ANALYSIS OF SOME SELECTED TOXIC METALS AND PESTICIDE RESIDUES IN OFADA RICE *(ORYZA SATIVA L.)* SAMPLES PRODUCED IN SOUTH WESTERN REGION OF NIGERIA.

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Abstract

Rice (Oryza sativa L.) is the most important cereal crop in the developing world and is the staple food of over half the world's population. It is generally considered a semi-aquatic annual grass plant. About 20 species of the genus are recognized, but nearly all cultivated rice is O. sativa L. thus the need to evaluate the toxic metal and pesticide content. This study aim to determine the concentration of heavy metals and pesticide residues in ofada rice samples obtained from major markets in 10 local governments in Lagos state, Nigeria.

The rice samples were digested using concentrated nitric acid and the digested samples were analyzed using atomic absorption spectrophotometer. The extractions of the pesticides from the rice samples were done using QuEChERS method of extraction. Fifteen types of pesticides were analyzed using the GC-MS.

The result showed that all the metals were present in the rice samples. The concentration of lead in each sample ranged from 0.054-0.139µg/g, Copper 1.265-27.652µg/g, Arsenic 0.080-0.207µg/g, Mercury 0.039-0.093µg/g, and Cadmium 0.255-0.650µg/g. The Oral Component Limit for lead, copper, arsenic, mercury and cadmium as stated by the USP are 1µg/g, 250µg/g, 1.5µg/g, 1.5µg/g, 0.5µg/g respectively. All the metals except cadmium in 3 samples have concentrations below the USP. The rice sample had no detectable amount of pesticide residue as the concentrations are below detection limit.

All the samples contained detectable amount of the metal of interest suggesting significant risk to c consumers considering the toxicity and half-lives of heavy metals.

Keywords: Ofada, heavy metals, pesticides, Lagos, spectrophotometer, GCMS

Introduction

Rice is the seed of the monocot plant of the genus *Oryza* and it is of the grass family *Poaceae* (formally *Graminae*) which includes twenty wild species and two cultivated ones, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Oryza sativa is the most commonly grown species throughout the world today. Rice has been considered the best staple food among all cereals and is the staple food for over 3 billion people, constituting over half of the world's population (Cantral and Reeves, 2002). Rice is the grain with the second highest worldwide production after maize corn (Otitoju *et al.,* 2014). It contains predominantly carbohydrates besides vitamins and fibre and has higher proportion

of protein than in wheat, corn, and sorghum (USA Rice Federation, 2002). Rice is a major source of income and nutrition in many food insecure regions of the world. About 85% of the total production of rice is meant for human consumption (Somorin and Bankole, 2010). Rice accounts for about 60 - 70% of total food intake in the world and currently, it has become the predominant staple food in about 33 countries of the world including Nigeria (FAO, 2004). About 90 - 95% of Nigerians consume rice and this cut across all economic class where it is eaten in different recipes (Wudiri, 1992).

Rice is grown in all the ecological and dietary zones of Nigeria, with different varieties possessing adaptation traits for each ecology (Sanni *et al.,* 2005). The two commonly cultivated varieties of rice in Nigeria are *O. sativa* and *O. glabberima* (Oko A. O. *et al*, 2011). Consumption of rice contaminated with heavy metals, especially those imported from other countries may pose adverse health challenges in the general populace (Otitoju *et. al.,* 2014). In Nigeria, rice is one of the few food items whose consumption has no cultural, religious, ethnic or geographical boundary. The amino acid profile of rice shows that glutamic and aspartic acids are the major amino acids present in rice, while lysine is the limiting amino acid present (FAO, 2004).

In the other hand, rice consumption can contribute to arsenic exposure, if the rice consumed contained some toxic elements, like heavy metals and mycotoxins. For example, in the United States, there was a positive relationship between rice consumption and urinary arsenic excretion in women (Gilbert-Diamond *et al.,* 2011).

However, the arsenic content of rice was still varied in different rice cultivar (Williams *et al.,* 2005). Soils can be contaminated by highly toxic heavy metals (such as As, Cu, Cd, Pb and Hg) from either aerial depositions or irrigation. The heavy metals are likely to induce a corresponding contamination in paddy (Nan *et al.,* 2002). Paddy in or close to contaminated sites can uptake and accumulate these metals, and then exert potential risk to humans and animals (Fu et al., 2008). Malfunction of organs and chronic syndromes may be caused by ingestion of relatively low doses of toxic heavy metals over a long period present in rice. The metals present in crops can pose serious risk in the consumers in terms of carcinogenesis, mutagenesis and teratogenesis (Radwan *et al.,* 2006).

In addition, rice can also be contaminated with pesticides residue coming from land used to grow rice. Most pesticides used in rice are insecticides, and the most common ones were organochlorines and organophosphates such as endosulfan, methylparathion, cypermethrin and monocrotofos (Elfman *et al.,* 2011). With the advance of science and technology, rice can be added with whitening agent, which is harmful to human health such as chlorine dioxide. Therefore, these toxic elements present in food should be controlled in order to meet the quality of rice. Some countries have set up the maximum limit of these toxic elements in rice (Rohman *et al.,* 2014).

Pesticides are chemical compounds, which are frequently used in modern agriculture practices to keep the crops from different pests and diseases (Wardani *et al.,* 2014).

The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others (Aktar *et al.,* 2009). Pesticides have substantially contributed to the controlling of pests and increasing crop yields in meeting the food demand of escalating population and control of vector-borne diseases. One of the major factors of pesticide contamination or poisoning in developing countries is the unsafe use or misuse of pesticides (Adeola, 2012). However, despite the contribution of pesticides to agricultural production, evidences in the last few decades have shown that they could also be detrimental to human health and the ecosystem (Tadesse and Asferachew, 2008).

Material and Methods
Instruments
- Buck model 205 atomic absorption spectrophotometer, USA.
- Metler Toledo AL204 weighted balance, USA.
- Shimadzu GC/MS (GC-17A), GERMANY.
- Automatic pipettes (for 1 -10 µl, 200-1000µl, and 1-10ml)
- 50ml Teflon® centrifuge tubes with screws.
- Centrifuges for 50ml and 10ml.
- 1.5ml vials for GC-autosampler.

Reagents
All reagents were of analytical grade
- Nitric acid 99.8% (Manufacturer: Merck)
- Ultra pure water
- 1000ppm fishers' scientific reference AAS standard for each element.
- Acetonitrile pesticides residue grade (Manufacturer: Sigma-Aldrich)

- Sodium Chloride (Manufacturer: Merck)
- Bondesil-PSA 40um (Varian article no 12213023/10g)
- Magnesium Sulphate Anhydrous (Manufacturer: Fluka)
- Formic acid (manufacturer: Merck)
- Pesticides standards for organophosphates (manufacturer: Promochem)

Sample collection
Major markets in various local governments were visited and 10 samples of locally produced rice (Ofada rice) were purchased. The rice obtained were different varieties of rice grown within the areas of Ogun state, Ekiti and Osun States of Nigeria.

Standard solutions of toxic heavy metals preparation
Fisher's scientific reference AAS standard, 1000ppm for each element was diluted to the desired concentrations of mercury, lead, copper, arsenic and cadmium. By serial dilution, 1000ppm was diluted to 100ppm. The standard solution, 25ml was taken, put in a 250ml volumetric flask and made up to volume with ultra pure water. The stock standard solution was 100 ppm while the working standard solutions 0.5, 1.0, 1.5, 2.0 ppm were prepared for arsenic and mercury. For, Lead, Copper, Cadmium, 0.0, 2.0, 4.0, 6.0, 8.0 ppm was prepared.

Standard solutions of pesticides
Stock solutions of pure standards of pesticides were prepared and then serially diluted to produce different concentrations range 0, 0.05, 0.1, 0.25, 0.5 and 1.0 ppm of the pesticides. Stock standard solutions were stored in amber colour bottles at 40C

in a refrigerator while working standard solutions were prepared fresh before use. Standard solutions of the pesticides were run on GC/MS under the set chromatographic conditions and mean peak areas were plotted against concentrations to obtain calibration curves of individual pesticides. The calibration curves for all of the pesticides were plotted.

Digestion of samples for metal analysis

All the samples were prepared using the method as described in the literature by (Ziarati *et. al.,* 2013). All samples were collected in from May to July 2015. For heavy metal analyses 50 gram of each sample was weighed, the rice sample were hand-picked, and oven-dried at 60^{0}c to a constant weight. Each oven-dried sample was grounded until it could pass through a 60 mesh sieve. The samples were stored in clean, dry, high density polyethylene bottles of 100 ml capacity with screw caps. All glassware and plastic containers used were washed with liquid soap, rinsed with water, soaked in 10% volume/volume nitric acid for 24hrs, cleaned thoroughly with distilled water and dried in such a manner to ensure that all contaminants are removed.

One gram of the pulverized rice sample was carefully weighed into a digestion tube. 10ml of concentrated nitric acid was measured in a fume cupboard with a 20ml measuring cylinder and added to the sample in the digestion tube. The sample solution was digested using an acid digester at a temperature of $270^{o}C$ until all the brown fumes had disappeared. The digested solution is allowed to cool at room temperature and filtered. The filtrate is made up to 25ml with deionized water,

transferred into sample bottles and stored for metal analysis.

Analysis of toxic heavy metals

The analysis of arsenic, mercury, cadmium, lead and copper was carried out with a buck model 205 atomic absorption spectrophotometer. In all cases, air-acetylene was the flame used and hollow cathode lamp of the individual metals was the resonance line source. For each element the instrument was zeroed using the blank (ultrapure water) after which the standard was aspirated into the flame starting from the lowest concentration. The corresponding absorbance values were obtained and the graph of absorbance against concentration was plotted by the instrument (Oluyemi and Olabanji, 2011). The digested samples were then analyzed in duplicates with the average concentration of the metals present being displayed in parts per million (ppm) by the instruments after extrapolation from the standard curve.

Extraction of pesticides

Extraction of samples for the analysis was according to the methods of Anastassiades *et al.,* 2003. The samples were milled with a sieve at 1.0 mm. 10ml of cold water is added to 5g of the rice sample and shaken to homogenize the sample. 10g of sample was weighed into a 50ml centrifuge tube with screw cap, 10ml acetonitrile was added and shaken vigorously by hand for 1 min. 4g mgso4, 1g NaCl, 1g trisodium citrate dehydrate and 0,5g disodium hydrogen citrate sesquihydrate. The mixture was shaken vigorously for 1 min. it was centrifuge for 5 minutes at 3000rpm. This gave three layers; the supernatant

which is the acetonitrile layer is then decanted. 5ml of the extract was transferred into a single use centrifuge tube, which contains 25mg PSA (primary secondary amine) and 150mg MgSO4, and shaken for 30 sec. The mixture is then centrifuge for 5min at 3000rpm. 2ml of the extract was transferred into a screw cup vial and acidified with 20ul 5% formic acid in acetonitrile (10µl/ml extract). The cleaned and acidified extracts are transferred into auto sampler vials and used for the residue determination by GCMS.

Analysis of pesticides

The GC/MS equipped with fluorescence detector was used for the chromatographic separation and was achieved by using a 35% diphenyl/65% dimethyl polysiloxane column. The oven was programmed as follows: initial temperature 40 °C, 1.5 min, 25 °C/min to 150 °C, 0.0 min, 5 °C/min to 200 °C, 7.5 min, 25 °C/min to 290 °C with a final hold time of 12 min and a constant column flow rate of 1 mL/min.

Results

Results of metal standard analysis

A calibration plot for each metal was obtained by plotting the absorbance versus the concentration of variable standard solution prepared. This was then used to determine the concentration of the digested samples. The results obtained and their plots are represented thus:
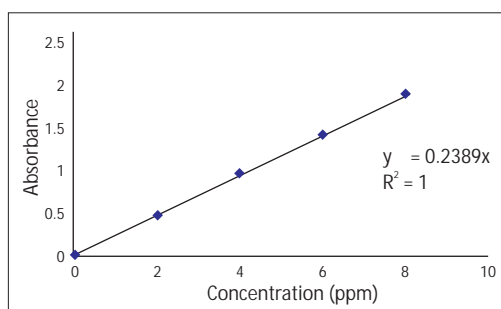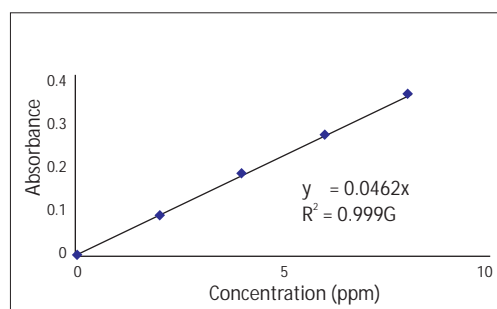

Figure 1: Calibration Plot for Lead Standard

In the plot: $y = 0.2389x$, $R^2 = 1$

Figure 2: Calibration Plot for Copper Standard

In the plot: $y = 0.0462x$, $R^2 = 0.999G$
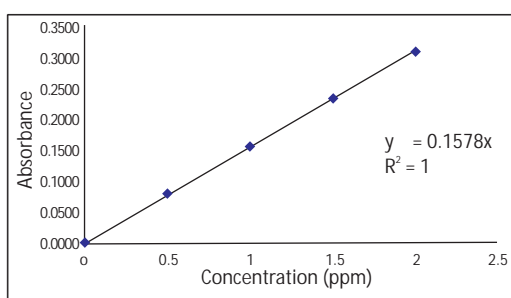
Figure 3: Calibration Plot for Arsenic Standard

In the plot: $y = 0.1578x$, $R^2 = 1$
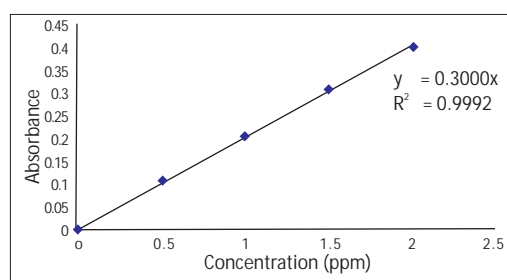
Figure 4: Calibration Plot for Mercury Standard

In the plot: $y = 0.3000x$, $R^2 = 0.9992$
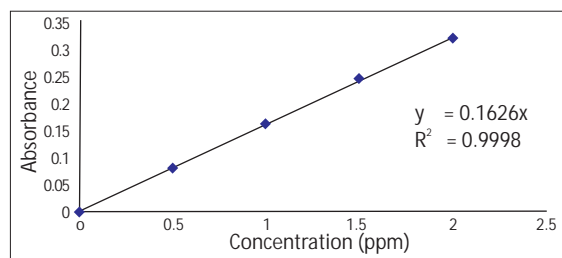
Figure 5: Calibration Plot for Cadmium Standard

Limit of detection and quantification

To determine the LOD of the instrument, the blank was analyzed eight (8) times for each element and the LOD calculated as three (3) times standard deviation (STD). The limit of quantification was calculated as ten (10) times STD.

Table 1: Blanks for Each Metal

	Lead	Copper	Arsenic	Mercury	Cadmium
BLANK 1	0.000	0.046	0.001	0.004	0.009
BLANK 2	0.000	0.071	0.002	0.005	0.004
BLANK 3	0.005	0.033	0.001	0.005	0.004
BLANK 4	0.002	0.003	0.001	0.005	0.005
BLANK 5	0.001	0.048	0.002	0.006	0.005
BLANK 6	0.014	0.037	0.001	0.006	0.006
BLANK 7	0.000	0.033	0.002	0.005	0.011
BLANK 8	0.002	0.023	0.002	0.005	0.005

Table 2: Limit of Detection (LOD) and Limit of Quantification (LOQ) for Each Metal

METAL	STD	LOD (ppm)	LOQ (ppm)
Lead	0.005	0.049	0.049
Copper	0.020	0.197	0.197
Arsenic	0.001	0.006	0.006
Mercury	0.001	0.007	0.007
Cadmium	0.003	0.049	0.027

Determined metal concentrations in each rice sample

After calibrating the system with standard solutions, spectrophotometer automatically determined the concentration of each metal present in the digested matrix of the rice samples by extrapolation in part per million (ppm). The analysis was carried out in duplicates to enable necessary statistical analysis to be carried out.

Table 3: Determined Heavy Metal Concentration for Each Sample in μg/g

Variety	Avg Pb ±SD	AvgCu±SD	AvgAs±SD	AvgHg±SD	AvgCd±SD
1	0.121±0.006	24.371±1.026	0.180±0.008	0.082±0.003	0.567±0.026
2	0.139±0.001	27.652±0.220	0.207±0.002	0.093±0.001	0.650±0.006
3	0.070±0.002	14.521±0.416	0.104±0.003	0.050±0.001	0.330±0.010
4	0.105±0.004	21.359±0.714	0.157±0.006	0.072±0.002	0.493±0.017
5	0.057±0.002	11.965±0.301	0.085±0.002	0.041±0.001	0.271±0.007
6	0.100±0.002	20.076±0.378	0.149±0.003	0.068±0.001	0.468±0.009
7	0.054±0.004	11.265±0.267	0.080±0.006	0.039±0.003	0.255±0.019
8	0.100±0.001	20.368±0.128	0.149±0.001	0.069±0.000	0.469±0.003
9	0.121±0.001	24.370±0.216	0.180±0.002	0.082±0.001	0.567±0.005
10	0.062±0.001	12.905±0.191	0.092±0.001	0.044±0.001	0.292±0.004

Summary of metal analysis

Table 4: Summary Statistics of Metal Analysis

	Lead	Copper	Arsenic	Mercury	Cadmium
Number of samples	10	10	10	10	10
Number of samples with detectable metal	10	10	10	10	10
% of samples with detectable metal	100	100	100	100	100
Minimum conc. Of metal ion detected (ug/g)	0.054	11.265	0.080	0.039	0.255
Maximum conc. Of metal ion detected (ug/g)	0.139	27.652	0.207	0.093	0.650
USP Oral component limit (OCL) (ug/g)	1	250	1.5	1.5	0.5
Number above USP OCL	0	0	0	0	3

The number of samples with detectable metal ions, the percentage of samples with detectable metal ion, minimum and maximum concentration of metal ions detected, as well as the percentage of samples with detectable metal ion above the United State Pharmacopoiea (USP)Oral Component Limits (OCL) were determined .

Result of pesticides standard analysis
A calibration plot for each pesticide was obtained by plotting the Peak area versus the Concentration of variable standard solution prepared.
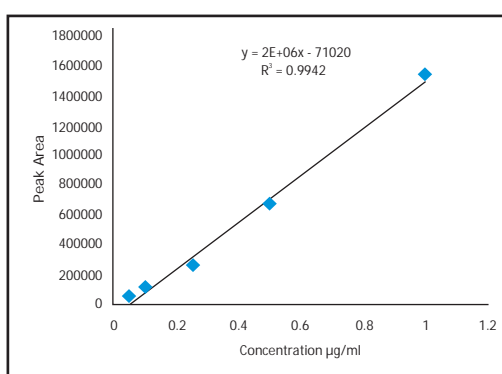
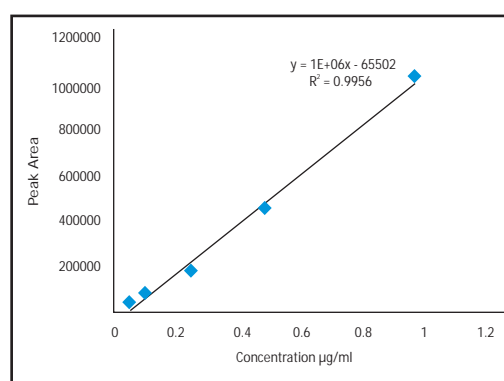
Fig. 6: Calibration Plot for Diclorvos Standard

$y = 2E+06x - 71020$
$R^2 = 0.9942$

Fig. 7: Calibration Plot for Mevinfos Standard
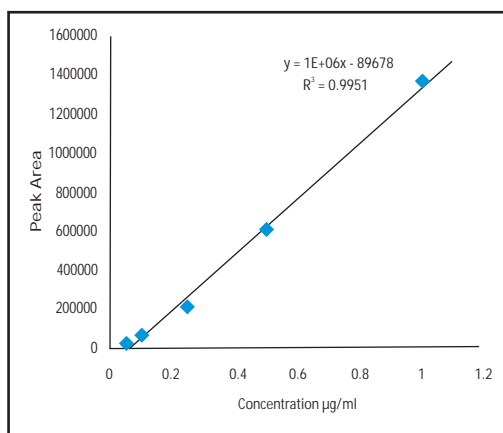
$y = 1E+06x - 65502$
$R^2 = 0.9956$

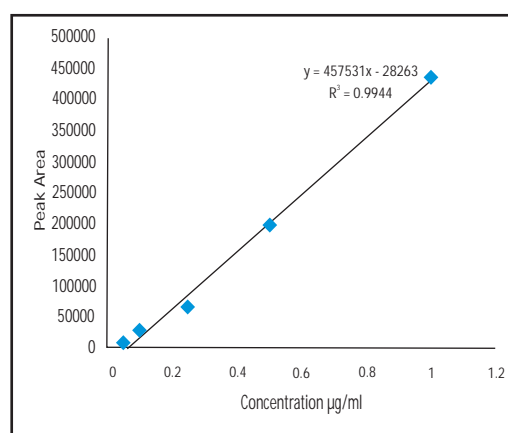Fig. 8: Calibration Plot for Carbaryl Standard

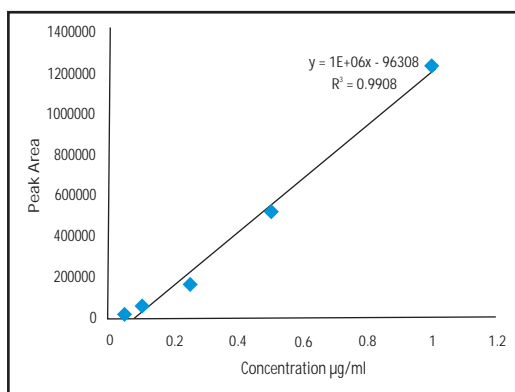Fig. 9: Calibration Plot for Dimethoate Standard
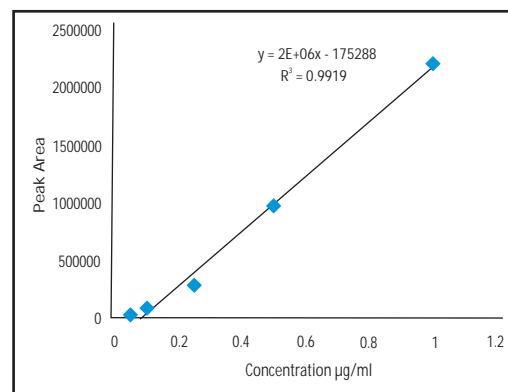
Fig. 10 Calibration Plot for Dimethoate Standard

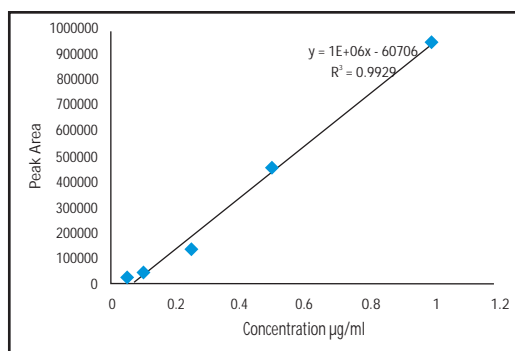Fig. 11 Calibration Plot for Diclofenthion Standard

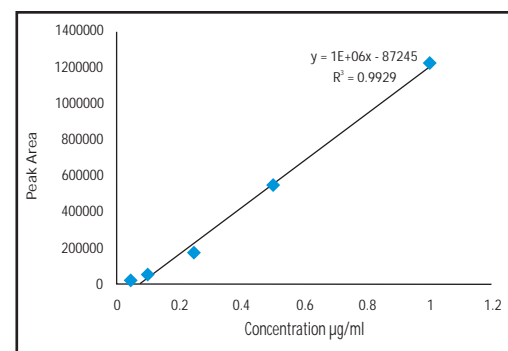Fig. 12 Calibration Plot for Methylparathion Standard

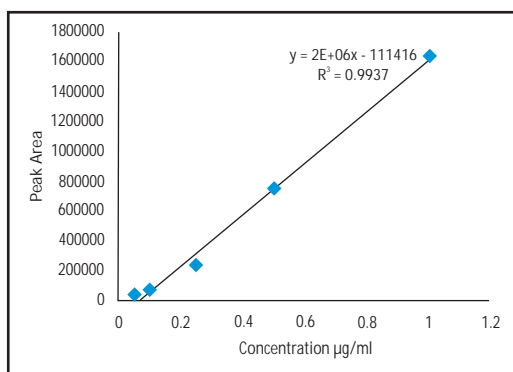Fig. 13 Calibration Plot for Pirimiphos-Methyl Standard

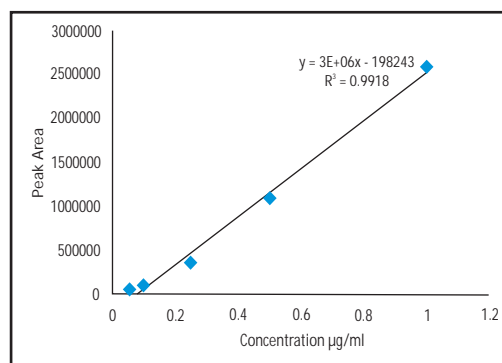Fig. 14 Calibration Plot for Malathion Standard

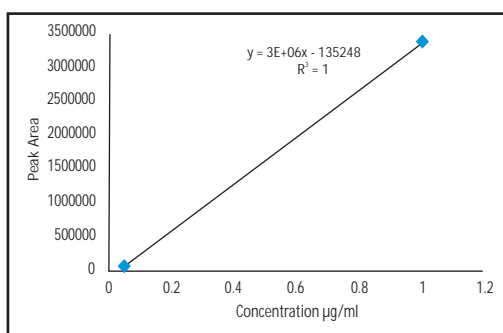Fig. 15 Calibration Plot for Fenthion Standard

Fig. 16 Calibration Plot for Parathion Standard
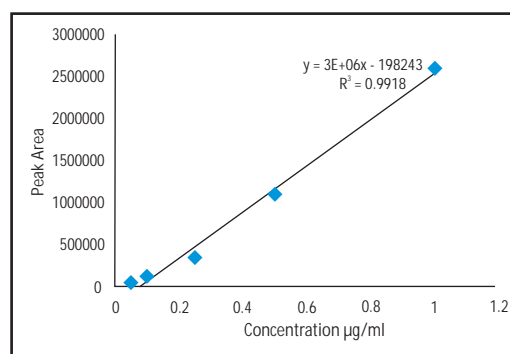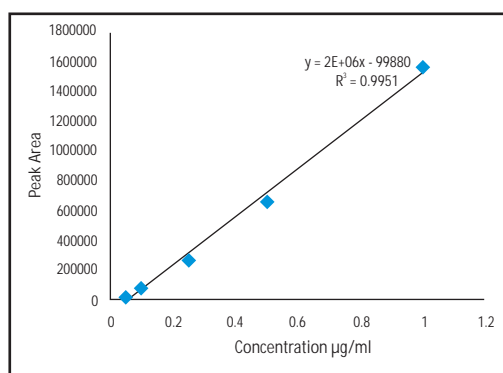

Fig. 17 Calibration Plot for Isofenphos Standard

Fig. 18 Calibration Plot for Bromophos-Ethyl Standard
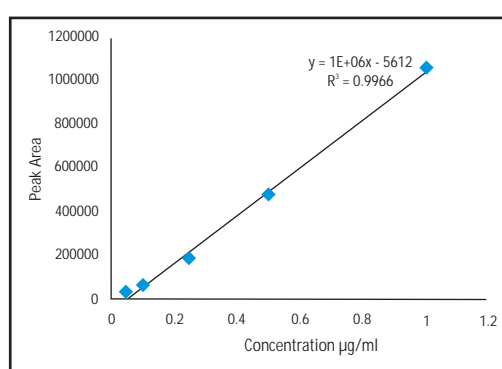
Fig. 19: Calibration Plot for Ethion Standard
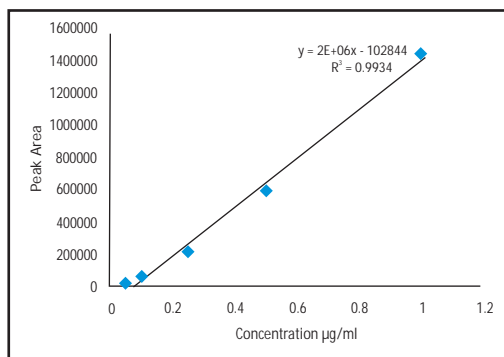
Fig. 20: Calibration Plot for Ethion Standard

Summary of standard chromatogram

Table 5: Names, Retention time and Coefficient of Determination for Pesticides Standard

Pesticide	RETENTION TIME (min)	COEFFICIENT OF DETERMINATION (R^2)
Diclorvos	7.293	0.9942
Mevinfos	9.065	0.9956
Carbaryl	9.991	0.9951
Dimetheoate	12.577	0.9944
Diazinon	13.175	0.9908
Diclofenthion	13.858	0.9919
Methyl Parathion	14.169	0.9929
Pirimiphos Methyl	14.421	0.9929
Malathion	14.644	0.9937
Fenthion	14.711	0.9910
Parathion	14.714	1.0000
Isofenphos	15.265	0.9918
Bromophos-Ethyl	15.552	0.9951
Ethion	16.659	0.9965
Carbofenthion	16.807	0.9934

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Ethion	16.659	0.9965
Carbofenthion	16.807	0.9934

Determined pesticides concentration in each rice sample

The concentration of each pesticide in the rice sample was determined in ppm (µg/ml) by GC-MS. The result obtained is shown in the table below;

Table 6: Pesticides Residues in Rice Sample

Pesticide	S-1	S-2	S-3	S-4	S-5	S-6	S-7
Diclorvos	ND	ND	ND	ND	ND	ND	ND
Mevinfos	ND	ND	ND	ND	ND	ND	ND
Carbaryl	ND	ND	ND	ND	ND	ND	ND
Dimetheoate	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND
Diclofenthion	ND	ND	ND	ND	ND	ND	ND
Methyl Parathion	ND	ND	ND	ND	ND	ND	ND
Pirimiphos Methyl	ND	ND	ND	ND	ND	ND	ND
Malathion	ND	ND	ND	ND	ND	ND	ND
Fenthion	ND	ND	ND	ND	ND	ND	ND
Parathion	ND	ND	ND	ND	ND	ND	ND
Isofenphos	ND	ND	ND	ND	ND	ND	ND
Bromophos-Ethyl	ND	ND	ND	ND	ND	ND	ND
Ethion	ND	ND	ND	ND	ND	ND	ND
Carbofenthion	ND	ND	ND	ND	ND	ND	ND

ND: NOT DETECTED

Table 7: Elemental Impurities and Their Proposed Limits

Metals/Parameters	Oral Rfd (µg/kg/day)	Recommended Daily Oral Dose*PDE (µg/day)	Oral Component Limit (OCL) (µg/g)	Parenteral Component Limit (PCL) (µg/g)
Lead	0.2	10	1	0.1
Copper	50	2500	250	25
Arsenic	0.3	15	1.5	0.15
Mercury	0.3	15	1.5	0.15
Cadmium	0.1	5	0.5	0.05

*recommended daily oral dose based on a 50kg person (Jenkins, 2010)

Discussions

For safety of human health, various regulatory organizations such as United States Pharmacopoeia (USP), British Pharmacopoeia (BP), World Health organization (WHO), and United States Environmental Protection Agency (USEPA) have set up parameters to limit the presence of heavy metals in foods. Parameters such as permissible daily exposure (PDE), rationale for reference doses (RfD's), oral component limit (OCL) and parenteral component limits (PCL) are guidelines set to regulate elemental contaminations as well as dietary vitamin intake in rice.

From this research work, calibration plots were obtained for each metal by plotting a graph of variable concentrations of the standard solutions for each metal against their corresponding absorbance. All five calibration plots were linear with each having a correlation coefficient of 0.99- 1.0.

These calibration plots were then used to determine the concentrations of heavy metal contaminants in each of the samples. Table 3 shows the determined heavy metal concentration in each sample in µg/g. The average of the result obtained was used to represent the concentration of each metal. The standard deviation for each metal analysis was determined to estimate how far away the mean value each result was.

The summary of the result of the metal analysis as shown in table 4, indicates three (3) samples containing cadmium level above the OCL. The concentration level of Lead in each sample ranged from 0.054- 0.139µg/g, Copper ranged from 11.265- 27.652µg/g, Arsenic from 0.080-0.207µg/g, Mercury from 0.039-0.093 µg/g, and Cadmium from 0.255-0.650µg/g. Lead, Copper, Arsenic, Mercury, and Cadmium were detected in all the rice samples. However with reference to the USP Oral component limit (OCL), all the

metals falls below the limit except for Cadmium in three (3) samples which have concentrations above the USP Oral Component Limit (OCL).

Olayiwola (2013), reported the accumulation and contamination of toxic metals in soil. One of the main reasons for exposure of human to heavy metals is the soil-crop-food. Almost all the heavy metals in the human body have deleterious effects. Rice is one of the world's most widely consumed grains in the diet of the people (Ghazanfarirad *et al.,* 2014). In most cases food contamination accrued from environmental pollution which main sources has been rapid expansion of cities (cars exhaust, etc.), water pollution caused by industrial waste discharge, agricultural land irrigated with sewage, electronic waste, use of fertilizers, pesticides etc. (Rai, 2002).

Huang *et al.* (2013), working on polished rice samples obtained from local markets in Zhejiang, China, reported that mean levels of heavy metals found in rice were as follows: As, 0.080 mg/kg; Cd, 0.037 mg/kg; Hg, 0.005 mg/kg; Pb, 0.060 mg/kg. This result is similar to those obtained in this study. Umar and Wunzani (2013) working on wild rice grain in Wure, Kangoro and Kaduna, all in Kaduna State found out that Copper concentration in wild rice grain studied was 2.617mgkg^{-1} and Lead concentration was 0.182mgkg^{-1}

Salama and Radwan (2005)reported that Cd levels found in foodstuffs from Egyptian markets were above the acceptable levels according to international food standards for heavy metals. Moreover, these results can also be used to test the chemical quality of foodstuff in order to evaluate the possible

risk associated with their consumption by humans. It is concluded that atmospheric deposition from urban and agricultural areas may play an important role in the enrichment of agricultural produce from Cd and/ or Pb. The use of fertilizers and metal based pesticides in agriculture are also responsible for the contamination Jarvis *et al.* (1976) reported that Cd was easily taken up by plants and transported to different organs although it had no beneficial effects to plants and animals.

Bakhtiarian (2001), determined heavy metals in rice in north Iran and found that the maximum levels of lead and cadmium in rice with Hassani brand were 0.0793 and 0.965 ppm, respectively. Al-Saleh and Shinwari, 2001 reported average levels of cadmium and lead for rice 0.02 mg/kg to 0.135 mg/kg, respectively. Also, Zeng and his colleagues (Zeng *et al.,* 2008) reported that the amounts of lead and cadmium in rice in South Korea were 0.01 to 0.032 and 0.032 to 0.374 mg /kg, respectively.

The presence of this toxic metals in rice is due to soil contaminated by highly toxic heavy metals (such as As, Cu, Cd, Pb and Hg) from either aerial depositions or irrigation. The heavy metals are likely to induce a corresponding contamination in rice especially those in or close to contaminated sites which can uptake and accumulate these metals, and then exert potential risk to humans.

Pesticides are used globally in farming sector to control insect and pest population. A study of the possible contamination ofada rice (*Oryza sativa L.)* in 10 major markets in Lagos state was carried out. Fifteen types of pesticides were investigated in the rice sample.

Calibration plots were obtained for each pesticide by plotting a graph of variable concentrations of the standard solutions for each pesticide against their corresponding mean peak area.

These calibration plots were used to determine the concentration of pesticides in the rice sample as shown in Table 6. From the results it was observed that all of the pesticides residues were not detected i.e. found to be below the limit of quantification levels.

Investigation of pyrethroid pesticide residues in rice carried out by Ravikumar C. *et al.* (2013) revealed that there were no detectable pesticides in the rice sample. The results were similar to those obtained from this study.

Pesticide contamination poses significant risks to the environment and non-target organisms. Although pesticides residues were not detected, there is a need to convey the message that prevention of adverse health effects and promotion of health are profitable investments for consumer.

Conclusion

Based on the results obtained, it can be concluded from this research that the toxic metal present in local rice samples obtained from staple food markets in Lagos State, Nigeria were below the USP Oral Component Limit except for the three (3) samples which contained cadmium above the USP Oral Component Limit. The determined pesticides of interest were not present as they were below detectable limits in all the rice samples.

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