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Research Article

Heavy Metals in Soil, Maize and Water Due To Disposal of Pharmaceuticals in Four Selected Dumpsites in Lagos and Environs Using Inductively Coupled Plasma and Mass Spectrometer (ICP-MS): A Global Warning

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Abstract: Since many disposal sites are open dumps without any barrier especially in developing countries, there is danger of leaching, infiltration of contaminated compounds into the soil which could influence the quality of ground water and vegetation that is near to the dumpsites. This study however becomes important as a result of indiscriminate disposal of pharmaceuticals due to open incineration in landfill which exposes human to health risk. The overview of the study is aimed at assessing the presence of suspected heavy metals like Cd, Hg, Pb, Zn, Fe, Cu, Cr, Co, As, Mn and Ni by inductively coupled plasma and mass spectrometer (ICP-MS) in soil within 10-20cm depth, maize and water from borehole of 150ft deep, river and well. Samples were prepared for analysis by acid digestion using 5% HNO3 and 30% H2 O2 .A total of 13 water samples in wet season,14 in dry season, 19 soil sample in wet season and 18 all samples included control samples, maize was 5 from wet season. The distribution of mean concentration of As ((3855.76 ± 986.31ppm) in Epe soil and Olusosun water ((326813.51 ± 424857.56ppm), Hg in Epe soil (1785.75± 1001.4ppm)were high, Cd ((36.68 ± 190.6ppm) at Epe ,Co (2932821.87 ± 1461049.91ppm) in soil, Co (9.75 ± 5.8ppm) in water were high. The samples were obtained from active dumpsites and control sites in four LGA during wet and dry season for a better risk analysis and comparism. Soil analysis had As above WHO/FAO (2001) permissible limit of 20ppm, Cd recorded at all sites were above the WHO/FAO (2001) permissible limit of 3ppm for soils. The Hg mean concentration in soil was recorded above WHO/FAO (2001) permissible limit of 2.00ppm but noticed to be low or absent in water ($p < 0.01$), this could be as a result of open digestion that led to escape of Hg compounds. It was observed that high accumulation of heavy metals were in soil samples, this exceeded their WHO/FAO threshold while the mean concentration of water were significantly low. This article gives a general overview of presence of heavy metals across dumpsites.

Keywords: Borehole, Control site, Dumpsites (Abule-Egba, Epe, Olusosun, Shagamu), Elemental pollutants, Health risk, River, Well.

INTRODUCTION

Heavy metal is a term used to describe over a dozen elements that are classified as either metals or metalloids. They include arsenic, lead, mercury, chromium, cadmium, and manganese and are persistent in all parts of the environment (Montgomery and Coppotelli, 2010). Heavy metals are present in both natural and contaminated environments and they occur at low and high concentrations which result in public health impacts (UNEP,2004). No matter where it originated, a contaminant moves across the interfaces between water, soil, and air to become distributed, to different degrees, into every phase it contacts (Weiner, 2000). The movement of contaminants through soil is a process of continuous redistribution among the different phases it encounters, it is a process controlled by gravity, capillarity, sorption to surfaces, miscibility with water, and volatility (Weiner, 2000). Maina *et al.* (2009) reported that the levels of heavy metals in the vicinity of Ashaka cement factory was in abundance order of Mn>Cu>Zn>Pb with significant increases in soil as one moves away from the factory along the wind direction with highest concentrations at about 5 to 10

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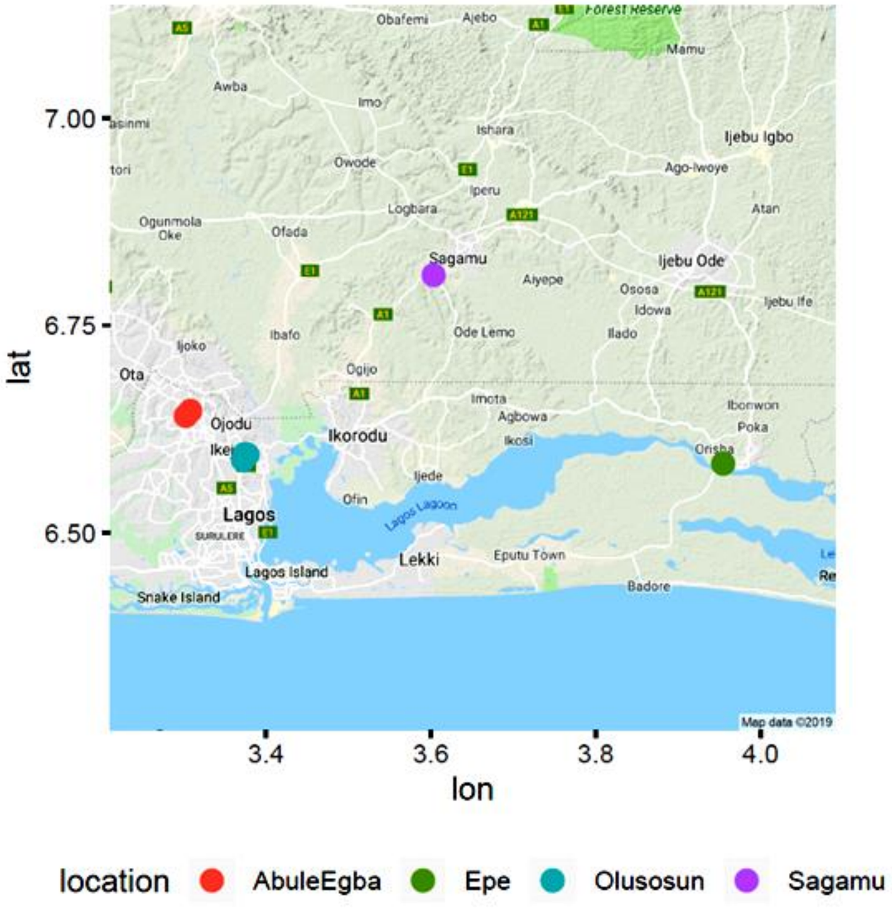
km. Gary and Donald (2004). Studies have found increased Pb levels in road side plants and soils, and the populations in general have been exposed to higher levels of lead because of the use of leaded gasoline. Hong-gui *et al*, (2012) found out that the contents of Cr, Hg, and Pb in the living areas are 2 – 4 times of the background value, the contents of As, Cd and Pb in the industrial areas were 2-4 times of the background value, and the content of Hg even is as high as 9 times and 18 times. A survey on Pb, Hg, and Cr showed that the contents is higher than the other elements in the living areas because of the use of paints and batteries, which contains a lot of Pb, Hg, and Cr. Iwegbue *et al*. (2006) . It was reported that the concentration of heavy metals decreased with the depth of the soil profile and lateral distance from the dumpsites; the levels found in this study exceeded background concentrations and limits for agricultural and residential purposes; the distribution pattern of heavy metals in the soil profiles were in the order Pb > Zn > Cu > Cd > Ni > Cr, with the mechanic waste dumps representing a potential sources of heavy metal pollution to environment Iwegbue *et al*. (2006). Dumpsites contain significant amount of toxic and essential elements, as significant difference existed between the concentration of these elements in the dumpsites and 10 km away from the dumpsite $p > 0.05$ (Eddy *et al*., 2006). Inuwa *et al*. (2007) reported that the heavy metals in the soil around the major industrial areas of the North western state of Nigeria ranged between (0.1 to 0.7 μg/g) Cd, (14.2 to 92.7 μg/g) Cr, (151.5 to 540 μg/g) Pb, and (3.5 to 24.7 μg/g) Ni. The results indicating relatively high concentrations of tested metals in industrial areas than those of the control sites. Igwilo *et al*. (2006) showed that the mean metal contents of soil samples from Otuocha agricultural river basin is Cd (0.07 to 3.345 ppm), Cu (4.38 to 13.54 ppm), Pb (0.59 to 7.34 ppm) and Ni (0.36 to 5.64 ppm), which revealed that the obtained values for Pb, Cd, Cu, Ni exceeded the WHO guidelines for the parameter in soil. Adewuyi and Opasina (2011) also reported high concentrations of Fe, Mn, Cu, Zn, Ni, Cd and Pb, and all the parameters were above control, and also exceeded FEPA and WHO guidelines. Kassim, (2012) reported that the metals concentration in agricultural soil of Keffi were found to be Cd = 0.76, Ni =6.02, Co = 8.77, Cu = 9.74, Mn = 26.53, Pb = 12.74 and Zn = 16.02 *μg/g.* Cobbina *et al*. (2015) assessed the levels of heavy metals in drinking water sources in two small-scale mining communities (Nangodi and Tinga) in northern Ghana. Samples were collected from boreholes; hand dug wells, dugout, and a stream in the twomining communities. The levels of mercury (Hg), arsenic (As), lead (Pb), zinc (Zn), and cadmium (Cd) were determined using an atomic absorption spectrophotometer (AAS). Mean levels (mg/l) of heavy metals in water samples from Nangodi and Tinga communities were 0.038 and 0.064 (Hg), 0.031 and 0.002 (As), 0.250 and 0.031 (Pb), 0.034 and 0.002 (Zn), and 0.534 and 0.023 (Cd), respectively, for each community .Generally, levels of Hg, As, Pb, Zn, and Cd in water from Nangodi exceeded the World Health Organization (WHO) stipulated limits of 0.010 for Hg, As, and Pb, 3.0 for Zn and 0.003 for Cd for drinking water, and levels of Hg, Pb, and Cd recorded in Tinga, exceeded the stipulated WHO limits. Ingestion of water, containing elevated levels of Hg, As, and Cd by residents in these mining communities may pose significant health risks therefore continuous monitoring of the quality of drinking water sources in these two communities is recommended. Inductively Coupled Plasma Mass Spectrometer (ICP-MS) was used for the determination of concentrations of heavy elements in water, soil and maize where samples need to be in ionic form prior to entering the mass analyzer in order to be detected. This study decided to use ICP-MS because of its ability to carry out rapid multi element determinations at the ultra-trace level, and its multi element characteristics, speed of analysis, detection limits, quantitative tool to determine the concentration of a specific analyte, and metal speciation in a sample.The instrument is used in analytical method for quality control of high-purity material, which is capable of detecting and several at concentrations as low as one part in 10^{15}(part per quadrillion, ppq) on non-interfered low-background isotopes. Chen, M, Ma, L.Q, (1998). It also has greater speed, precision, sensitivity, and outstanding properties such as high sensitivity (ppt–ppq), relative salt tolerance, compound independent element response, and highest quantitative accuracy that lead to the unchallenged performance in efficiently detecting, identifying, and reliably quantifying trace elements and heavy metals (Hossner, L.R., 1996). Heavy metals are pollutants in the environment only if it’s present in large quantities (this fact is usually attributed to industrial activities).

TABLE-1: Summary Results of Wet Season Soil/ Maize Samples

ELEMENT	**Pb208 (PPM)**	**As75 (PPM)**	**Cd111 (PPM)**	**Hg202 (PPM)**	**Fe57 (PPM)**	**Cu63 (PPM)**	**Zn66 (PPM)**	**Mn55 (PPM)**	**Cr52 (PPM)**	**Co59 (PPM)**	**Ni 60 (PPM)**
SAMPLES (WETSE SON)					**MEAN CONC**						
STD 1											
STD 2	0.959	2.37	2.36	0.841	5.04	9.89	9.81	4.93	4.94	1.03	1.799
STD 3	2.03	5.33	5.29	1.98	10	17.7	17.8	10.2	10.1	1.09	1.76
ASO 41	2.15e+004	5.67e+003	1.53e+003	5.86e+003	1.36e+007	1.33e+004	4.58e+004	1.11e+004	3.11e+004	3.8e+006	1.53e+004
SSO 21	1.47e+004	3.1e+003	1.75e+003	1.83e+003	2.93e+007	1.57e+004	2.49e+005	5.65e+004	5.14e+004	4.49e+006	.91e+003
OSC 03	1.14e+004	3.3e+003	-107	1.32e+003	1.03e+007	5.96e+003	5.72e+004	9.92e+004	1.9e+004	3.92e+006	1.39e+004
OSO 31	6.18e+004	1.81e+003	763	1.06e+003	1.93e+007	1.13e+004	1.41e+005	1.26e+005	4.03e004	3.66e006	4.99e+003
ASO 41B	1.04e+006	772	109	1.05e+003	9.74e+006	3.46e+004	4.5e+005	1.12e+005	1.9e+004	3.58e+006	2.05e+004
OSO31 B	5.23e+004	1.28e+003	1.08e+003	6.87e+003	2.25e+007	1.28e+004	1.6e+005	1.32e+005	0.76e+004	3.85e+006	7.58e+003
SMO 2	6.91e+003	−1.02e+003	-324	95	8.87e+006	3.35e+003	1.6e+004	2.53e+005	2.35e+004	3.98e+006	4.66e+003
ESCO 2	4.83e+003	−508	−017	−189	1.88e+006	7.64e+003	1.39e+004	6.5e+003	5.85e+003	4.95e+005	3.28e+003
SSO 2	1.34e+005	255	323	190	1.81e+007	7.1e+004	2.64e+005	1.92e005	3.45e+004	4.61e+006	2.43e+004
Zero Value											
STD 2	1.97e+005	5.42e+005	5.4e+005	1.86e+005	1.07e+006	1.9e+006	1.85e+006	1.05e+006	1.07e+006	2.52e+005	1.92e+005
ESCO 1	1.01e+004	4.62e+003	1.96e+003	4.11e+003	9.98e+006	1.45e+004	5.33e+004	8.46e+004	2.5e+004	2.79e+006	8.15e+003
ESCO 21	3.9e+003	6.94e+003	−435	1.24e+003	7.13e+006	2.8e+003	6.88e+003	8.27e+003	1.94e+004	9.3e+005	968
ASCO 41	2.22e+004	516	873	480	9.61e+006	3.63e+004	1.27e+005	8.91e+004	1.8e+004	2.19e+006	2.18e+004
SSOO2	6.2e+003	259	1.1e+003	1.35e+003	9.33e+006	2.78e+003	1.46e+004	2.42e+005	2.2e+004	2.46e+006	5.85e+003
OSCO31	2.25e+003	−1.53e+003	−5.92e−005	664	2.87e+007	1.01e+003	1e+004	3.64e+004	6.1e+003	1.95e+006	3.97e+003
OSO 3	4.62e+003	759	−4.71e−005	471	2.03e+006	5.95e+003	4.52e+005	2.53e+004	2.69e+004	5.21e+006	2.72e+003
SMO 21	5.42e+003	−1.29e+003	−109	−1.16e−004	8.92e+006	3.75e+003	1.28e+004	1.57e+005	2.12e+004	3.95e+006	4.86e+003
ASO 4	2.21e+003	2.33e+003	−328	193	3.98e+006	1.79e+003	6.36e+003	7.24e+003	1.45e+004	7.2e+005	1.39e+003
ESO2	6.64e+003	569	547	−96.3	8.28e+006	1.45e+004	1.49e+005	1.18e+005	6.94e+003	4.68e+006	3.2e+004
SMOO2	296	−513	109	191	6.39e+005	2.62e+003	2.71e+004	1.13e+004	5.64−+003	4.28e+005	1.79e+003
SMO2B	308	−1.04$_{+}$+003	330	291	681e+005	2.61e+003	2.49e+004	1.27e+004	2.17e+003	2.17e+005	2.94e+003

Study Area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6.75
6.50
lat
3.4
3.6
3.8
4.0
lon
Sagamu
Ikorodu
Lagos
Ojodu
Lekki
Lagos Island
Ijebu Ode
Lagos Lagoon
Map data ©2019
location
AbuleEgba
Epe
Olusosun
Sagamu

Description of Study Areas:

The study was conducted in four local government areas in Lagos and environs as shown in Figure 1.The sites were technically selected after survey due to peculiar activities carried out e.g destructions of substandard, fake, counterfeit, expired drugs, open incineration, burying of waste in landfill etc. Abule-Egba dumpsite (10.5 ha) landfill began operation in 1992 and is located along Oshodi–Sango Ota road in Alimosho LGA in the North Western part of Lagos State, Nigeria, it shares boundary with Oko- Oba market. It is 17.1 km from Lagos capital and receives 250,000 tonnes of waste annually, its geographical location is 6.87 ^{0}N, 3.38 ^{0}E. Epe wetland dumpsite is located in Orisa, LGA of Lagos State which lies between Latitudes 6 ^{0}33'00" and 6 ^{0}35'00"N and Longitudes 3 ^{0} 55'30" and 3 ^{0} 56'30"E on the northern flank of the Coastal Lagos Lagoon. The area is about so a hectare of land is 77.6km from Lagos, the site receives an average of about 2,250m3 of waste per day; the dumpsite has been in operation since 2006- 2019. Olushosun (42 ha) landfill is located at Ojota, in Ikeja LGA of northern part of Lagos State which lies within longitude 03 ^{0}372” E to 03 ^{0}374’ E and latitude 06 ^{0}588” N to 06 ^{0}595” N and is the largest government owned dump facility in Nigeria. It is 18 meters deep and 6.6km from Lagos capital, it began operation in 1992, the size of the landfill is about 42.7 hectares with lifespan of 27 years. The landfill shares same boundary with Oregun, Ketu and Ojota communities and receives an average of 1,200,000 tonnes of waste annually which is approximately 40% of the total wastes deposits in Lagos and and is presently serving as a pilot project for biogas production in Nigeria, (Adebisi, 2000). Shagamu also called Ike-diya is located in southwestern Nigeria with the dumpsite at the Eastern part of Dahomey Embayment, which lies within the Ewekoro depression. It has a high topography of 48.3sq/m above ground level and is situated to the Northeast of old Ikorodu road close to Lafarge cement industry, a boundary with Lagos. It is 55.7km from Lagos capital, Oke-Diya covers area of approximately 184m and has been in operation since 1996 (Avon,1990).

MATERIALS/ EQUIPMENTS:

Inductively Coupled Plasma ICP-MS, round bottom flasks, measuring cylinder (10cm^3),conical flask, burette (100cm^3), pipette, clamps, Spatula, Sensitive Weighing balance (capable of accurate weighing to 0.01 g.) ,Soil particles, water samples, Syringes, desiccators, Plastic sample bottles, Sample Digestion vessel, Vapour Recovery Device (e.g., ribbed watch glasses, appropriate refluxing device),Dry Oven 30^{0}C-40^{0}C (able to maintain 30EC + 4EC.), Thermometer (to at least 125EC with suitable precision and accuracy, What man Filter paper (No.41),Centrifuge and it’s tubes, Controllable Heating Source 90^{0}C-100^{0}C,Volumetric Flask (100-mL.),Heating sauce (that can maintain a temperature of 90-950C.).

Chemical/Reagents:

Nitric Acid, Sodium Sulphate ($NaSO_4$), 30% Hydrogen Peroxide, Hydrochloric Acid supplied by Katchey Company limited, Distilled water from NAFDAC Laboratory, Argon gas, high-purity grade (99.99%) was supplied by Sigma-Aldrich and Agilent Technologies.

METHOD:

Soil / Maize Digestion

This procedure adopted was EPA Method 3050B 1996 using open digestion for elemental analysis while EPA 3010A was adopted for sample preparation. Fine granules of soil were sieved and mixed thoroughly to achieve homogeneity; the digestion of soil and maize samples for analysis had the following steps:

A 1g (dry weight) was weighed into digestion tubes and 10ml HNO_3 and 30% Vol H_2O_2 were added to each tube in ratio 1:1 (Hoenig, 1995).Samples were heated to 95^{0}C ± 5 ^{0} C in digestion vessel under fume cupboard until effervescence subsides and cool in the vessel while covered with vapour recovery device (note: care must be taken to ensure that losses do not occur due to excessively vigorous effervescence).While cooling, 5 mL of concentrated HNO_3 was added and refluxed for 10-15 minutes with close cover then allowed to cool. Sample was refluxed for 30minutes (brown fumes were generated; this was an indication of oxidation of samples) the process was repeated by adding 5ml HNO_3 severally until no brown fumes were given off by samples, this indicated the complete reaction with HNO_3.A ribbed watch or vapour recovery system was used to allow solution to evaporate to 5ml and heated until 5ml of the solution was recovered. The resultant digested samples were reduced in volume while heating with hot HCl and hot distilled water. Filter paper using Whatman No. 41 filter paper and residue were returned to the digestion flask and refluxed with additional HCl and filtered again and finally diluted to a final volume of 100 ml with 5% $HNO_{3,}$ Sample was centrifuged to allow settling to separate the clear solution from the sample digested, the clear sample solution was now ready for analysis by ICP-MS.

Water Digestion

The procedure adopted was EPA method 3005A, 1992 with little modification. A 50ml of water samples were acidified using Nitric Acid (HNO3), 30%Hydrogen Peroxide ($H\ ^2O^2$) in the ratio of 1:1 in 100 ml volumetric flask. Samples were filtered and made up to 100ml and stored for 24hours ready for ICP-MS analysis.

RESULTS AND DISCUSSION:

Distribution of Elemental analysis within Abule-Egba,Epe, Olusosun and Shagamu are shown below:

TABLE 2: Summary Results of Wet Season Water

ELEMENT	**Pb208 (PPM)**	**As75 (PPM)**	**Cd111 (PPM)**	**Hg202 (PPM)**	**Fe57 (PPM)**	**Cu63 (PPM)**	**Zn66 (PPM)**	**Mn55 (PPM)**	**Cr52 (PPM)**	**Co59 (PPM)**	**Ni 60 (PPM)**
SAMPLES (Wet) SEASON)ID			e−		MEAN	CONC					
EWC02	9.48 e−004	5.2 e−003	3.63 e−010	9.69 e−004	1.43	4.94 e−003	2.56 e−002	2.46 e−002	5.13 e−003	−3.98 e−007	1.4 e−002
EWC021	8.37 e−003	1.82 e−002	1.1 e−003	0.13	1.15	1.84 e−002	0.337	1.173	1.97 e−003	4.34	5.6 e−003
EW01	3.63 e−003	1.82 e−002	1.1 e−003	−9.69 e−004	14	8.54 e−003	0.303	0.528	4.34 e−003	115.4	6.85 e−002
EW002	6.32 e−004	7.81 e−003	−5.5 e−003	9.69 e−004	1.92	2.25 e−003	5.69 e−003	7.39 e−003	1.1 e−002	−0.362	5.6−003
EWC01	2.29−003	5.73−010	−3.3 e−003	−1.94 e−003	1.44	4.49 e−003	2.13 e−003	1.93 e−002	−3.94 e−004	−0.362	6.99 e−003
SW002	2.05 e−003	−2.6 e−003	−4.4 e−003	2.91 e−003	2.26	5.39 e−003	2.99 e−002	0.279	7.89 e−004	11.2	8.39 e−003
SWC021	2.13 e−003	5.73 e−010	−2.2 e−003	−2.13 e−010	2.37	1.8 e−003	0.109	2.15 e−002	8.68 e−011	1.81	9.79 e−003
AWC041	6 e−003	2.6 e−003	−4.4 e−003	−1.94−003	0.433	1.08−002	2.13−002	7.46−002	−7.89 e−004	2.9	5.6 e−003
AWC04	6.08 e−003	1.3 e−002	1.1 e−003	−2.13 e−010	0.562	1.39 e−002	0.161	9.67 e−002	−7.89 e−004	2.9	4.2 e−003
OWC031	3 e−003	−1.19 e−018	−4.4 e−003	3.88 e−003	2.08	4.94 e−003	5.26 e−002	3.52 e−002	−1.97 e−004	−3.58 e−007	1.82 e−002
OWC03	2.77 e−003	1.04 e−002	3.3 e−003	−1.94 e−003	2.09	8.09 e−003	2.99 e−002	8.93 e−002	7.49 e−003	0.362	6.99 e−003
OW03	1.82 e−003	5.2 e−003	−1.1 e−003	−1.94 e−003	2.44	7.64 e−003	8.53 e−003	1 e−002	1.58 e−003	1.09	6.99 e−003

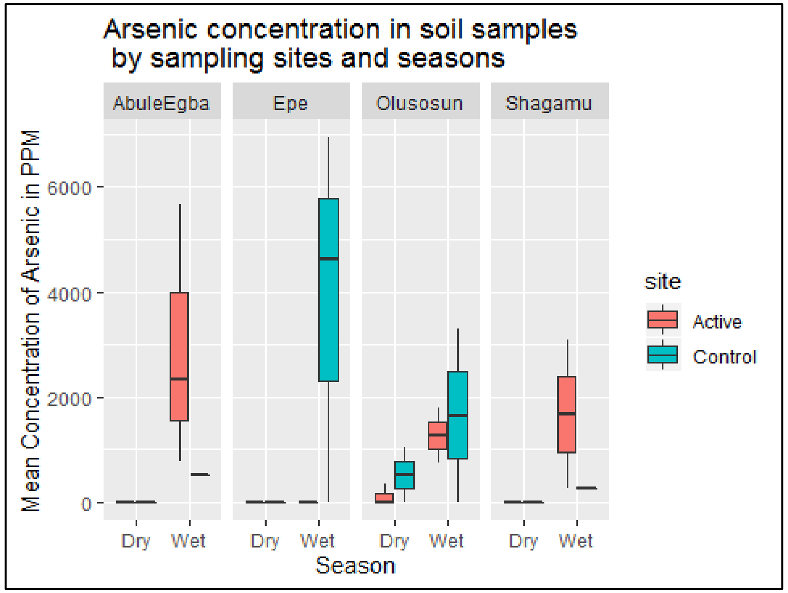

Figure 2: Distribution of Arsenic (As) in soil samples 0 – 20 cm depth within **four** dumpsites.

TABLE 3: Summary Results of Dry Season Soil/Maize Samples

ELEMENT	**Pb208 (PPM)**	**As75 (PPM)**	**Cd111 (PPM)**	**Hg202 (PPM)**	**Fe57 (PPM)**	**Cu63 (PPM)**	**Zn66 (PPM)**	**Mn55 (PPM)**	**Cr52 (PPM)**	**Co59 (PPM)**	**Ni 60 (PPM)**
SAMPLES (DRY SEASON)					**MEAN CONC**						
DSECN	9.33e+003	−260	220	194	1.89e+007	1.01e+004	2.06e.004	7.09e+004	3.07e+004	1.09e+006	4.06e+003
D0S02	2.78e+004	−520	880	−194	2.22e+007	3.26e+004	2.1e+005	1.41e+005	5.53e+004	2.86e+006	1.44e+004
DACN1	2.29e+004	−1.04e+003	−220	−484	2.14e+007	1.23e+004	1.78e+004	1.1e+005	4.06e+004	1.59e+006	6.43e+003
DOCS01	6.25e+004	1.04e+003	440	−96.9	1.25e+007	2.35e+004	1.46e+005	4.72e+005	2.51e+004	6.08e+006	1.15e+004
DES01	5.27e+003	−520	110	−96.1	2.07e+006	7.82e+003	1.79e+004	9.02e+003	4.02+003	7.97e+005	839
D0PSC02	1.33e+004	−520	−110	96.9	4.95e+006	6.56e+003	8.66e+004	3.2e+005	2.13e+004	3.26e+006	4.48e+003
DES02	1.3e+003	−1.56e+003	−110	−194	4.5e+005	2.2e+003	1.07e+004	4.8e+003	4.18e+003	4.34e+005	2.22e+003
DOS1	7.43e+003	−520	−220	484	2.31e+007	4.9e+003	2.4e+004	4.21e+004	5.6e+004	9.78e+005	5.46e+003
DAS01	4.8e+003	−520	220	96.9e+006	1.65e+006	4.54e+003	1.58e+004	5.5e+003	4.69e+003	5.07e+005	3.78e+003
DSFCS1	1.13e+004	5.73e+005	−7.62e+005	−194	1.37e+007	4.94e+003	2.91e+004	1.56e+005	2.26e+004	2.53e+006	7.69e+003

DSS01	2.71e+004	−1.82e+003	220	−96.9	9.89e+006	2.36e+004	7.36e+004	3.85e+004	1.71e+004	1.92e+006	6.57e+007
D0S03	2.35e+004	−520	440	−388	1.24e+007	1.25e+004	4.02e+004	6.04e+005	2.49e+004	6.73e+006	7.69e+003
DAS03	1.08e+004	−773	218	−384	1.43e+007	1.29e+004	1.11e+004	2.82e+005	2.5e+004	5.16e+006	6.51e+003
DAS01	−111	−1.42e+003	−2.04e−005	−291	9.58e+004	225	1.42 e+003	2.2 e+003	118	−3.62e+005	280
DECS01	3.51e+003	−520	110	194	4.89 e+006	3.01 e+003	1.34 e+004	4.05 e+004	1.01 e+004	1.3 e+006	4.62 e+003
DESC03	6.67 e+003	−1.04 e+003	−440	−291	5.03 e+006	4.81 e+003	3.34 e+004	3.54 e+004	1.49 e+004	1.88 e+006	8.81 e+003
DSECS2	5.38 e+003	−758	−214	−188	1.2 e+007	6.2 e+003	1.93 e+004	5.17 e+004	2.2 e+004	2.43 e+006	5.16 e+003
DECS02	1.95 e−002	2.6 e−002	−2.42 e−010	−2.491e−002	30.3	1.84e−002	6.4 e−002	6.33 e−002	0.121	4.34	1.26 e−002
Empty Digest 1	−1.58 e−004	−1.56 e−002	3.3 e−003	9.69 e−004	0.921	5.39 e−003	8.53 e−003	2.15 e−002	6.31 e−003	0.724	4.2 e−003
Empty Digest 2	3.16 e−004	−5.2 e−002	−2.2 e−003	−1.94 e−003	0.939	6.29 e−003	2.13 e−002	2.11 e−002	1.97 e−003	−0.362	−1.54 e−002
Zero Value STD 2	1.42 e−003	1.3 e−002	6.6 e−003	5.81 e−003	12.8	4.94 e−003	0.3	0.544	3.94 e−004	11.6	9.65 e−002

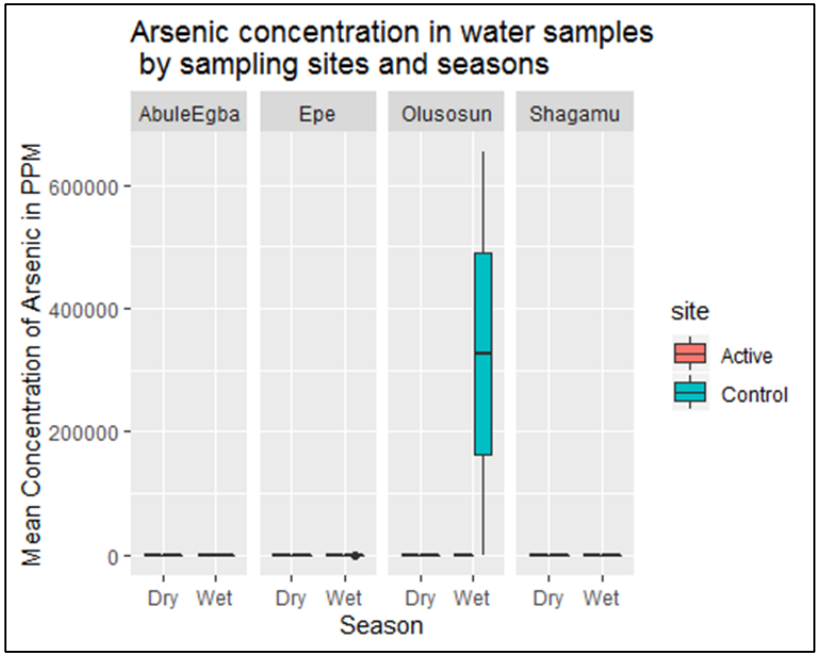

Figure 3: Distribution of Arsenic (As) in water samples within four dumpsites.

TABLE 4: Summary Results of Dry Season Water Samples

ELEMENT	**Pb208 (PPM)**	**As75 (PPM)**	**Cd111 (PPM)**	**Hg202 (PPM)**	**Fe57 (PPM)**	**Cu63 (PPM)**	**Zn66 (PPM)**	**Mn55 (PPM)**	**Cr52 (PPM)**	**Co59 (PPM)**	**Ni 60 (PPM)**
SAMPLES (Dry) SEASON)	**ID**		**e−**		**MEAN CONC**						
DEWC02	1.42 e−003	5.2 e−003	−2.2 e−003	4.84 e−003	1.34	−2.97 e−010	2.84 e−003	0.13	3.15 e−003	5.07	1.4 e−002
DEWC01	1.9 e−003	7.81 e−003	−4.4 e−003	1.94 e−003	1.24	1.98 e−002	2.42 e−002	0.197	3.94 e−004	6.16	9.79 e−003
DEWC03	2.92 e−003	2.34 e−002	−2.2 e−003	7.75 e−003	21.2	4.49 e−004	1.71 e−002	0.723	9.07 e−003	18.1	0.138
DEW01	64.74 e−004	1.04 e−002	−3.3 e−003	1.94 e−003	4.06	2.7 e−003	1.28 e−002	2.39 e−003	−1.45 e−019	−0.724	2.8 e−002
DEW02	1.19 e−003	5.73 e−010	−2.2 e−003	9.69 e−004	4.06	8.09 e−003	8.53 e−003	1.52 e−003	1.58 e−003	−2.39 e−007	3.22 e−003
DSECW	1.9 e−003	2.08 e−002	−1.1 e−003	3.53 e−003	22.9	3.15 e−003	0.107	0.756	8.28 e−003	31.9	0.106
DSDW01	3.32 e−003	−2.6 e−003	−3.3 e−003	2.91 e−003	1.87	1.30 e−002	5.12 e−002	0.177	9.07 e−003	7.6	8.39 e−003
DAW01	1.74 e−003	1.3 e−002	−2.2 e−003	5.81 e−003	1.11	5.84 e−003	1.56 e−002	0.134	1.06 e−002	9.41	8.39 e−003
DACW1	4.35 e−003	1.3 e−002	−2.2 e−003	9.69 e−003	1.77	1.57 e−002	7.11 e−002	0.172	2.76 e−003	9.41	1.96 e−002
DAW02	4.75	7.81 e−003	−3.3 e−003	8.72 e−003	2.41	6.7 e−002	0.145	8.06 e−002	5.91 e−003	2.17	1.26 e−002
DOCW1	1.98 e−002	5.2 e−003	−3.3 e−003	1.07 e−002	2.27	4.04 e−003	5.69 e−003	0.173	3.15 e−003	7.97	8.39 e−003
DOBW2	2.37 e−004	2.86 e−002	2.2 e−003	7.75 e−003	−8.29 e−002						
DOPWC02	1.58 e−003	−7.81 e−003	−7.81 e−003	−2.2 e−003	3.88 e−003	0.857					
DOBW1	1.3 e−003	2.6 e−003	−3.3 e−003	6.78 e−003	0.718	225					

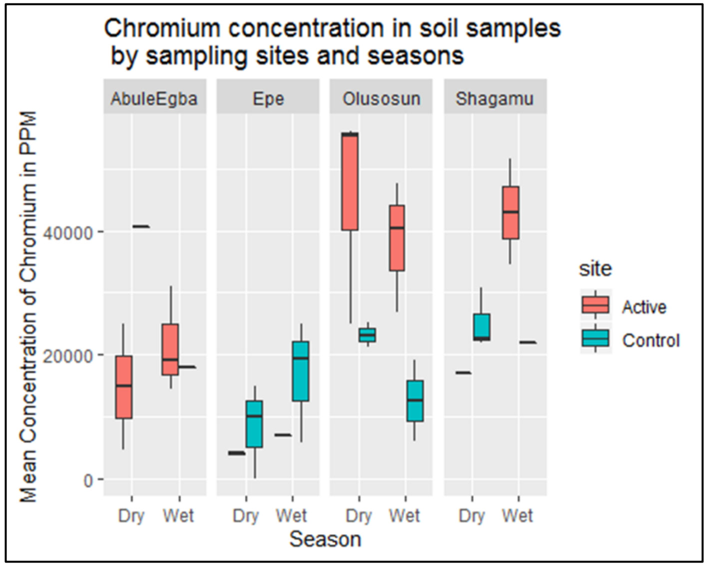

Figure 4: Chromium Concentration 0 – 20 cm depth by Sampling Sites soil

Table 5: Distribution of Cr in water samples within four dumpsite

	Dry Season		**Wet Season**	
Site Location	**Active (ppm) (Mean ± SD)**	**Control (ppm) (Mean ± SD)**	**Active (ppm) (Mean ± SD)**	**Control (ppm) (Mean ± SD)**
Abule-Egba	0.01 ± 0	0 ± 0	-	0 ± 0
Epe	0 ± 0	2.06 ± 1.31	0.06 ± 0.04	0 ± 0
Olusosun	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Shagamu	0.01 ± 0.01	0.01 ± 0.01	0 ± 0	0 ± 0

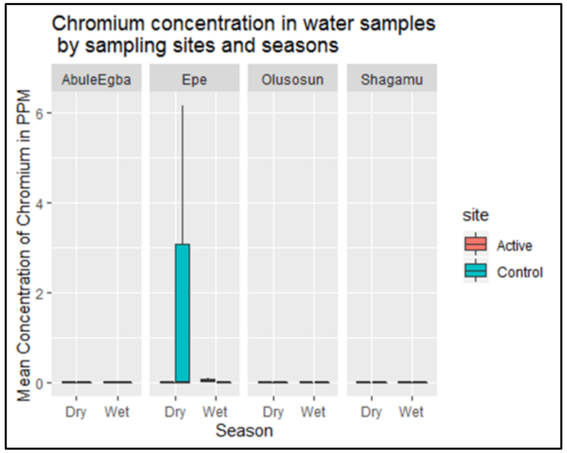

Figure 5: Distribution of Cu in water samples within four dumpsite

NOTE:****(0-20cm stands for only soil)

Table 6: Distribution of Cu in soil samples 0 – 20 cm depth within four dumpsites

Site Location	**Dry Season**		**Wet Season**		
	Active(ppm)(Mean ± SD)	**Control(ppm) (Mean ± SD)**	**Active(ppm) (Mean ± SD)**	**Control(ppm) (Mean ± SD)**	**Control(ppm) (Mean ± SD)**
Abule-Egba	8721.98± 4627.36	12269.66± 5691.9	16578.67± 6201.03	36347.41± 13586.66	-
Epe	5011.22± 2282.76	2606.74± 1586.25	14474.95± 4986.62	8299.48± 2237.52	-
Olusosun	16659.27± 8368.46	15033.76± 7610.2	10033.62± 5262.7	3682.34± 2082.44	-
Shagamu	23550.69± 12126.25	7084.09± 4225.76	43349.68± 19275.16	2775.4± 1756	3236.37± 1386.64

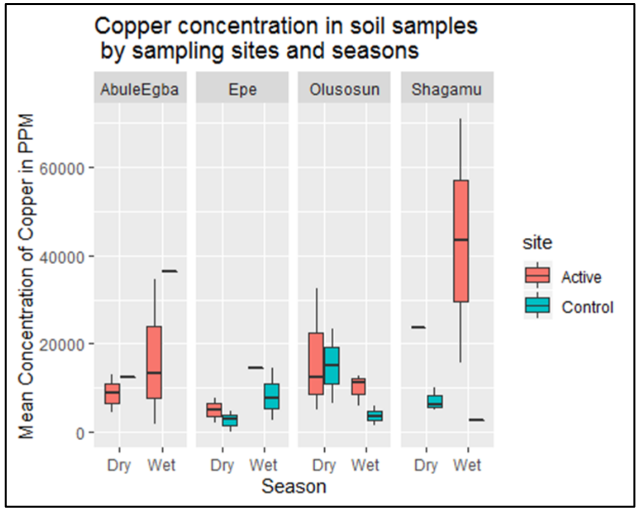

Figure 6: Distribution of Cu in water samples within four dumpsite

NOTE:****(0-20cm stands for only soil)

Table 7: Distribution of Cu in water samples within four dumpsite

	Dry Season		**Wet Season**	
Site Location	**Active (ppm) (Mean ± SD)**	**Control (ppm) (Mean ± SD)**	**Active (ppm) (Mean ± SD)**	**Control(ppm) (Mean ± SD)**
Abule-Egba	0.04 ± 0.03	0.02 ± 0.02	-	0.01 ± 0.01
Epe	0.01 ± 0	0.01 ± 0.01	0.01 ± 0	0.01 ± 0.01
Olusosun	0 ± 0	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0
Shagamu	0.01 ± 0.01	0 ± 0	0 ± 0	0 ± 0

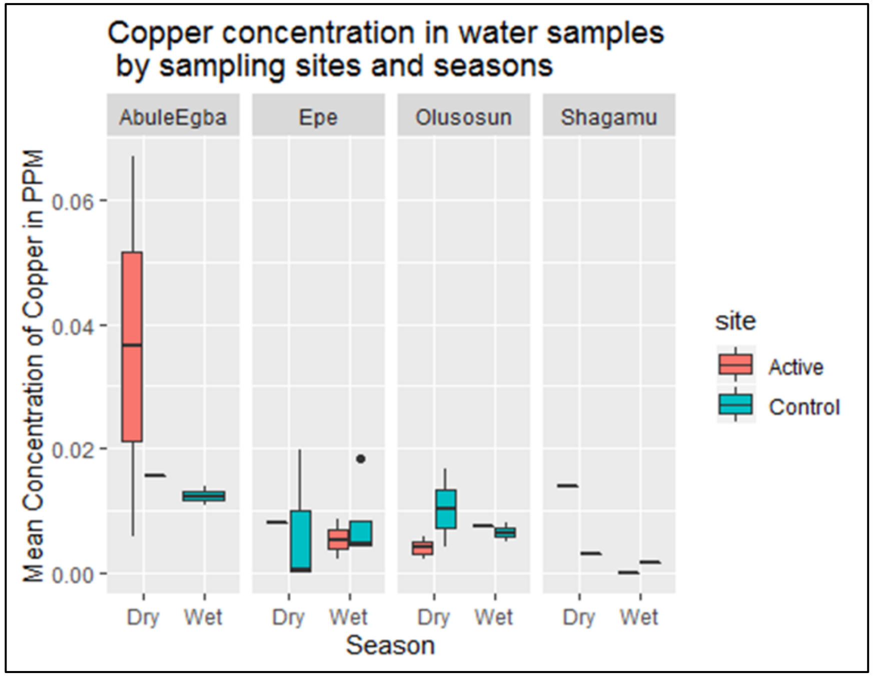

Figure 7: Distribution of Cu in water samples within four dumpsite

Table 8: Distribution of Fe in soil samples 0 – 20 cm depth within four dumpsites

Iron concentration by sampling sites
Soil

Location	Dry Season		Wet Season		
	Active Site (Mean ± SD)	Controlled Site (Mean ± SD)	Active Site (Mean ± SD)	Controlled Site (Mean ± SD)	Controlled Site Maize
Abule-Egba	7983956.1 ± 4083493.44	2144023 ± 1023127.78	9102104.47 ± 4293628.32	9614978.4 ± 4120979.74	-
Epe	2355479.2 ± 1177265.55	3305064.1 ± 1700270.77	8282632.07 ± 3782678.07	3334818.95 ± 1430610.51	-
Olusosun	12569939.27 ± 6118559.66	8733481.5 ± 4115668.98	20725733.93 ± 11279905.64	6605990.09 ± 3794936.59	-
Shagamu	9893222.6 ± 4666633.1	4099412.76 ± 2080889.38	23693825 ± 13739432	9327914.95 ± 4304832.75	6141507.84 ± 2608284.1

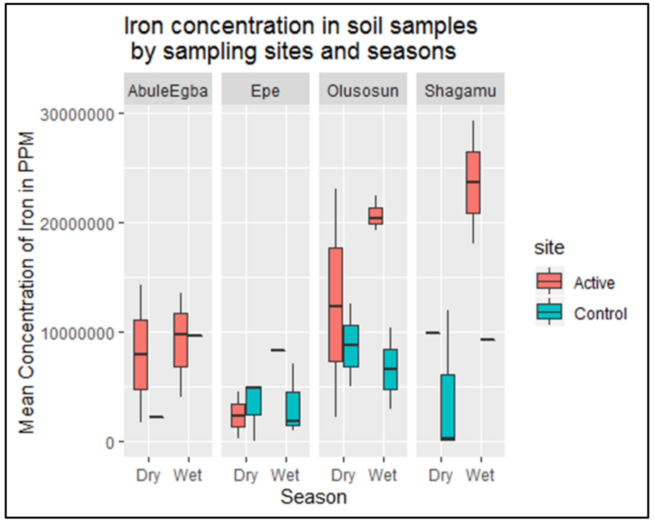

Figure 8: Distribution of Fe in soil samples 0 – 20 cm depth within four dumpsites

Table 9: Distribution of Fe in water samples 0 – 20 cm depth within four dumpsites

	Dry Season		**Wet Season**	
Site Location	**Active (Mean ± SD)**	**Control (Mean ± SD)**	**Active (Mean ± SD)**	**Control (Mean ± SD)**
Abule-Egba	1.76 ± 1.11	1.7 ± 1.27	-	0.5 ± 0.28
Epe	3.7 ± 2.42	7.91 ± 4.97	7.95 ± 4.07	3.03 ± 1.77
Olusosun	0.36 ± 0.36	1.56 ± 0.97	2.4 ± 1.54	2 ± 1.23
Shagamu	1.8 ± 1.11	22.9 ± 13.27	2.2 ± 1.31	2 ± 0.9

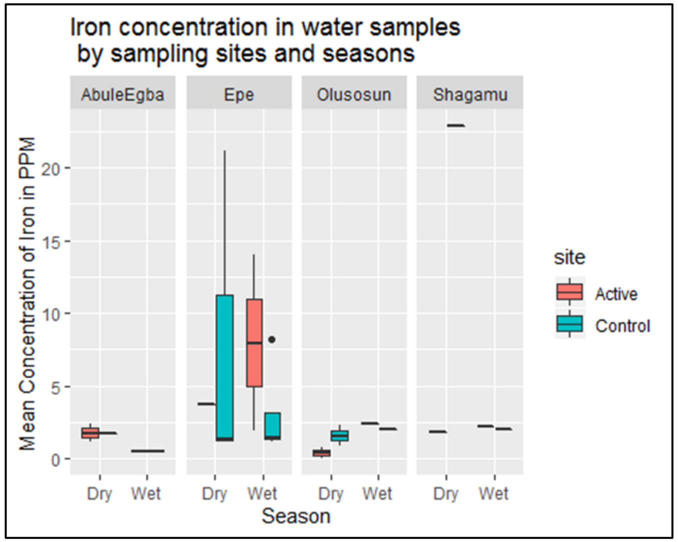

Figure 9: Distribution of Fe in water samples 0 – 20 cm depth within four dumpsites
NOTE:****(0-20cm stands for only soil)

Table 10: Distribution of Mn in soil samples 0 – 20 cm depth within four dumpsites

	Dry Season		**Wet Season**		
Site Location	**Active (ppm) (Mean± SD)**	**Control (ppm) (Mean ±SD)**	**Active (ppm) (Mean ±SD)**	**Control(ppm(Mean±D)**	**Control (Maize)**
Abule-Egba	143732.69±73003.38	109737±51356.92	76654.88±34461.15	0.09 ± 0.04	-
Epe	6913.27 ± 2350.13	25280.61±13278.37	117857.5±51810.16	0.1 ± 0.04	-
Olusosun	262407.87±134454.55	396037.08±195600.8	94250.37±56627.45	0.06 ± 0.04	-
Shagamu	38540.36 ± 17377.85	92779.12 ± 46483.03	124220.08±58424.26	0.02 ± 0.01	140499.54±1124.

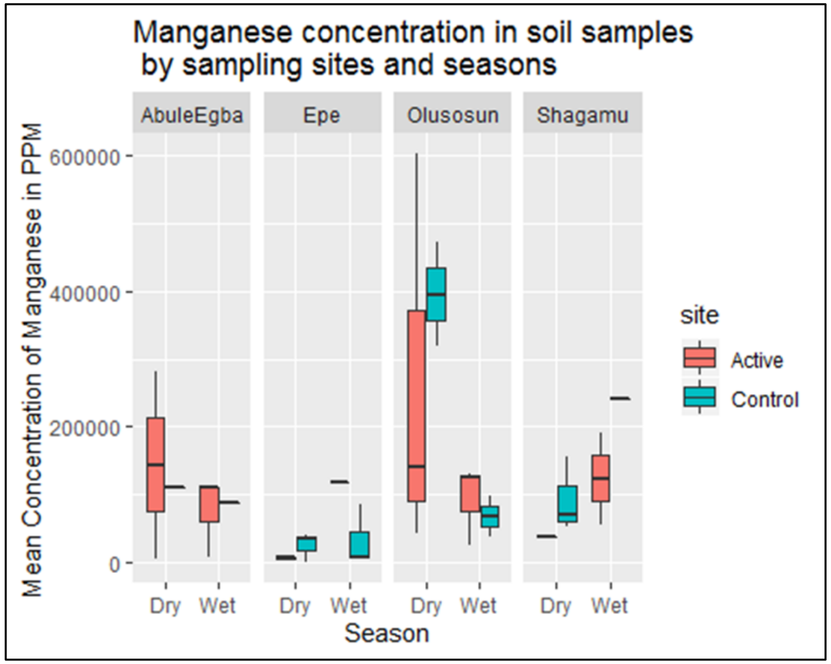

Figure 10: Distribution of Mn in soil samples 0 – 20 cm depth within four dumpsites

Table 11: Distribution of Mn in water samples 0 – 20 cm depth within four dumpsites

	Dry Season		**Wet Season**	
Site Location	**Active (ppm) (Mean ± SD)**	**Control (ppm) (Mean ± SD)**	**Active (ppm) (Mean ± SD)**	**Control (ppm) (Mean ± SD)**
Abule-Egba	0.11 ± 0.06	0.17 ± 0.11	-	0.09 ± 0.04
Epe	0 ± 0	0.35 ± 0.21	0.27 ± 0.13	0.1 ± 0.04
Olusosun	0.05 ± 0.04	0.11 ± 0.08	0.01 ± 0	0.06 ± 0.04
Shagamu	0.18 ± 0.11	0.76 ± 0.43	0 ± 0	0.02 ± 0.01

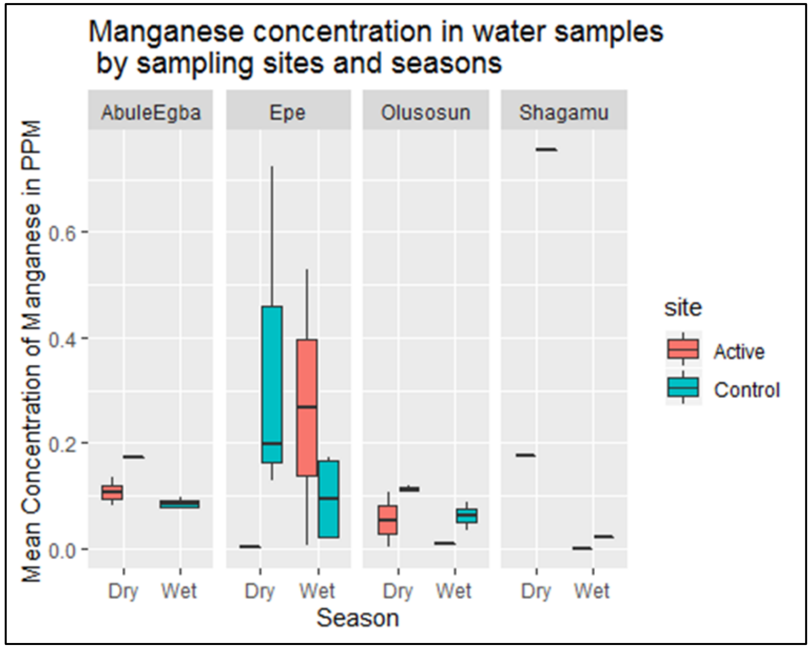

Figure 11: Distribution of Mn in water samples 0 – 20 cm depth within four dumpsites
NOTE:***(0-20cm stands for only soil)

Table 12: Distribution of Ni in soil samples 0 – 20 cm depth within four dumpsites

	Dry Season		Wet Season		
Site Location	**Active (Mean±SD)**	**Control (Mean±SD)**	**Active (Mean ±SD)**	**Control (Mean ±SD)**	**Control (Maize)**
Abule-Egba	5143.18±2925.18	6434.69±4032.62	12372.77±6707.45	21766.04±7398.28	-
Epe	2028.32±1211.35	2952.97±2043.88	31981.7±12248.99	4131.14 ± 1937.83	-
Olusosun	9185.76±3861.47	7973.42±3962.86	5097.46 ± 2201.82	8938 ± 4089.49	-
Shagamu	6574.57±1892.16	5637.03±2174.42	16219.04±5793.78	5851.74 ± 2610.46	3771.11± 1693.31

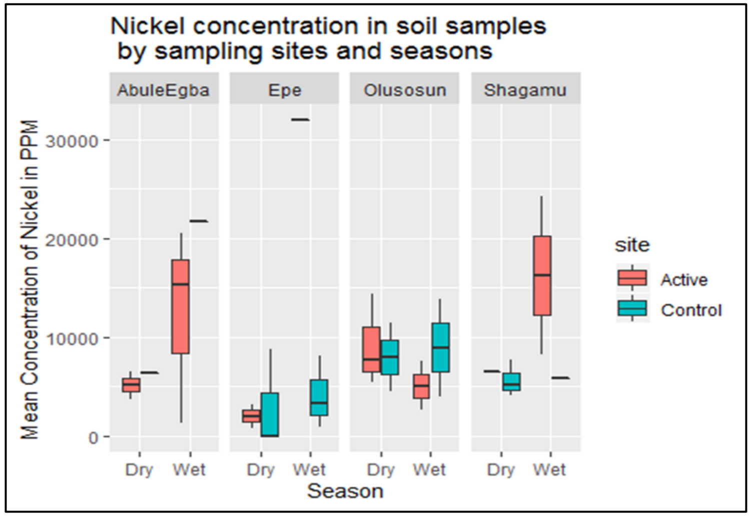

Figure 12: Distribution of Ni in soil samples 0 – 20 cm depth within four dumpsites

Table 13: Distribution of Ni in water samples 0 – 20 cm depth within four dumpsites

	Dry Season		**Wet Season**	
Site Location	**Active (Mean ± SD)**	**Control (Mean ± SD)**	**Active (Mean ± SD)**	**Control (Mean ± SD)**
Abule-Egba	0.01 ± 0.01	0.02 ± 0.02	-	0 ± 0.01
Epe	0.03 ± 0.01	0.05 ± 0.03	0.04 ± 0.02	0.02 ± 0.01
Olusosun	0.01 ± 0.01	0.01 ± 0	0.01 ± 0	0.01 ± 0.01
Shagamu	0.01 ± 0.01	0.11 ± 0.06	0 ± 0	0.01 ± 0.01

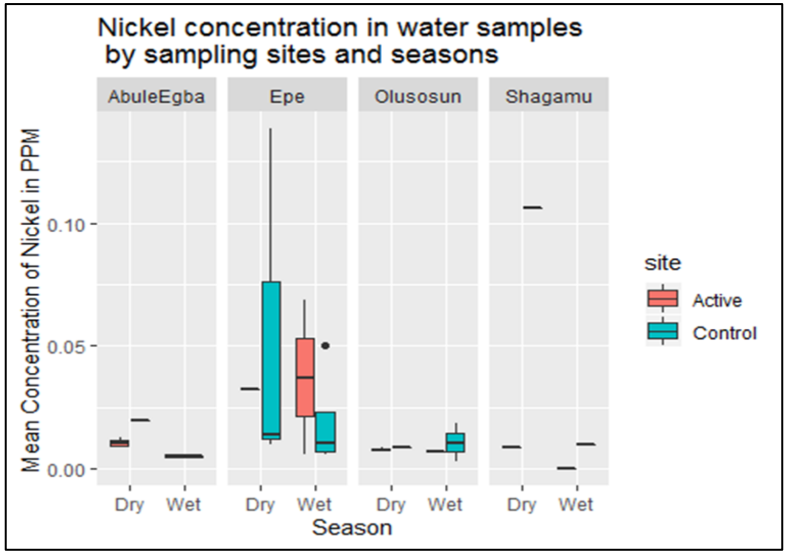

Figure 13: Distribution of Ni in water samples 0 – 20 cm depth within four dumpsites
NOTE:****(0-20cm stands for only soil)

Table 14: Distribution of Pb in soil samples 0 – 20 cm depth within four dumpsites

	Dry Season		**Wet Season**		
Site Location	**Active (Mean ±SD)**	**Control (Mean ±SD)**	**Active (Mean ±SD)**	**Control (Mean ±SD)**	**Control(Maize)**
Abule-Egba	7806.86±3609.62	22864.63±10339.39	353280.63±144433.83	22151.67±9414.46	-
Epe	3286.53±1679.53	3391.89 ± 1648.91	6643.85 ± 2845.56	6264.59 ± 2505.94	-
Olusosun	19588.55±9828.32	37887.07±18129.55	39562.86 ± 22289.4	6830.65 ± 3844.52	-
Shagamu	27131.3±11709.87	8676.1 ± 4145.17	74500.47 ± 30820.22	6200.68 ± 2717.14	4206.94 ± 1648.1

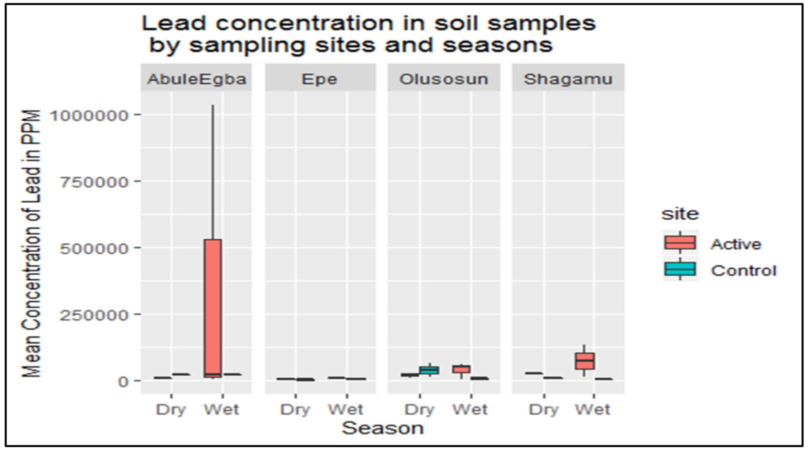

Figure 14: Distribution of Pb in soil samples 0 – 20 cm depth within four dumpsites

Table 15: Distribution of Pb in water samples within four dumpsites

Location	Dry Season Active (Mean ± SD)	Dry Season Control (Mean ± SD)	Wet Season Active (Mean ± SD)	Wet Season Control (Mean ± SD)
Abule-Egba	2.37 ± 1.41	0 ± 0	-	0.01 ± 0
Epe	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Olusosun	0 ± 0	0.01 ± 0.01	0 ± 0	0 ± 0
Shagamu	0 ± 0	0 ± 0	0 ± 0	0 ± 0

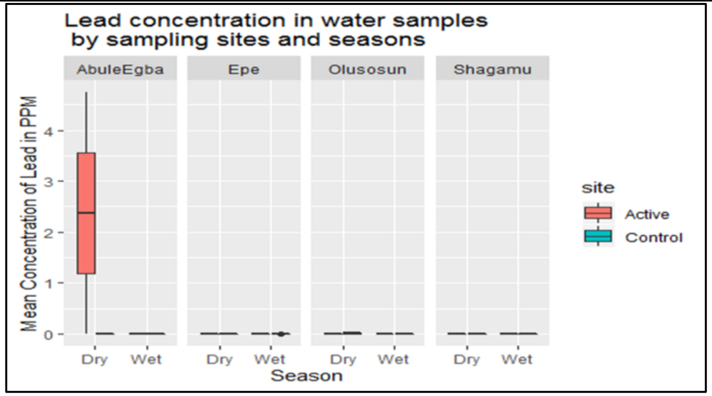

Figure 15: Distribution of Pb in water samples within four dumpsites

Table 16: Distribution of Zn in Soil samples 0 – 20 cm depth within Four Dumpsites

Location	**Dry Season**		**Wet Season**		
	Active Site (Mean ± SD)	**Controlled Site (Mean ± SD)**	**Active Site (Mean ± SD)**	**Controlled Site (Mean ± SD)**	**Controlled Site Maize**
Abule-Egba	13450 ± 8041.23	17770.6 ± 8764.46	167385.94 ± 81255.21	127372.7 ± 59877.91	-
Epe	14287.52 ± 7384.15	15259.03 ± 9332.44	148950.94 ± 71392.18	24698.78 ± 10935.51	-
Olusosun	91556.25 ± 48220.75	116292.68 ± 58949.73	251174.29 ± 127989.71	33621.04 ± 19968.3	-
Shagamu	73641.98 ± 35627.99	23027.03 ± 10519.6	256195.38 ± 142717.14	14584.62 ± 6102.21	18640.57 ± 7469.81

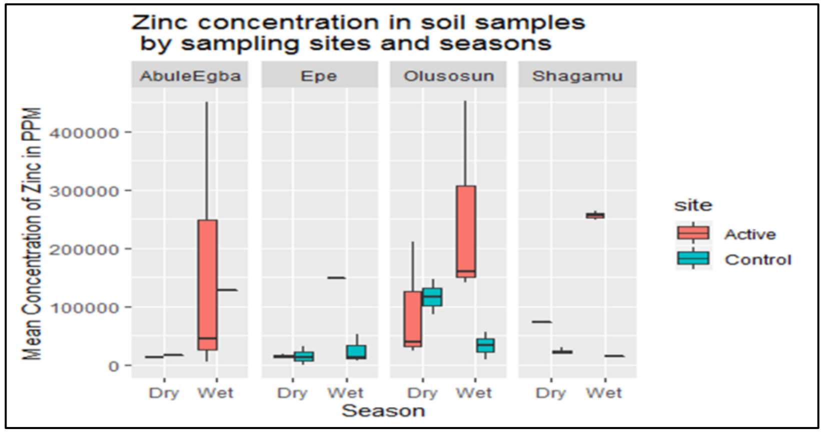

Figure 16: Distribution of Zn in Soil samples 0 – 20 cm depth within Four Dumpsites

Table 17: Distribution of Zn in water samples 0 – 20 cm depth within four dumpsites

Location	**Dry Season**		**Wet Season**	
	Active (Mean ± SD)	**Control (Mean ± SD)**	**Active (Mean ± SD)**	**Control (Mean ± SD)**
Abule-Egba	0.08 ± 0.04	0.07 ± 0.05	-	0.09 ± 0.05
Epe	0.01 ± 0.01	0.01 ± 0.02	0.15 ± 0.08	0.23 ± 0.21
Olusosun	0.02 ± 0.01	0.08 ± 0.05	0.01 ± 0.01	0.04 ± 0.02
Shagamu	0.05 ± 0.03	0.11 ± 0.06	0 ± 0	0.11 ± 0.06

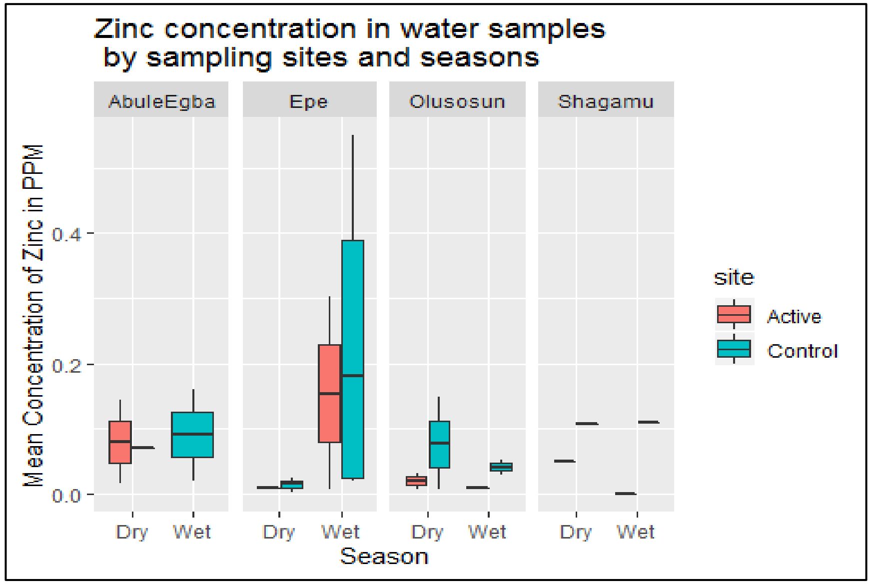

Figure 17: Distribution of Zn in water samples 0 – 20 cm depth within four dumpsites

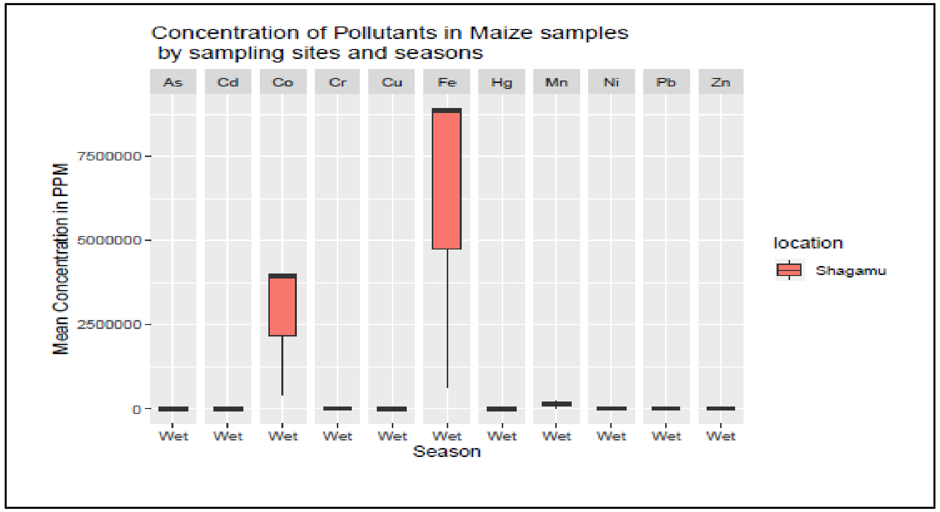

Figure 18: Distribution of element in Maize, soil and water samples 0 – 20 cm depth within four dumpsites

Table 19: Mercury Concentration by Sampling Sites (Soil)

	Dry Season		**Wet Season**		
Site Location	**Active (ppm) (Mean±SD)**	**Control (ppm) (Mean±SD)**	**Active (ppm) (Mean±SD)**	**Control (ppm) (Mean±SD)**	**Control(ppm) (Maize)**
Abule-Egba	48.44±335.62	0 ± 0	2368.04±1463.75	480.11±332.62	-
Epe	0 ± 0	64.59±201.68	0 ± 0	1785.75± 1001.4	-
Olusosun	161.48±111.87	48.44±419.53	2800.08±3923.14	992.82±1421.29	-
Shagamu	0 ± 0	127.3± 439.63	1008.01 ± 684.2	1351.01±1337.09	95.36±818.24

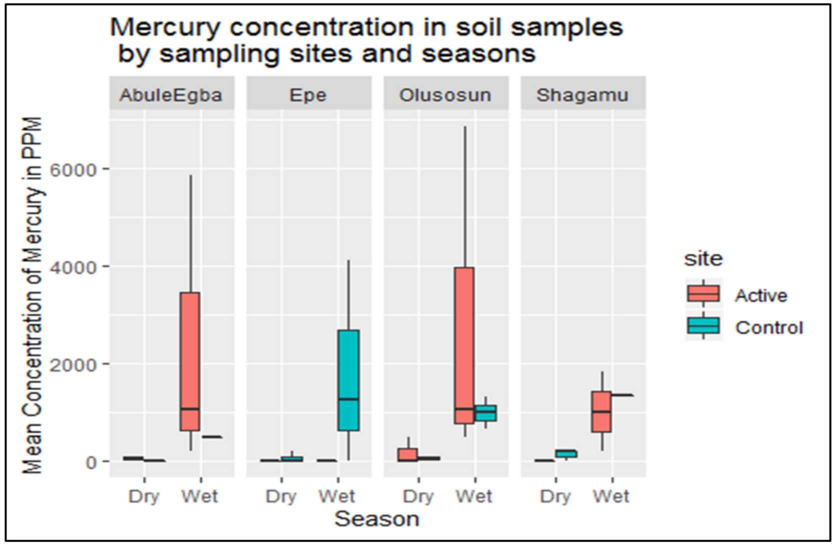

Figure 19: Distribution of Hg in soil samples 0 – 20 cm depth within four dumpsites

Table 20: Distribution of Hg in water samples 0 – 20 cm depth within four dumpsites

Site Location	Dry Season		Wet Season	
	Active (Mean ± SD)	Control (Mean ± SD)	Active (Mean ± SD)	Control (Mean ± SD)
Abule-Egba	0.01 ± 0.01	0.01 ± 0	-	0 ± 0
Epe	0 ± 0	0 ± 0.01	0 ± 0	0.03 ± 0.06
Olusosun	0.01 ± 0	0.01 ± 0	0 ± 0	0 ± 0
Shagamu	0 ± 0.01	142726±1073299.52	0 ± 0	0 ± 0

Distribution of Hg in water samples 0 – 20 cm depth within four dumpsites

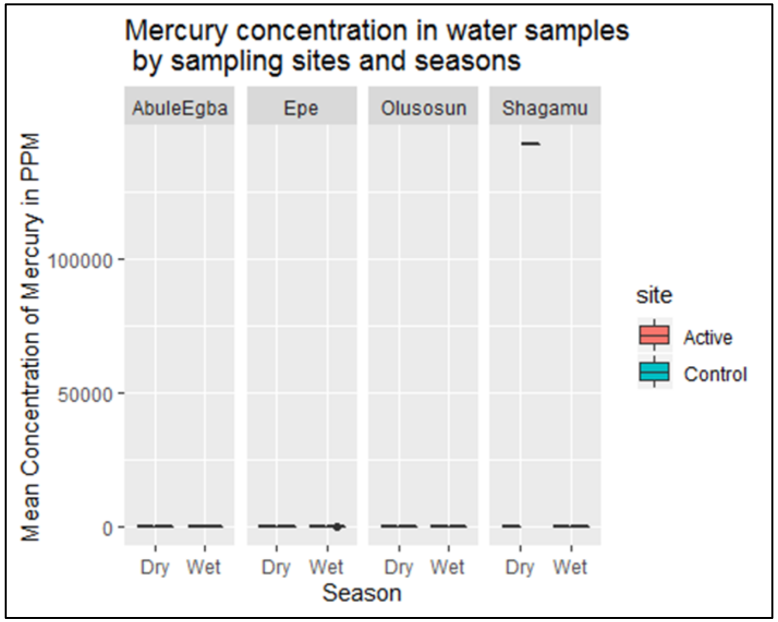

Figure 20. Distribution of Hg in water samples 0 – 20 cm depth within four dumpsites

DISCUSSION:

Table 2 show the distribution of Arsenic (As) in soil at 0-20cm depth within the vicinity of Abule-Eba, Epe, Olusosun, and Shagamu. The mean concentration of As in Epe wet season soil has highest value at control site (3855.76 ± 986.31ppm) but low at control site in dry season (0.01 ± 0.01ppm). The highest mean concentration of As in water was detected at Olusosun control site in wet season (326813.51 ± 424857.56ppm) as shown in figure 3. The mean seasonal variation between the dry and wet season showed the level of As that may occur as a result of deposit by air through wind-blown dust and water run-off and land in wet season (Commission Directives 2003/40/CE/ may 2003). In 2010, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) re-evaluated the effects of arsenic on human health, taking new data into account and concluded that for certain regions of the world where concentrations of inorganic arsenic in drinking water exceed 50–100 μg/L; there is some evidence of adverse effects. But in other areas, where arsenic concentrations in water are elevated (10–50 μg/L), JECFA concluded that while there is a possibility of adverse effects, these would be at a low incidence that would be difficult to detect in epidemiological studies. (Farzan SF, Karagas MR, Chen Y. 2013). The mean concentration of As in study sites were above WHO/FAO (2001) permissible limit of 20ppm for soil. The table 4 presents mean concentration of Chromium (Cr) in soil that is widely distributed in dump and control site Wet (38297.22 ± 21534.98) and dry (45414.42 ±23557.21) seasons at Olusosun and Abule-Egba wet (21548.63 ± 8161.79) and dry (14839.9 ± 6939.55) season but widely distributed at control sites of all study areas. Water was recorded to have the highest deposit of Cr at control site in dry season (2.06 ± 1.31ppm) as compare to other sites. Chromium is toxic, mutagenic, and carcinogenic metal, it is toxic to microorganism, plants, animals, and humans, Barnhart J (1997). Industrial waste is used in land filling, which causes the seepage, and the leaching of toxic chromium from soil into water bodies poses a threat to the environment. (McGrath and Smith, 1990).The permissible limit of Chromium for plants is 1.30mg/kg recommended by WHO, the maximum permissible limit for Cr in water is 0.1 mg/l. (Zigham Hassan *et al* 2012). Table 6 and 7 shows the distribution of Copper (Cu) in soil at 0-20 cm depth, maize and water within Abule-Egba, Epe, Olusosun, and Shagamu dumpsites respectively. The Cu mean concentrations in Shagamu was highest (43349.68 ± 19275.16ppm) in wet season in the dump site and Low at Epe dumpsite in dry season (5011.22 ± 2282.76ppm).From the figures, Cu was widely detected in study sites but with low concentrations. Dry season active site of Abule-Egba was observed to be below (8721.98 ± 4627.36ppm) when compare to wet season active site (16578.67 ± 6201.03ppm). A significant concentration of Cu was detected in dry season at Abule-Egba dump site (0.04 ± 0.03ppm) for water sample but with low concentrations at control sites. Excess of Cu in plants is induces stress, and causes injury to plants; this leads to plant growth retardation and leaf chlorosis (Lewis *et al*., 2001; Nagajyoti *et al*., 2010) and deficiency can be seen by light green to yellow leaves. Misra and Mani (1991) gave the concentration of Cu in plants as 4.15 μg/g (Nagajyoti *et al*., 2010). The recommended daily allowance of copper 2 - 3 mg/day, daily intakes of copper during pregnancy and breast-feeding should be 3 - 4 mg/ day (Shorrocks, 1984). The permissible limit of copper for plants is 10mg/kg recommended by WHO (Zigham Hassan *et al*., 2012). Contamination of drinking water with high level of copper may lead to chronic anemia (Asma Iqbal *et al*., 2011). The mean concentration of copper recorded in all the sites were above WHO/FAO (2001) permissible limit100ppm which poses health risk. Table 8 and 9 shows the distribution of Iron (Fe) in soil at 0 – 20 cm depth, maize and water at Abule-Egba, Epe, Olusosun, and Shagamu. The mean concentration of Fe in dry season active site of Abule-Egba was (7983956.1 ± 4083493.44ppm) which is significantly high. The dry season highest concentration of Fe (12569939.27 ± 6118559.66ppm) was detected in Olusosun dump site but low in wet season dump site with concentration of (20725733.93 ± 11279905.64ppm). Both control sites for wet and dry season at Olusosun had comparable concentrations of (8733481.5 ± 4115668.ppm) and (6605990.09 ± 3794936.59ppm). But water from Epe dumpsite in dry season was (3.7 ± 2.42ppm) but significantly high at the control site (7.91 ± 4.97ppm) .This could be as a result of long time deposit and concentration of decomposed compounds in the soil and water ways. Fe functions as haemoglobin in the transport of oxygen (Soetan *et al.*, 2010) and exists in the blood mainly as haemoglobin in the erythrocytes and as transferrin in the plasma (Soetan *et al.*, 2010). Recommended dietary intake of Iron are 9 mg/day for infants, 8-10 mg/day for children, 8-11 mg/day for adult male, 15-18 mg/day for adult female, 27 mg/day pregnant women and 9-10 mg/day for lactating women (Saunders *et al*., 2012) while maximum allowed concentration of iron in drinking water is 1.0 mg/L according to WHO report (Gutam Patel *et al*., 2011). The WHO recommended level of iron in plants is 20 mg/kg (Afzal Shah *et al*., 2011). Figures 10 and 11 show the distribution of Manganese (Mn) in soil at 0 – 20 cm depth, maize and water at Abule-Egba, Epe, Olusosun, and Shagamu. Mn mean concentration in dry season at Olusosun was observed to be the highest in soil dumpsite (262407.87±134454.55) and also widely distributed in study sites with low concentrations. Mn in water from the study sites have comparative deposit in Epe dumpsite (0.27 ± 0.13) dry season and control site (0.35 ± 0.21) in wet seasons. Mn is found naturally in many types of rock and soil and found in low levels in water, air, soil, and food and is an essential element for plants, intervening in several metabolic processes, mainly in photosynthesis and as an enzyme antioxidant-cofactor (Millaleo *et al.*, 2010).The average Mn levels in the various drinking water are approximately 0.004 parts per million (ppm), and the average daily intake from food ranges from 1 to 5 mg per day.

Recommended Daily Intake (RDI) for Mn is 3 – 600 µg/day in infants, 1.2 – 1.5 mg/day in children, 2.3 mg/day for adult men and 1.8 mg/day for adult women. Mn is an essential nutrient necessary for a variety of metabolic functions including those involved in normal human development, activation of certain metallo enzymes, energy metabolism (ATSDR, 2000; IOM, 2011; Avila *et al*., 2013) while deficiency and excess of Mn have detrimental health effects and may result in several disorders including skeletal defects, infertility, heart disease, hyper-tension, and altered lipid and carbohydrate metabolis. The US National Research Council has established an estimated safe and adequate dietary intake of 2–5 mg per day for adults. In 2001, the US National Academy of Sciences established an adequate intake of Mn to be 2.3 and 1.8-mg/per day in adult males and females, respectively.WHO (1996) permissible limit of Mn is 10mg/kg. Figure 12 and 13 shows the distribution of Nickel (Ni) in soil at 0 – 20 cm depth, maize and water in Abule-Egba, Epe, Olusosun and Shagamu respectively. The mean concentration of Ni was higher in wet season dumpsite at Abule-Egba (12372.77 ± 6707.45ppm) and Shagamu (16219.04 ± 5793.78ppm) though the control sites had the presence of Ni as shown in figure 12. Ni was seen widely distributed at control site for water samples in all study areas with the highest deposited at Epe control site (0.05 ± 0.03) in dry season as shown in figure 12.The mean concentration of Ni recorded at various sites were above the WHO/FAO (2001) permissible limit of 50ppm for soil. Figure 14 and 15 show the distribution of Lead (Pb) in soil at 0 – 20 cm depth, maize and water in Abule-Egba, Epe, Olusosun and Shagamu. The distribution of Pb in soil at Abule-Egba dump site at wet season was seen to be the highest (353280.63 ± 144433.83ppm) and lowest in wet season dumpsite site (39562.86 ± 22289.4ppm) at Olusosun. The high concentration could be as a result of high waste disposal in wet season. . A significant concentration of Pb was detected in water sample in dry season dump site (2.37 ± 1.41ppm) with low concentrations at control sites as shown in figure 15. Lead is one of the most abundant heavy metals in nature that is exposed from air and land; it does not biodegrade but instead remains in the soil and poses serious health risks especially to children as exposure can cause developmental and behavioural problems such as learning disabilities, inattention, delayed growth, and brain damage. Lead is also of concern in soil, when it's used for gardening e.g vegetables or herbs grown in contaminated soil can lead-to-lead poisoning. It is recommended that soil with lead levels between 100 and 400 ppm not be used for leafy vegetables or herbs, because lead can be stored in the leaves (Adrian Ammann. J. Mass Spectrom, (2007).It is an essential nutrient but could be also toxic for human. Maximum permissible limit for lead in drinking water is 0.01 mg/l .The WHO/FAO (2001) permissible limit of Pb in soil is 50.00ppm which is be lower as obtained in all the sites.

Figure 16 and 17 shows the distribution of Zinc (Zn) in water samples in Abule-Egba, Epe, Olusosun and Shagamu in well,borehole,river and stream.The mean concentration of Zn in dry season at Abule-Egba active site was(0.08 ± 0.04ppm) and above detection limit at the control site (0.07 ± 0.05ppm).Zn was absent in wet season active site but was detected in a significant amount at control site (0.09 ± 0.05ppm). The mean concentration of Zn in dry season at Epe active site (0.01 ± 0.01ppm) and control site (0.01 ± 0.02ppm) were low but was significantly high in wet season active site (0.15 ± 0.08ppm).The highest mean concentration was detected in wet season control site with value of (0.23 ± 0.21ppm). The water result shows the highest mean concentration of Zn was detected in wet season control site at Epe with value of (0.23 ± 0.21ppm). Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms as it is an essential element for all living organisms (CIBA *et al*., 1996 in Wyszkowska *et al*., 2013). A typical range of zinc in soils is 10 – 300 mg/kg with a mean of 55 mg/kg. Zinc is an important micronutrient and is needed for protein synthesis; it helps regulate the expression of genes needed to protect cells when under environmental stress conditions. Zinc deficiency is a large problem in crop and pasture plants around the world, resulting in decreased yields. V. Martorell, M. D. Galindo-Riano, M. García-Vargas, M. D.2009. The permissible limit of zinc in water according to WHO standards is 5mg/l. WHO's recommended limit of zinc in plants is 50 mg/kg (Afzal Shah *et al* 2011). Recommended dietary intake of zinc are 2-3 mg/day for infants, 3-5 mg/day for children, 8-11 mg/day for adult male, 8-9 mg/day for adult female, 11-13 mg/day pregnant women and 12-14 mg/day for Lactating women, (Devi *et al*., 2014). Concentration of zinc in soil samples ranged between 0.033 to 0.349mg/kg. A typical range of zinc in soils is 10 – 300 mg/kg with a mean of 55 mg/kg.Zinc ions are present in a concentration greater than 5 mg/l in water, which gives an astringent taste. WHO/FAO (2001) recommended permissible limit of Zn of 300mg/kg for soil and concentration in water to be less than 5 mg/l. Figure 18 shows the distribution of heavy elements in maize samples in Abule-Egba, Epe, Olusosun and Shagamu in wet season. The maize result was obtained as a control sample at about 500m-1km away from Shagamu dump site. This is to determine the impact of heavy metals in agricultural produce .Co at 35000ppm and Fe750000ppm were widely distributed and absent of elements like As,Cd,Cr,Cu,Hg,Mn,Ni,Pb, and Zn.

Table 19 and 20 shows the distribution of Mercury (Hg) in soil samples at Abule-Egba, Epe, Olusosun, and Shagamu at 0 – 20 cm depth. Hg in soil was significantly detected at Epe control site (1785.75± 1001.4ppm) but low at olusosun control site (48.44±419.53ppm) wet season. Hg was dictated in a minute quantity, this was as a result of open digestion where most of the compounds evaporated into organo mercury form (Environmental Health and Safety Manual, 2000) hence could not be widely distributed. In dry season at Epe, the mean concentration of Hg was not detected but detected in a low concentration at control site (64.59±201.68ppm), Hg was among other elements recorded to be high in the areas of study for soil. The Hg compound was detected in a low concentration in dry season at Olusosun dump site (161.48±111.87ppm) and control site (48.44±419.53ppm) with a significant high concentration in wet season active (2800.08±3923.14ppm) and control site (992.82±1421.29ppm). Mercury is a toxic pollutant, persistent, bio accumulative when released into the environment, it accumulates in water laid sediments. Mercury contamination has a significant public health and environmental problem; it is introduced into the environment by emitting into the atmosphere naturally from volcanoes, the weathering of rocks, forest fires, and soils. Second, mercury is emitted as a result of human activities such as the burning of fossil fuels and municipal or pharmaceutical/medical waste (USEPA, 1997). The long atmospheric lifetime (of the order of 1 year) of its gaseous form means the emission, transport and deposition of mercury which is a global issue as concern over it in the environment arises from the extremely toxic forms in which mercury can occur. The main pathway for mercury to humans is through the food chain and not by inhalation. Primarily exposed to fish being a major source of methyl mercury exposure in water. (Navarro *et al.*, 1993).The Hg mean concentration was recorded to be above WHO/FAO(2001) permissible limit of 2.00ppm for soils.

CONCLUSION:

The result showed determination of heavy metals using Inductively Coupled Plasma and Mass Spectrometer ICP-MS such as As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Ni in active and control sites for soil, maize, water and to compile Measured Environmental Concentrations (MEC) of heavy metals, the results however, has identified the location and areas of high levels concentration of these metals. The highest concentration of As was identified at Epe soil in control site were (3855 ± 986.31), Cr, in Epe control water (2.06 ±1.31) Most of the compounds of interest were detected from control sites for soil, water, and maize samples and had high concentration of these elements. This poses the environment and vegetation to high risk.

Recommendations:

- A national database on the volume and impact of heavy metals and locations of hotspot should be created to illustrate the global relevance of these elements in the environment considering high risk to human, animal and ecosystem as a whole.
- A sensitization workshop to understand, educate and train on application on safe methods of handling waste during disposal should be frequently organized and conducted by responsible regulatory agencies, Non-Governmental Organisations and Private sectors.

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