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Assessment of the Levels of Pesticide Residues Present in Soil Samples from *Wazo* Market, Ogbomoso, Nigeria.

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ABSTRACT

The use of pesticides in agriculture and households is widespread. An investigation was carried out on soil samples collected from *Wazo* market, Ogbomoso, Nigeria during dry (February and March) and rainy seasons (June and July) in the year 2015 to assess the contamination levels of pesticides in soil. The samples were separately extracted in a soxhlet extractor using a mixture of acetone and n-hexane (3:2). The extracts were then subjected to Gas Chromatography-Electron Capture Detector (GC-ECD) to determine pesticides concentration. The pesticides detected in the top soils of *Wazobia* market include alpha-BHC, beta-BHC, heptachlor, aldrin, gamma-BHC, delta-BHC, heptachlor epoxide, endosulfan I, p,p'-DDE, dieldrin, endrin ,p,p'-DDD, endosulfan II, p,p'-DDT, endrin aldehyde, endosulfan sulfate and methoxychlor. Alpha-BHC, beta-BHC, gamma-BHC, methoxychlor and endosulfan sulfate were found to be higher than the maximum permissible limits (0.0074, 0.0006, 0.8710, 0.01 and 0.008mg/kg respectively) during the sampling period. The levels of the pesticides were higher during the dry season than in the rainy season except dieldrin and heptachlor epoxide which were a little bit higher during the rainy season. This study revealed that *Wazo* market top soil is contaminated with pesticide residue.

Keywords: Pesticides, *Wazo* market, GC-ECD, Top soil

Introduction

Soil pollution is caused by the presence of human made chemicals like Polycyclic Aromatic Hydrocarbons (PAHs), solvents, pesticides and other heavy metals or other alteration in the natural soil environment (Panagos *et al.*, 2014). *Wazo* market is a food market where a large variety of agricultural products are stored and sold. Storage of agricultural products in this market involves the use of pesticides for preservation which makes the market soil environment to be highly susceptible to

being contaminated by pesticides. This suspicion is based on the premise that pesticides have soil as their main sink and humans are exposed to these pollutants directly or indirectly when they accumulate in soil through dermal contact and inhalation. Therefore, to what extent has pesticides for preservation affected the soils in *Wazo* market. Consequently, there is need to assess the levels of pesticides in the soil of this popular food market established about seven years ago (Carvalho, 2017).

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While the greatest source of pesticide exposure comes from residues that remain in final food products (FAOUN, 2012), they can also be found in environmental samples such as water and soil. The many negative health impacts associated with pesticide residues, requires that scientific information on pesticidal residues in environment should be regularly acquired and made available to the public in other to reduce health risks associated with them. This study was embarked upon to assess the contribution of market activities (sale and storage of agricultural produces) to the pesticide residue in *Wazo* market soil, Ogbomoso, Nigeria.

Materials and methods

Study Area

The area of study is *Wazo* market which is located along Ogbomoso-Ilorin expressway. It lies between longitude 4°15'27.61''E and latitude 8°9'56.96''N. *Wazo* market is predominantly agricultural products based market. Major farm products and perishable goods such as beans, maize, rice, tomatoes etc. are sold and stored there.

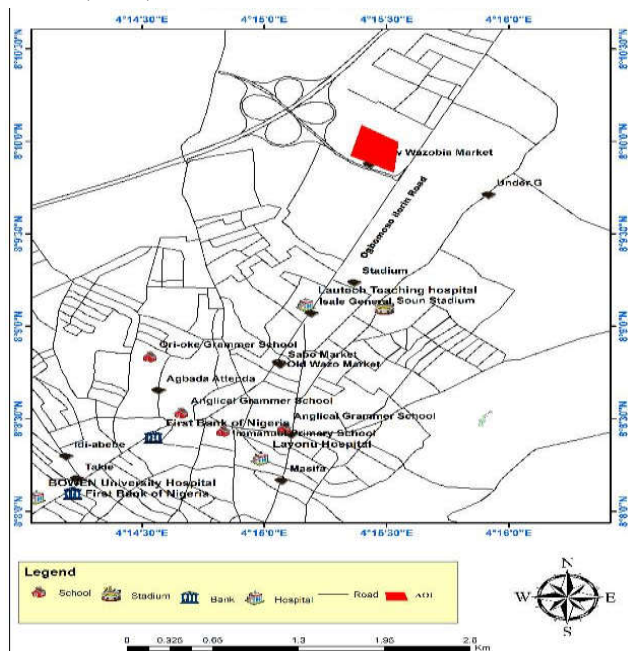


Figure 1: Location of Wazo Market (Adapted from the Urban and regional planning center Ogbomoso North Local Government)

Sample Collection

Soil samples were collected from five different spots (the four cardinal point of the market 50m apart) and 500m away from the market with a soil auger (depth 0-5cm) and stored in a stainless steel lined with aluminum foil during the dry season (February-March) and rainy season (June-July) in year 2015. The samples were air dried at room temperature for 48 hours. The samples were then passed through a 2 mm sieve to remove the coarse soil fraction. The control was taken at the back of Faculty of Science, LAUTECH.

Determination of pH

The soil sample (15g) was weighed into a beaker and 20ml distilled water added. The suspension was stirred for 15minutes using a glass rod manually and allowed to settle for 20minutes. The pH meter (Oakton 35423-10 Eco Test pH 2, USA) was standardized using buffer solutions (pH 4 and pH 7). The electrodes of the pH meter were inserted into supernatant and the pH of the samples was measured to the nearest 0.10. The electrodes of the pH were rinsed with distilled water before each reading. The pH of the various suspension was recorded digitally by the pH meter (Emmanuel, 2013). This experiment way repeated twice.

Determination of Total Organic Carbon

Five grams of the air dried soil samples was weighed into a 100ml volumetric flask. 10ml of $K_2Cr_2O_7$ was added by pipette. 10ml of concentrated H_2SO_4 was then added and swirled gently. The suspension was allowed to stand on insulating pad for 30minutes to avoid rapid heat loss. The suspension was washed with 100ml of distilled water and filtered to remove suspended particles, three drops of ferroin indicator was then added and the resulting solution titrated with 0.5 N ferrous sulphate solution. As the end point was approached, the solution took on a greenish cast and then changed to dark green at which point

ferrous sulphate was added drop by drop until the colour changed rapidly from blue to maroon red. This procedure was then repeated two times for the remaining samples. The blank titration was carried out. The result of the TOC was then calculated as equation 1 (Adedosu *et al.*, 2013).

$$\% \text{ Organic Carbon} = \frac{[(A - B) \times 0.003 \times 100]}{C} \quad 1$$

where A is normality of $K_2Cr_2O_7$ x ml of solution, B is normality of $FeSO_4$ x ml of solution, C is mass of air-dry soil (g)

Extraction of pesticide Residue from Soil Samples

The soil samples collected were air dried at room temperature for 48 hours. Each of the dried samples were then passed through a 2 mm sieve to remove the coarse soil fraction. Extraction of the pesticide residues from the soil samples was carried out using Soxhlet apparatus (Barriada-Pereira *et al.*, 2003; Sporrying *et al.*, 2005). 5g of the air dried soil samples was extracted with acetone and n-hexane (3:2) for 8hrs. After extraction, the extract was removed, concentrated and taken for analysis using Gas Chromatography coupled with Electron Capture Detector (GC-ECD).

Instrumental Analysis

An Agilent 7890A GC-ECD was used for determination. The following gas chromatographic conditions were optimized to achieve proper separation using microcapillary column of 30m x 250um x 0.25um). The carrier gas was helium and the temperature of the injector operating in splitless mode were held at 250°C while the detector temperature was 290°C with a flow rate of 2ml per minute. The column oven temperature was programmed at initial 150°C and increased to 280°C at 6°C per minute. The injector volume was 1µl and total run time was 22minutes. Organochlorine pesticides were identified by comparing the retention time of the peak present

in the extracts with the retention time of the standard.

Statistical Analysis

Statistical Package for Social Sciences (SPSS) software version 25.0 (released 2017) was used to generate the means of the results. Pearson correlation analysis was carried out to establish the correlation between the physicochemical parameters of soil and the concentrations of pesticides detected. The statistical significance tests were carried out at 5% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

pH and Total Organic Carbon Wazo market topsoil during the sampling period

The pH analysis of the soil samples ranges from 7.47 to 8.02 during this study. The decreasing order of the percentage of total organic carbons in Wazo market soil are February sample > July sample > March sample > June sample as showed in (Table 1). This revealed that Wazo market soil is an alkali soil and it is difficult to use alkaline soils for agricultural purpose due to their low infiltration capacity which makes rain water to stagnate on the soil easily.

Table 1: Physicochemical parameters during the sampling period

Month	Mean pH	Mean TOC (%)
February	7.47±0.76	2.31±0.24
March	8.02±0.61	0.92±0.52
June	7.77±0.32	0.69±0.20
July	7.85±0.46	0.93±0.62

n = (3) where n is the number of times the experiment was carried out.

Concentration of Pesticides in Wazo market topsoil during the sampling period

Table 2 illustrate the concentration of pesticides detected in Wazo market topsoil using Gas

Chromatography-Electron Capture Detector. In the month of in February the concentration of Alpha-BHC, Beta-BHC, gamma-BHC, methoxychlor and endosulfan sulfate pesticides where higher than the maximum permissible limit provided by the Agency for Toxic Substances and Disease Registry (ATSDR). Alpha-BHC, methoxychlor and endosulfan sulfate concentration in Wazo top soil where also found to be higher than the maximum permissible limit in the month of March.

The result obtained from the analysis of soil samples from Wazo market revealed that the top soil are contaminated with high concentration of pesticides (such as alpha-BHC, Beta-BHC, gamma-BHC, methoxychlor and endosulfan) above the maximum permissible limit as provided by the Agency for Toxic Substances and Disease Registry (ATSDR). This shows that pesticide residues are accumulated in the soil. The presence of higher concentrations of some pesticides above the maximum permissible levels in Wazo topsoil market is not good health wise for the marketers because high concentrations of pesticides in the soil implies high constant exposure of the marketers to these pesticides. In addition, neighboring water bodies close to Wazo market may become polluted via run off from this market, therefore making people who use such water to also become exposed to these pesticides.

Alpha-BHC, gamma-BHC and beta-BHC at higher doses have effects on the liver while gamma-BHC is the most acutely neurotoxic. Acute and intermediate duration exposure of humans to high oral doses of gamma-BHC or beta BHC affects the central nervous system as evidenced by behavior disorders, decreased nerve conduction velocity, neurological changes, convulsions, seizures and coma (ATSDR 2005). High levels of methoxychlor can also lead to seizures and convulsions and also affects the ovaries, uterus and mating cycle in females. Endosulfan sulfate in high doses can lead to

vomiting, diarrhea, agitation, convulsions and loss of consciousness (Smith and Andrew, 1991). However, the source of these pesticides can be apportioned thus:

(i) BHCs (Alpha-BHC, Beta-BHC, gamma-BHC)

Among the three isomers of BHC found in the top soil of Wazo market, Alpha-BHC has the highest followed by beta-BHC and gamma-BHC respectively. The sum of concentrations of both Beta-BHC and gamma-BHC was lower than the concentration of Alpha-BHC. Meanwhile, because there was alpha-BHC and gamma-BHC, a small portion of BHCs in the soils probably arises from the technical BHC input. Both technical BHC and beta-BHC are used in agriculture, pest control in rice, wheat and maize (Yang et al., 2008) and this indicates the source of the pesticides in Wazo market soil.

(ii) DDTs

Technical DDT and Dicofol containing high DDT related compound impurities were the main sources of DDT pollution. Dicofols are used as acaricides which are substances that kill acarids (acarids are parasitic arachnid such as termites and ticks) and this indicates the possible source of p'p-DDT in Wazo market.

(iii) Endosulfans (Endosulfan I, Endosulfan II, Endosulfan sulphate)

Endosulfans are used to preserve many food crops such as grains, fruit and vegetables (Ajmer et al 2017). Endosulfan levels in wazo market may be attributed to fruits, grains and vegetables sold in the market.

(iv) DRINs (Aldrin, Dieldrin, Endrin)

Aldrin was used to control soil pests (namely termites) on corn and potato crops. Dieldrin was an insecticide used on fruit, soil and seed. Endrin has been used primarily as an agricultural insecticide on tobacco, apple trees, sugar cane,

rice and grains (Smith and Andrew, 1991). Both aldrin and dieldrin may be volatilized from sediment and redistributed by air currents, contaminating areas far from their sources. Dieldrin, endrin and aldrin in Wazo market soil may be traced to corn, grains and fruits as these are some of the agricultural products sold in the market. Dieldrin, endrin and Aldrin are used in the preservation of aforementioned foodstuffs.

Seasonal Variation of Pesticides in Wazo Market Top Soil

The seasonal variation of pesticides in soil samples taken from Wazo market throughout the

sampling period is shown in figure 2. It was observed that mostly the mean concentrations of pesticides during dry season is higher than the mean concentrations in the rainy season except for dieldrin and heptachlor epoxide pesticides that have mean concentrations which are a little bit higher during the rainy season. The difference in concentrations of the pesticides between dry and rainy season may be due to the heavy rainfall which led to the running off and washing off of the pesticides and may drain through the soil into lower soil layers and groundwater.

Table 2: Mean Concentration of Pesticides in the Top soil of Wazo Market during the sampling period in mg/kg. (M.P.L- Maximum Permissible Limit according to ATSDR Toxicological Profile, 2005)

Pesticides	February (mg/kg)	March (mg/kg)	June (mg/kg)	July (mg/kg)	M.P.L
Alpha-BHC	0.1678±0.19 (B.D.L)	0.0088±0.02 (B.D.L)	0.0109±0.01 (B.D.L)	0.0000±0.00(B.D.L)	0.0074
Beta-BHC	0.0687±0.11 (B.D.L)	0.0021±0.005 (B.D.L)	0.0015±0.003 (B.D.L)	0.0092±0.02 (B.D.L)	0.006
Heptachlor	0.5014±0.08 (B.D.L)	0.0011±0.001 (B.D.L)	0.0000±0.00 (B.D.L)	0.0215±0.03(B.D.L)	0.8710
Aldrin	0.0542±0.05 (0.0013)	0.0139±0.002 (B.D.L)	0.0071±0.003 (B.D.L)	0.0322±0.03(B.D.L)	0.94
Gamma-BHC	0.0242±0.04 (B.D.L)	0.0050±0.003 (B.D.L)	0.0003±0.005 (B.D.L)	0.0040±0.01(B.D.L)	0.009
Delta-BHC	0.1005±0.18 (B.D.L)	0.1388±0.13 (0.0005)	0.0462±0.09 (B.D.L)	0.0479±0.1(B.D.L)	0.4
Heptachlor epoxide	0.0184±0.02 (B.D.L)	0.0122±0.008 (B.D.L)	0.0233±0.04 (B.D.L)	0.0197±0.01(B.D.L)	1.005
Endosulfan I	0.0027±0.00 (B.D.L)	0.0051±0.007 (B.D.L)	0.0011±0.001 (B.D.L)	0.0003±0.001(B.D.L)	18
P,p'-DDE	0.0221±0.04 (B.D.L)	0.0052±0.005 (B.D.L)	0.0010±0.002 (B.D.L)	0.0010±0.001(B.D.L)	2
Dieldrin	0.0571±0.08 (B.D.L)	0.1086±0.14 (B.D.L)	0.0116±0.008 (B.D.L)	0.1591±0.3 (B.D.L)	0.603
Endrin	0.0140±0.02 (B.D.L)	0.3910±0.74 (B.D.L)	0.0014±0.001 (B.D.L)	0.0020±0.002(B.D.L)	1
P,p'-DDD	0.0221±0.03 (B.D.L)	0.0151±0.02 (B.D.L)	0.0149±0.01 (B.D.L)	0.0013±0.002(B.D.L)	3
Endosulfan II	0.0262±0.02 (B.D.L)	0.0477±0.04 (B.D.L)	0.0093±0.007 (B.D.L)	0.0338±0.1 (B.D.L)	18
P,p'-DDT	0.0560±0.07 (B.D.L)	0.0194±0.01 (B.D.L)	0.0033±0.001 (B.D.L)	0.0311±0.03 (B.D.L)	2
Endrin aldehyde	0.0339±0.03 (B.D.L)	0.0475±0.03 (0.0222)	0.0080±0.02 (B.D.L)	0.0172±0.01(B.D.L)	20
Endosulfan Sulfate	0.0285±0.03 (B.D.L)	0.0490±0.05 (B.D.L)	0.0077±0.01 (B.D.L)	0.0106±0.01 (B.D.L)	0.008
Methoxychlor	0.0379±0.04 (B.D.L)	0.0648±0.09 (B.D.L)	0.0068±0.01 (B.D.L)	0.0935±0.2 (B.D.L)	0.01

Key: BDL- Below Detection Limit; M.P.L- Maximum Permissible Limit; ATSDR- Agency for Toxic Substances and Disease Registry

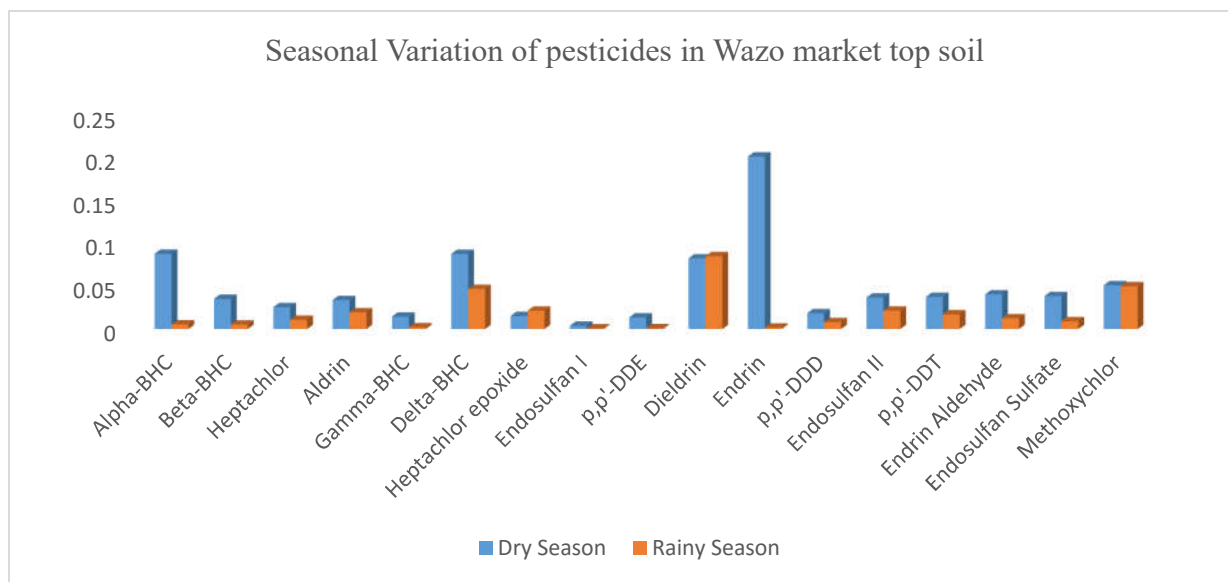


Figure 2: Graph of Seasonal Variation of Pesticides during the Sampling Period

Relationship between TOC and Total Pesticides Concentrations in Wazo market Topsoil during the sampling periods

Pesticides especially organochlorine pesticides have a tendency to bind with soil organic matter. Total organic carbon (TOC) content of soil can be an added carbon source to assist microbial degradation so TOC can influence the pesticidal residues in soil (Smith and Andrew, 1991). Scatter plot was used to assess the relationship between the percentage total organic carbon and total concentration of pesticides in Wazo topsoil during the sampling period as shown in figures 3a-d, pesticides significantly correlate with total organic carbon (TOC). The linear regression analysis showed positive correlation ($r^2 = 0.516$, $r^2 = 0.8537$, $r^2 = 0.7644$, $r^2 = 0.6556$) between total pesticides and percentage total organic carbon in the month of February, March, June and July. These relationships agree with previous studies that have shown that fate and distributions of organochlorine pesticides in soils are controlled by their organic matter content (Jiang *et al.*, 2009; McKenzie-Smith *et al.*, 1994).

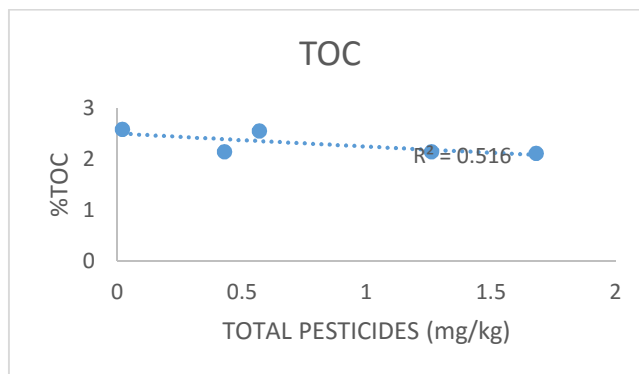


Figure 3a: Scatter plot of percentage TOC against Total pesticides in the month of February

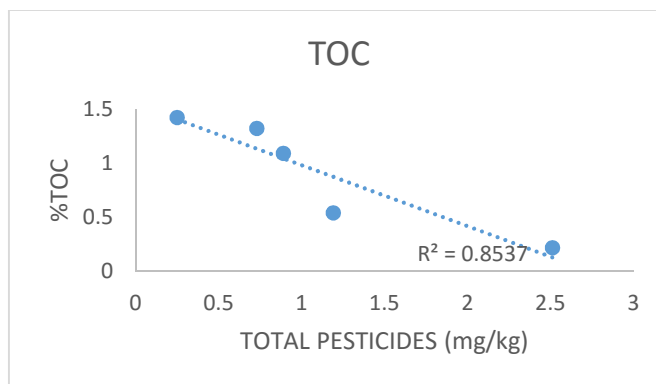


Figure 3b: Scatter plot of percentage TOC against Total pesticides in the month of March

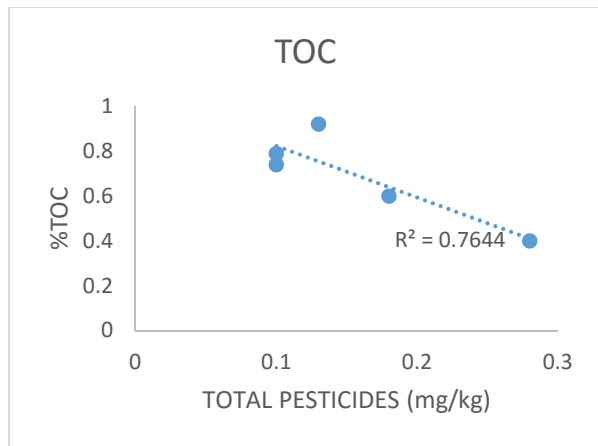


Figure 3c: Scatter plot of percentage TOC against Total pesticides in the month of June

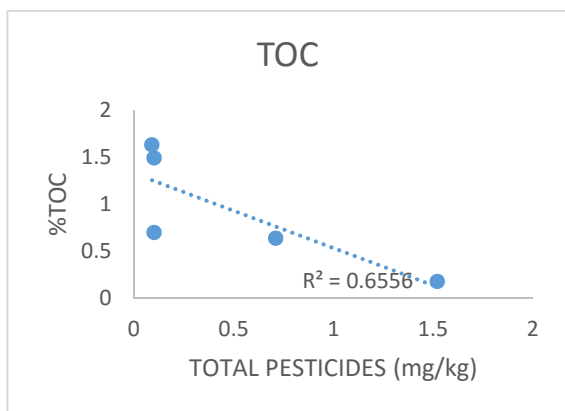


Figure 3d: Scatter plot of percentage TOC against Total pesticides in the month of July

Correlation analyses

The correlation between soil pH and pesticides residues detected in the soil in each month were analyzed using the correlation of Pearson (Table 3a-d where A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q represents alpha BHC, beta BHC, heptachlor, Aldrin, gamma BHC, delta-BHC heptachlor epoxide, endosulfan I, p'p'-DDE, dieldrin, endrin, p, p'-DDD, endosulfan II, p, p'-DDT, endrin aldehyde, endosulfan sulfate and methoxychlor respectively). During the dry season (February and March), there was no positive correlation between the pesticides

residue and the soil pH. This finding is similar to a study by Aiyesanmi and Idowu (2012) which reported no significant correlations between soil pH and organochlorine concentrations measured in soil samples from cocoa farms in Ondo State Central District in Nigeria (Aiyesanmi and Idowu, 2012). However, during the rainy season (June and July), a strong positive correlation between was observed soil pH and dieldrin in the month of June and in the month of July, a strong positive correlation was observed between the soil pH and heptachlor epoxide and this indicates that soil pH could have enhanced the adsorption of the pesticides and thus, soil pH influences the fate of dieldrin and heptachlor epoxide in the rainy season (Fosu-Mensah *et al.*, 2016).

However, a strong positive correlation was observed among some of the pesticides, thus suggesting they originated from a similar source. Table 3a shows a very strong correlation occurs between alpha-BHC/p,p'-DDD/p,p'-DDT, beta-BHC/delta-BHC/endrin aldehyde/endosulfan sulfate, delta-BHC/p,p'-DDE/endrinaldehyde/endosulfan sulfate, endosulfan I/endosulfan sulfate/methoxychlor. It can be seen from table 3b that there is a very strong correlation between alpha-BHC/heptachlor/endosulfan I, beta-BHC/endrin aldehyde/methoxychlor, gamma-BHC/p,p'-DDE/p'p,-DDT and this suggests same origin.

Table 3c indicates a strong correlation between alpha-BHC/beta-BHC/gamma-BHC/delta-BHC, endrin/endrin aldehyde, endosulfan II/methoxychlor thus indicating same source and a strong negative correlation existed between p'p'-DDT/endrin aldehyde and this indicates they are from a different source. Table 3d shows a very strong correlation between beta-BHC/heptachlor/ delta-BHC/dieldrin/endosulfan II, aldrin/p'p,-DDE, delta-BHC/dieldrin/endosulfan II, endosulfan I/p'p,-DDD thereby indicating same origin.

Table 3a: Pearson Correlation Coefficient (r) of pesticide in Wazo market Topsoil in February

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	pH
A	1	0.046	0.016	0.569	0.193	-0.168	0.018	0.552	-0.133	-0.086	-0.412	0.958*	0.673	0.906**	-0.131	0.176	0.602	0.320
B		1	0.999**	-0.033	-0.239	0.975**	-0.068	0.817	0.984**	-0.025	-0.204	0.064	-0.361	-0.323	0.980*	0.954**	0.765	-0.418
C			1	-0.030	-0.281	0.980**	-0.106	0.810	0.988**	-0.060	-0.178	0.046	-0.389	0.307	0.986**	0.956**	0.757	-0.439
D				1	-0.359	0.105	0.516	0.456	-0.141	-0.518	0.485	0.716	0.683	0.713	-0.057	0.263	0.527	-0.395
E					1	-0.284	0.967**	-0.315	-0.257	0.933**	-0.376	-0.8821	0.421	0.181	0.314	-0.382	0.322	0.809
F						1	0.081	0.696	0.997**	-0.011	-0.054	-0.136	-0.460	0.134	0.999**	0.916**	0.637	0.331
G							1	0.284	-0.054	0.989**	-0.383	-0.267	0.222	0.307	0.118	0.258	0.312	0.821
H								1	0.709	-0.293	-0.202	0.616	0.075	0.805	0.729	0.913**	0.996**	-0.659
I									1	0.006	-0.134	-0.111	-0.474	0.155	0.995**	0.912*	0.648	-0.345
J										1	-0.274	-0.361	0.187	0.378	-0.051	-0.213	-0.326	0.859
K											1	0.261	0.205	-0.240	-0.046	-0.025	0.173	0.138
L												1	0.605	0.963**	0.089	0.250	0.674	0.531
M													1	0.493	0.437	0.179	0.145	0.273
N														1	0.181	0.501	0.848	0.622
O															1	0.936*	0.674	-0.371
P																1	0.883*	0.541
Q																	1	0.670
pH																		1

*Correlation is significant at 0.05 level (2-tailed)

**Correlation is significant at 0.01 level (2-tailed)

Table 3b: Pearson Correlation Coefficient (r) of pesticide in Wazo market Topsoil in March

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	pH
A	1	0.009	1.000**	0.398	0.750	0.233	0.165	0.966**	0.856	-	-	-	0.679	0.847	-	-	-	0.509
B		1	-	0.691	0.571	-	-	0.248	0.506	-	-	-	0.644	0.519	0.944**	-	0.889	-
C			1	0.398	0.750	0.233	0.165	0.966**	0.856	-	-	0.679	-	0.847	-	-	-	0.509
D				1	0.727	0.168	0.264	0.583	0.697	-	-	0.189	0.332	0.665	0.530	0.302	0.343	-
E					1	0.334	0.674	0.874	0.958**	-	-	0.564	-	0.946**	0.293	-	0.444	0.040
F						1	0.353	0.167	0.133	0.836	0.844	0.878	0.413	0.074	-	0.287	-	-
G							1	0.314	0.491	-	0.052	0.359	0.003	0.498	0.508	0.467	0.807	-
H								1	0.959**	-	-	0.560	-	0.954**	-	-	0.051	0.425
I									1	-	-	0.468	-	0.997**	-	-	0.315	0.272
J										1	0.990**	0.531	-	-	-	0.594	-	-
K												1	0.558	-	-	0.479	-	-
L														0.418	-	-	-	-
M													1	-	0.832	0.443	0.535	0.578
N														1	0.262	-	0.341	0.322
O															1	0.043	0.892	0.429
P																1	-	0.756
Q																	1	-
pH																		1

*Correlation is significant at 0.05 level (2-tailed)

**Correlation is significant at 0.01 level (2-tailed)

Table 3c: Pearson Correlation Coefficient (r) of pesticide in Wazo market Topsoil in June

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	pH
A	1	0.88 5*	B	0.82 5	0.887 *	0.886 *	- 0.01 4	0.70 9	0.02 0	0.02 8	- 0.52 4	- 0.78 9	- 0.15 5	0.13 6	-0.470 6	- 0.37 6	- 0.467	0.430
B		1	B	0.81 4	0.828 *	1.000 *	- 0.23 5	0.83 2	- 0.29 8	0.43 1	- 0.29 0	- 0.57 2	- 0.25 4	0.11 1	-0.320 1	- 0.40 1	- 0.493	- 0.032
C			B	B	B	B	B	B	b	B	B	B	B	B	B	B	b	b
D				1	0.657	0.813	0.05 3	0.88 6	- 0.21 9	- 0.04 7	- 0.77 6	- 0.54 5	0.29 3	0.63 7	-0.802 8	0.01 8	0.024	0.200
E					1	0.826	- 0.43 7	0.75 3	0.28 6	- 0.11 8	- 0.29 9	- 0.46 7	0.47 6	0.00 7	-0.184 5	- 0.19 5	- 0.687	0.221
F						1	0.22 8	0.82 8	- 0.30 1	- 0.42 9	- 0.29 0	- 0.57 7	0.25 2	.109 1	-0.321 6	0.40 6	0.492	0.029
G							1	- 0.50 4	- 0.31 1	- 0.52 2	- 0.23 5	- 0.58 3	0.54 3	0.00 1	-0.309 4	- 0.42 4	0.399	0.577
H								1	0.11 2	- 0.34 2	- 0.52 6	- 0.20 0	- 0.00 6	0.53 2	-0.530 4	0.17 4	- 0.168	- 0.145
I									1	0.59 0	- 0.09 9	0.15 8	- 0.29 9	- 0.12 1	0.149 7	0.39 7	- 0.264	0.476
J										1	- 0.53 2	- 0.29 1	0.43 1	0.21 5	-0.389 5	0.23 5	0.329	0.887 *
K											1	0.43 4	- 0.67 8	- 0.83 4	0.988 **	- 0.36 2	- 0.448	- 0.562
L												1	- 0.07 0	0.429 6	0.66 9	0.259	- 0.678	
M													1	0.79 9	-0.777 6	0.41 6	0.940 *	0.237
N														1	-0.880 7	0.66 7	0.722	0.068
O															1	- 0.03 2	- 0.554	- 0.423
P																1	0.567	- 0.143
Q																	1	0.009
P																		1

*Correlation is significant at 0.05 level (2-tailed)

**Correlation is significant at 0.01 level (2-tailed)

b cannot be computed because at least one of the variables is constant

Table 3d: Pearson Correlation Coefficient (r) of pesticide in Wazo market Topsoil in July

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	pH
A	A																	
B	1	A																
C	0.954*	0.95	A															
D	0.319	0.3	0.775	A														
E	0.875	0.8	0.955**	0.782	A													
F	1.000	1.00	0.955**	0.782	0.955**	A												
G	0.871	0.8	0.955**	0.782	0.955**	0.871	A											
H	0.400	0.4	0.955**	0.782	0.955**	0.400	0.400	A										
I	0.446	0.44	0.955**	0.782	0.955**	0.446	0.446	0.446	A									
J	1.000	1.00	0.955**	0.782	0.955**	1.000	1.000	1.000	0.446	A								
K	0.796	0.79	0.955**	0.782	0.955**	0.796	0.796	0.796	0.446	0.796	A							
L	0.370	0.37	0.955**	0.782	0.955**	0.370	0.370	0.370	0.446	0.370	0.370	A						
M	0.966	0.96	0.955**	0.782	0.955**	0.966	0.966	0.966	0.446	0.966	0.966	0.966	A					
N	0.251	0.25	0.955**	0.782	0.955**	0.251	0.251	0.251	0.446	0.251	0.251	0.251	0.251	A				
O	0.867	0.86	0.955**	0.782	0.955**	0.867	0.867	0.867	0.446	0.867	0.867	0.867	0.867	0.867	A			
P	0.679	0.67	0.955**	0.782	0.955**	0.679	0.679	0.679	0.446	0.679	0.679	0.679	0.679	0.679	0.679	A		
Q	0.248	0.24	0.955**	0.782	0.955**	0.248	0.248	0.248	0.446	0.248	0.248	0.248	0.248	0.248	0.248	0.248	A	
pH	0.251	0.25	0.955**	0.782	0.955**	0.251	0.251	0.251	0.446	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	A

*Correlation is significant at 0.05 level (2-tailed)

**Correlation is significant at 0.01 level (2-tailed)

a cannot be computed because at least one of the variables is constant

CONCLUSION

Wazo market top soil may be described as being contaminated with alpha-BHC, beta-BHC, gamma-BHC, methoxychlor and endosulfan sulfate because the mean concentrations of these

pesticides were found to be higher than the maximum permissible limits during the sampling period.

It was also observed that the mean concentrations of pesticides were higher during

the dry season (February and march) than in the rainy season (June and July) except dieldrin and heptachlor epoxide and this variation may be due to the strong positive correlation observed between the pesticides and soil pH.

There is high probability of the water bodies around this market to be contaminated with pesticides via runoff because there is much difference between concentrations of these pesticides in dry and rainy seasons. The difference is likely to have been taken up in the runoff and deposited in the surrounding water bodies.

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