the developer (Lavanya *et al.,* 2013). The linearity was studies for each pesticides where mean peak areas were plotted against concentrations throughout the GC/MS run of standard solutions of the pesticides. The calibrating parameters of each pesticide are presented in Table 1.

Estimation of Daily Intake

Health risk indices of the pesticide residues via dietary intake of vegetables and fruits were assessed according to the guidelines recommended by the USEPA, where the estimated daily intake (EDI) was compared with the acceptable daily intake (ADI) (Wang *et al.*, 2005). By calculating the residual pesticide content (mg kg-^{1}) by the rate of food consumption (kg day^{-1}) and dividing by a body weight of 60 kg, the estimated daily intake (EDI) was determined for the adult population. The average daily vegetable and fruits intake for adults was considered to be 0.345 kg/person/day. The formula; HRI = EDI/ADI (EFSA 2007 & 2016) Was used to generate the Health Risk Index (HRI), where EDI stands for Estimated Daily Intake and ADI for Acceptable Daily Intake. According to Darko & Akoto (2008), an index greater than 1 is regarded as being unsafe for human health.

Statistical Analysis

Standard statistical techniques such as mean, standard deviation and t-test was employed to process the data generated from this study.

RESULT AND DISCUSSION

A total of thirty fruits and vegetables, ten from each of the three LGAs including guava, watermelon, pawpaw, banana, and cashew, tomatoes, okra, spinach, onions, and carrots were investigated for the presence of OC residues. The investigated pesticides compounds were b-cypermethrin, z-cypermethrin, delta-BHC, heptachlor epoxide, endusulfan I and II.

Validation result

Calibration curves were plotted for the purpose of quantifying the pesticide residues detected in fruit and vegetable samples. Linearity was detected alongside the peak areas of different concentrations prepared by using serial dilution of the pesticide standards under investigation.

Calibration curves of the studied analytes showed satisfactory linearity over the selected concentration range with regression correlation coefficients (r^2) ranging from 0.995 for z-cypermethrin to 0.999 for Delta-BHC table 1.

As indicated in table 1, the limits of detection (LOD) of OCPs ranged from 0.023 to 0.128 mg kg^{-1}, which were somewhat close to MRL values set by the EU, indicating that the method is suitable for quantification selected OCPs in fruit and vegetable samples. The limit of quantification (LOQ) values of OCPs ranged from 0.043–0.474 mg kg^{-1}. LOD and LOQ values, were below the lowest standard concentration, which indicates that the analytical method is able to detect and quantify still lower concentrations from the food matrices (Besufekad *et al.*, 2021).

Table 1: Validation Parameters of Organochlorine Pesticides

Pesticides	Linear range (ppm)	R^2	LOD (ppm)	LOQ (ppm)
Delta – BHC	5 – 40	0.9999	0.119	0.397
Heptachlor epoxide (B)	5 – 40	0.995	0.128	0.043
Endosulfan I	5 – 40	0.9979	0.103	0.343
Endosulfan II	5 – 40	0.9993	0.023	0.077
b-cypermethrin	5 – 40	0.9997	0.114	0.381
z-cypermethrin	5 – 40	0.9948	0.142	0.474

$\mathbf{R^2}$ = Correlation coefficient

LOD = Limit of detection, which was calculate using the formula (3Sa/b)

Where **Sa** = is the standard deviation of the response (the intercept of the least R^2 = 0.9948) (Garyd, 2008)

b = is the slope of the calibration curve.

LOQ = Limit of quantification, which was calculate using the formula (10sa/b).

Where **Sa** = is the standard deviation of the response (the intercept of the least R^2) (Garyd, 2008)

b = slope of the calibration curve.

Concentrations (mg/kg) of Organochlorine Pesticides Residues in Fruits and Vegetables

Mean residue concentrations of OCP residues in fruits and vegetables were presented in table 2. Endosulfan II appeared to be significantly higher in all the samples analyzed, banana had the highest concentration of 0.655mg/kg, and cashew with the lowest concentration of 0.029mg/kg. The results also showed the presence of heptachlor epoxide in all the samples analyzed in which watermelon has the highest concentration of 0.134mg/kg and the least concentration of 0.237mg/kg pawpaw. In the same vein, endosulfan I tested positive in four of the samples analyzed, while b-cypermethrin and delta-BHC tested positive in three of the samples analyzed. However, z-cypermethrin was not detected in all the samples analyzed. The pesticides detected are insecticides with broad-spectrum contact use on various fruits and vegetables (USEPA 2010).

Results from the t-test analysis showed that, in all the samples analysed, there was no significance difference between the pesticides MRL (mg/kg) and concentration (mg/kg). The findings is similar to the results of research conducted by, Suleiman *et al.*, (2021), and Ssemugabo *et al.*, (2022). Farmers' failure to adhere to the pre-harvest window between applying pesticides and harvesting may be a contributing factor to these residues. A research review reported by (Ssemugabo *et al.*, 2022) posited that to extend the shelf life of fruits and vegetables, several stakeholders also apply pesticides at various points throughout the supply chain. In fact, some market sellers claimed to have sprayed pesticides, particularly on tomatoes, in an effort to attract customers with visible

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residues. It has also been demonstrated that various handling techniques, such as washing, peeling, boiling, blending, and drying, can either increase or decrease the amount of pesticide residues in fruits and vegetables. (Aktar *et al.*, 2009) reported that some produce contamination may also be connected to the application of pesticides to prevent diseases and nuisances caused by rodents and vectors. However, the findings are not in agreement with the results reported by (Araoud *et al.*, 2007).

Table 2: Mean Concentrations (mg/kg) of Organochlorine Pesticide Residues in Fruits and Vegetables

Samples	b-cypermethrin	z-cypermethrin	delta-BHC	Heptachlor epoxide (B)	Endosulfan I	Endosulfan II
Guava	0.003 ±0.0040	0.0001 ±0.005	0.003 ±0.0040	0.260* ±0.0031	0.002 ±0.0081	0.60* ±0.050
Pawpaw	0.003 ±0.0040	0.001 ±0.005	0.003 ±0.0040	0.237* ±0.056	0.002 ±0.004	0.46* ±0.080
Tomatoes	0.036* ±0.0070	0.001 ±0.005	0.003 ±0.0040	0.047* ±0.076	0.205 ±0.037	0.059* ±0.080
Carrots	0.298* ±0.044	0.001 ±0.005	0.002 ±0.004	0.049 ±0.076	0.239 0.067	0.044 0.080
Spinach	0.003 ±0.0040	0.0002 ±0.005	0.233 ±0.048	0.058* ±0.096	0.044* ±0.067	0.620* ±0.42
Banana	ND	ND	0.340 ±0.56	0.055 ±0.082	0.003 ±0.004	0.655 ±0.094
Onions	0.306* ±0.60	0.001 ±0.005	0.004 ±0.0070	0.045* ±0.056	0.020 ±0.004	0.556* ±0.088
Watermelon	ND	ND	0.002 ±0.0041	0.134* ±0.023	0.020 ±0.009	0.353* ±0.080
Okra	0.004 ±0.0070	0.001 ±0.005	0.003 ±0.0040	0.035* ±0.066	0.208* ±0.099	0.629* ±0.230
Cashew	0.001 ±0.005	0.033* ±0.009	ND	0.056* ±0.070	0.003 ±0.0040	0.029* ±0.057

ND = Not Detected *> MRL

Concentrations (mg/kg) of Oganochlorine Pesticides Residues in Soils

Pesticides residues contents of soils from the study areas are shown in table 3. The results indicated that five out of six pesticides were significantly higher in clay soil with 0.670mg/kg of endosulfan II as the highest. However, z-cypermethrin were insignificantly lower with 0.001mg/kg. In the same vein, endosulfan II were significantly higher in loamy soil with a concentration of 0.057mg/kg, and b-cypermethrin has the lowest concentration value of 0.003mg/kg.

Furthermore, only three of the pesticide residues were detected in sandy soil with mean concentration of endusolfan II (0.007mg/kg) and delta-BHC (0.001mg/kg) as highest and lowest respectively. Aside from local variations in climate and time, the landform and land use have the greatest impact on soil characteristics. The residue concentrations are higher in clay soils, this might be due to its high retention properties. Clay soils, on the other hand, contain more electrically charged tiny particles. Clay particles also have many layers that attract and trap organic matter. This implies that a variety of pesticides can be drawn to clay particles and bound there.
On the other hand, only 2 of the pesticide residues were above the MRL limits in loamy soil and all the pesticides detected were also below the MRL limits in sandy soil. National Pesticides Information Center (NPIC) reported that the more sand and silt a soil has, the less attractive it is to an organic (carbon-based) pesticide. This is so that these pesticides can't bond to the sand and silt particles (big and medium-sized particles).

Table 3: Mean Concentrations (mg/kg) of Organochlorine Pesticide Residues in Soil from

Samples	b-cypermethrin	z-cypermethrin	delta-BHC	Heptachlor epoxide (B)	Endosulfan I	Endosulfan II
Clay soil	0.037*	0.001	0.300*	0.036*	0.221*	0.670*
	±0.045	±0.0.002	±0.047	±0.082	±0.056	±0.094
Loamy soil	0.003	ND	0.023	0.202*	0.0211	0.057*
	±0.0040		±0.008	±0.082	±0.016	±0.014
Sandy soil	ND	ND	0.001	0.001	0.002	0.007
			±0.002	±0.002	±0.0004	±0.0014

ND = Not Detected
*>MRL

Health Risk Estimation of Organochlorine Pesticides Residues in Fruits
Pesticide residues in fruits and vegetables are unlikely to be completely removed by washing. Therefore, it is a very dangerous situation when consumers eat fruits and vegetables contaminated with high concentrations of pesticide residues over a long period time. Table 4.1 shows the ADI, EDI, and HRI of OCPs. The results indicated heptachlor epoxide and endusulfan II had 3.68 and 8.49 HRI in guava which was significantly above 1 HRI, while the remaining OCPs had less than 1 HRI. This implies that consuming guava from the study areas poses a great health risk. Similarly, heptachlor epoxide and endosulfan II were also more than 1 HRI in watermelon with 1.89 and 4.99 respectively, which also potent a great risk. The findings are consistent with the research study reported by (Suleiman *et al.*, 2021, & Nasiri *et al.*, 2016) but not in agreement with the study reported by (Szpyrka *et al.*, 2015). The study also showed high risk index of heptachlor epoxide-B and endusilfan II in pawpaw with 3.35 and 6.15 HRI respectively. Furthermore, eating banana from the study locations also pose a great health risk because enduslfan II and delta-BHC had a significant HRI of 9.20 and 4.81 respectively. However, none of the pesticide studied indicated more than 1 HRI in cashew.

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Higher residue levels could be the consequence of past usage and environmental contamination, especially from substances that have been shown to be environmental pesticides close to the research locations. It could also that farmers in this areas used these pesticides without adhering to Good Agricultural Practice (GAP) and most of the detected OCPs are inexpensive and widely available at Nigerian agrochemical stores. The study is similar to the findings reported by (Odion *et al.*, 2021) and (Suleiman 2021).

Table 4.1 Mean Concentrations (mg/kg), ADI, EDI, and HRI of Organochlorine Pesticide Residues in Fruits

Commodity	Pesticides	CONC (mg/kg)	MRL (mg/kg)	ADI (mg/kg/day)	EDI (mg/kg/bw/day)	HRI	Health Risk
Guava	b-cypermethrin	0.003	0.02	0.345	0.02	0.06	NO
	z-cypermethrin	0.001	0.02	0.345	0.01	0.03	NO
	delta-BHC	0.003	0.02	0.345	0.02	0.06	NO
	Hept. Expoxide (B)	0.260	0.02	0.345	1.27	3.68	YES
	Endosulfan I	0.002	0.02	0.345	0.01	0.03	NO
	Endosufan II	0.600	0.02	0.345	2.93	8.49	YES
Watermelon	b-cypermethrin	ND	ND	ND	ND	ND	ND
	z-cypermethrin	ND	ND	ND	ND	ND	ND
	delta-BHC	0.002	0.02	0.345	0.009	0.03	NO
	Hept. Expoxide (B)	0.134	0.02	0.345	0.65	1.89	YES
	Endosulfan I	0.020	0.02	0.345	0.098	0.29	NO
	Endosulfan II	0.353	0.02	0.345	1.723	4.99	YES
Pawpaw	b-cypermethrin	0.003	0.02	0.345	0.02	0.06	NO
	z-cypermethrin	0.001	0.02	0.345	0.004	0.014	NO
	delta-BHC	0.003	0.02	0.345	0.02	0.03	NO
	Hept. Expoxide (B)	0.237	0.02	0.345	1.12	3.35	YES
	Endosulfan I	0.002	0.02	0.345	0.009	0.28	NO
	Endosufan II	0.46	0.02	0.345	2.45	6.15	YES
Banana	b-cypermethrin	ND	ND	ND	ND	ND	ND
	z-cypermethrin	ND	ND	ND	ND	ND	ND
	delta-BHC	0.340	0.02	0.345	1.66	4.81	YES
	Hept. Expoxide (B)	0.055	0.02	0.345	0.27	0.78	NO
	Endosulfan I	0.003	0.02	0.345	0.015	0.04	NO
	Endosufan II	0.650	0.02	0.345	3.17	9.20	YES
Cashew	b-cypermethrin	0.001	0.02	0.345	0.004	0.014	NO
	z-cypermethrin	0.033	0.02	0.345	0.161	0.46	NO
	delta-BHC	ND	-	-	-	-	NO
	Hept. Expoxide (B)	0.056	0.02	0.345	0.27	0.79	NO
	Endosulfan I	0.003	0.02	0.345	0.015	0.042	NO
	Endosufan II	0.03	0.02	0.345	0.194	0.452	NO

Health Risk Estimation of Organochlorine Pesticides Residues in Vegetables

The ADI, EDI, and HRI of OCP residues in vegetables are given in table 4.2. As illustrated in table 4.2, delta-BHC and endosulfan II were significantly higher in spinach with HRI of 3.29 and 8.78

respectively. The results also indicated that b-cypermethrin and edosulfan-I were also higher than 1 HRI in carrots, with 4.22 and 3.38 respectively. Similarly, endosulfan-II and b-cypermethrin were more than 1 HRI in onions with 7.87 and 4.33 HRI. Obviously, all the OCP residues detected present serious health risk. In another way, endosulfan-I were more than HRI in both okra and tomatoes with 2.94 and 2.90 HRI respectively. Contaminated surfaces from distribution and storage procedures are one possible source of contamination. It might also be because high volatility pesticides can be absorbed by spray drift and by crop roots in dry soil. They can also be absorbed by the leaves of nontarget crops. The finding is in agreement with the research study reported by (Łozowicka *et al*., 2013) but not in agreement with the research findings reported by (Suleiman *et al.,* 2021).

Table 4.2 Mean Concentrations (mg/kg), ADI, EDI, and HRI of Organochlorine Pesticide Residues in Vegetables

Commodity	Pesticides	CONC (mg/kg)	MRL (mg/kg)	ADI (mg/kg/day)	EDI (mg/kg/bw/day)	HRI	Health Risk
Spinach	b-cypermethrin	0.003	0.02	0.345	0.014	0.04	NO
	z-cypermethrin	0.0002	0.02	0.345	0.001	0.003	NO
	delta-BHC	0.233	0.02	0.345	1.138	3.29	YES
	Hept. Expoxide (B)	0.058	0.02	0.345	0.28	0.82	NO
	Endosulfan I	0.044	0.02	0.345	0.213	0.62	NO
	Endosufan II	0.62	0.02	0.345	3.03	8.78	YES
Carrots	b-cypermethrin	0.238	0.02	0.345	1.46	4.22	YES
	z-cypermethrin	0.001	0.02	0.345	0.004	0.01	NO
	delta-BHC	0.002	0.02	0.345	0.01	0.03	NO
	Hept. Expoxide (B)	0.049	0.02	0.345	0.24	0.69	NO
	Endosulfan I	0.239	0.02	0.345	1.17	3.38	YES
Okra	b-cypermethrin	0.004	0.02	0.345	0.02	0.06	NO
	z-cypermethrin	0.001	0.02	0.345	0.004	0.01	NO
	delta-BHC	0.003	0.02	0.345	0.015	0.04	NO
	Hept. Expoxide (B)	0.035	0.02	0.345	0.17	0.49	NO
	Endosulfan I	0.208	0.02	0.345	1.02	2.94	YES
Onions	b-cypermethrin	0.306	0.02	0.345	1.49	4.33	YES
	z-cypermethrin	0.001	0.02	0.345	0.004	0.014	NO
	delta-BHC	0.004	0.02	0.345	0.02	0.06	NO
	Hept. Expoxide (B)	0.045	0.02	0.345	0.22	0.64	NO
	Endosulfan I	0.020	0.02	0.345	0.09	0.28	NO
	Endosufan II	0.556	0.02	0.345	2.72	7.87	YES
Tomatoes	b-cypermethrin	0.036	0.02	0.345	0.18	0.51	NO
	z-cypermethrin	0.001	0.02	0.345	0.004	0.01	NO
	delta-BHC	0.003	0.02	0.345	0.015	0.04	NO
	Hept. Expoxide (B)	0.047	0.02	0.345	0.23	0.67	NO
	Endosulfan I	0.205	0.02	0.345	1.00	2.90	YES
	Endosufan II	0.059	0.02	0.345	0.23	0.84	NO

CONC = Concentration (mg/kg)
MRL = Maximum Residue Limits of pesticide residues (0.02mg/kg)

ADI = Average Daily Intake of fruits and vegetables (0.345mg/kg per person per day)
EDI = Estimated Daily Intake of fruits and vegetables:

- EDI = concentration of pesticides residues x food consumption rate (239g) / Adult body weight (60g)

HRI = Health Risk Index

- HRI = EDI/ADI

Health Risk Index greater than 1 is considered unsafe for human health.

CONCLUSION

The findings suggests that fruits, vegetables and farmland soils from the study areas contained residues of different pesticides in varying concentrations. From the samples analyzed, endosulfan I and II, heptachlor epoxide – B, delta – BHC, and b-cypermethrin were above the reference standard of 1 for adults. Therefore, according to EU MRLs, the contamination levels of these residues may constitute a major public health concern. This suggests that immediate action is required to design comprehensive intervention measures to lower the possible danger to consumers' health. In all the samples analyzed only, z-cypermethrin was not detected.
Thus, it may be stated that consumers in the research areas are more susceptible to health risks as a result of pesticide consumption through fruits and vegetables. The study also showed the presence of pesticide residues and their concentrations in clay and loamy soil samples. A few pesticides detected have the potential of leaching thus, there is a risk of groundwater pollution.

Recommendations

Developing suitable measures for control, monitoring, and management of pesticide usage by the authorized body is crucial for the authentication of organic crops. To grow fruit and vegetable crops free of contamination, conducting a thorough health risk evaluation of the discovered chemical and implementing proper agricultural practices would be ideal. In addition, Pesticides banned by the country should be properly checked by the regulatory bodies so as to ensure a complete phase-out of these highly hazardous pesticides, and farmers must ensure good agricultural practice (GAP) in the application of these pesticides. There is also need for comprehensive research utilizing residue trials is required to register pesticides and create a database of pesticide MRLs.

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