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Evaluation of Polycyclic Aromatic Hydrocarbons and Toxic Elements in Some Vegetables Cultivated Along Roadsides in Port Harcourt and Environs

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Abstract
The concentrations of PAHs and Toxic elements and the effect of traffic density and heat on their concentrations in Bitter leaf and Pumpkin leaf cultivated along roadsides in Port Harcourt, Nigeria were evaluated using Atomic Absorption Spectrophotometer (AAS) and Gas Chromatography-Mass Spectroscopy (GC-MS). The results showed that the highest concentration of PAHs in Fresh Bitter leaf samples was 0.33mg/kg at Eleme-Okrika road, Cr, 19.865mg/kg at Eleme-Okrika road, Pb, 35.836mg/kg at Igwuruta-Omagwa road, Cd, 0.739mg/kg at Igwuruta-Omagwa road, Cu, 17.953mg/kg at Igwuruta-Omagwa road and As, <0.001 mg/kg at all the stations. In boiled sample of Bitter leaf the highest concentration of PAHs was 0.131mg/kg at Eagle Island, Cr, <0.001mg/kg at all stations, Pb, 6.633mg/kg at Igwuruta-Omagwa road, Cd, 0.912 mg/kg at Igwuruta-Omagwa road, Cu, 17.953 mg/kg at Eleme-Okrika road, Ni at 13.234 mg/kg and As, <0.001mg/kg at all the stations. Similarly, in Fresh Pumpkin leaf PAHs recorded the highest concentration of 0.233 mg/kg at Eleme-Okrika road, Cr, 19.455 mg/kg at Eleme-Okrika road, Pb, 9.990 mg/kg at Eagle Island road, Cd, 0.610 mg/kg at Eagle Island, Cu, 21.442 mg/kg and As <0.001mg/kg at all stations. In boiled Pumpkin leaf PAHs had highest concentration of 0.054 mg/kg at Eagle Island, Cr, 4.595mg/kg at Eagle Island, Pb, 9.885mg/kg at Eagle Island, Cd, 0.541mg/kg at Eleme-Okrika road, Cu, 12.459mg/kg at Eleme-Okrika and As, <0.001mg/kg at all stations. The results showed higher traffic routes had higher Toxic elements and PAHs concentrations. There was no significant difference (p>0.05) in the concentrations of the elements between fresh and boiled leaves. Boling reduced the mean concentrations of PAHs in the vegetables. The concentrations of the elements in boiled and fresh pumpkin leaf followed the order Cu>Pb>Ni>Cr>Cd>As while in boiled and fresh Bitter leaf the concentration followed the order Pb > Cu> Ni > Cr > Cd > As. It was recommended that citizens should be advised through advocacy programmes to consider vegetable farming far away from high traffic routes to avoid heavy metals and PAHs pollution.

Key words: *Heavy Metals, Vegetables, Fresh, Boiled, Pumpkin, Bitter leaf, Traffic Density*

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I. Introduction

Protection of the environment has been the focus of growing public attention and debate since the early 1960s, and the concern for the environment has soared in the final decade of the twentieth century and early 21st century (Kalagbor *et al*., 2014). It appears now that people of many backgrounds and political persuasions prefer to be environmentally aware and manifest concern for the state of the environment.

Several anthropogenic and natural activities have contributed to the pollution of the environment. Activities such as industrial pollution, solid waste, municipal waste, sewage from households and automobile traffic etc, are some of the ways that man's activities contribute to the pollution of the environment (Nimyel *et al*., 2015). The pollution of the environment from automobile sources is a serious environmental concern. These activities are reported to release heavy metals into the environment. These heavy metals are released during different operations of the road transport such as combustion, leakage of fuel, wear of automobile components and corrosion of metals (Ogundele *et al.,* 2015)

Heavy metal is a general collective term that applies to a group of metals and metalloids with an atomic density greater than 5g/cm3 (Pam *et al*., 2013). Examples of heavy metals/metalloids include Mercury (Hg), Lead (Pd), Cadmium (Cd), Arsenic (As), Copper (Cu), Manganese (Mn) etc.

Heavy metals have a great ecological significance due to their toxicity and accumulative behavior, however, the presence of high amount of heavy metals in the environment, induced by human activity, is one of the most important tasks of the present environmental issues (Adedokun *et al.*, 2017). The enrichment of these elements is influenced by both, immobile and mobile sources. Edible vegetables sometimes are victims of this heavy traffic pollution especially those cultivated along heavy traffic routes. The accumulation of metal contaminants in edible vegetables can pose serious environmental and health problems to the immediate area and humans (Ideriah *et al.,* 2018). Trace metal contamination in as area and affect the soil and the bio-assimilation of metals in terrestrial organisms, resulting in potential long-term implications on human health and the ecosystem (Ideriah *et al*., 2018). Although some heavy metals are needed to facilitate the nutrients of plants, however, Heavy metals, when concentrated in living organisms beyond acceptable limits should be regarded as toxins towards mammals and particularly humans (Kalagbor, 2014).

The nutritional value and consumer acceptance of these edible vegetables must be taken into consideration when vegetables are being considered as food. Ideriah *et al*. (2019) sampled some vegetables from the open markets of Port Harcourt Nigeria and found out in their study that there is a reasonable proximate value, Polycyclic Aromatic Hydrocarbons (PAH) and heavy metals in Utazi leaf (*Gangronema Latifolium*), Green and red apples (*Malus Domestica*) and Walnut (*Tetracarpidium Conophorum*).

Polycyclic Aromatic Hydrocarbons (PAHs) are group of fused aromatic ring compounds formed during incomplete combustion of fossil fuel and garbage (Abdel-Sharfy, 2016).

They are organic substances made up of carbon and hydrogen atoms grouped into atleast two condensed or fused aromatic ring structure (CCME, 2012). They are a class of organic compounds consisting of two or more fused aromatic rings. PAHs arise from oil seepages and erosion of petroliferous states, incomplete combustion of wood and biomass via forest and grass fiber (Ideriah *et al.*, 2019). Some of these heavy metals Cu, Cd, Ni, Pb, Zn, Cr have been implicated in causing deadly health effects in humans, animals and plants (Adegoke *et al.*, 2017)

From the early 1980s to present, many studies have been carried out on the environmental impact of heavy metals and PAHs contamination on soils and vegetation along and majors roads across Asia to America, Europe to Australia and Africa to south America and the middle east, but only scanty literatures exist on the study of PAHs and heavy metals concentrations in edible vegetables cultivated along major roads especially traffic route around Port Harcourt Nigeria. It is a common place to find vegetables being cultivated along traffic routes in Port Harcourt thus, exposing them to heavy metals released from these automobile activities. This study therefore seeks to evaluate the concentrations of heavy metals and PAHs in some selected vegetables commonly cultivated along some major roads around Port Harcourt.

Heavy metal contamination of vegetables poses a serious health threat to the food chain. Population expansion, increased industrial activities, increase in vehicular activities are the several ways anthropogenic activities contribute to the pollution of the environment in Port Harcourt metropolis. As automobile activities in the town increases, there is a possibility of increase in the accumulation of heavy metals in vegetables planted along roadsides beyond the WHO/FAO, US-EPA acceptable limits.

Roadside gardens are common place in Port Harcourt metropolis. Due to increase urbanization, available open spaces along major roads are being utilized by farmers to grow gardens and the likelihood of these crops getting contaminated cannot be overemphasized. There is a high rate of consumption of the vegetables in and around Port Harcourt, both in boiled and raw form by citizens.

With the continuous awareness on environmental pollution and its attendant consequence on human health, soils and vegetation, the knowledge of the heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs) contamination of edible vegetables especially those grown along major traffic routes around Port Harcourt metropolis would help in providing information to farmers and consumers on the best location to plant and /or buy vegetables. It can equally help health officials in investigating illnesses in the sense that heavy metal poisoning could form part of the query during medical diagnosis.

Vegetables are important for human diet due to their nutrients content which includes minerals, vitamins, carbohydrates, proteins and fibers, but if they contain high levels of heavy metals, their consumption becomes a source of health concern to both humans and animals.

Due to rapid urbanization, Port Harcourt and its environs is growing in population hence, the demand for food crops is rising by the day, and as vegetables can be grown in small fields with intensive use of inputs within shorter period, its cultivation is gaining popularity and fetching profitability in semi-urban areas of mega cities. This is a matter of serious concern since vegetables particularly leafy ones, being prolific accumulators of heavy metals provide an easy entry into food chain to these metals. Many people also prefer to consume Pumpkin and Bitter Leaf in their raw state instead of boiled.

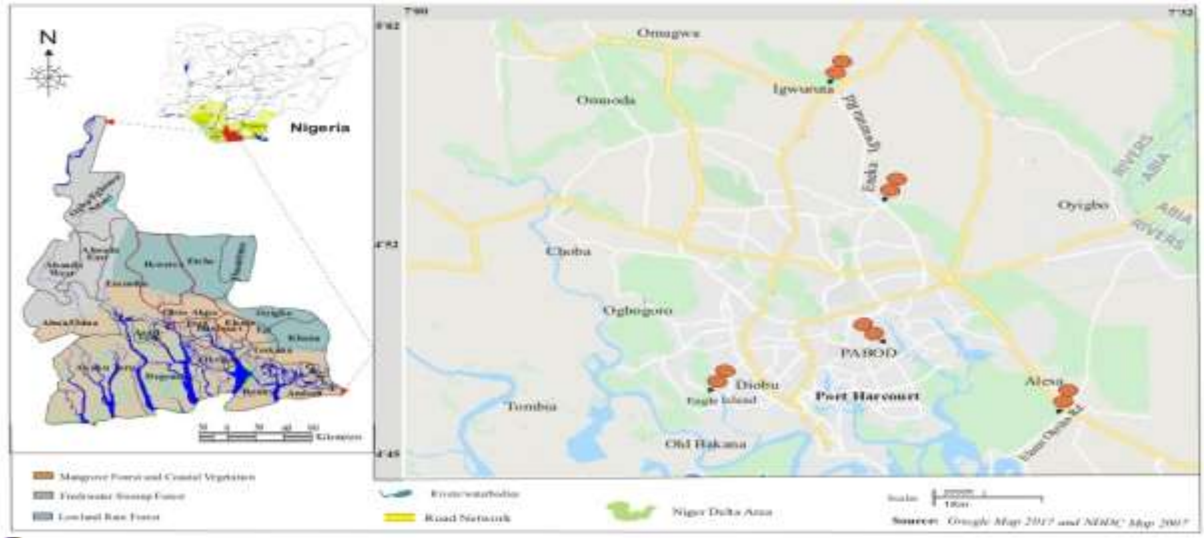
The occurrence of high heavy metals content in edible plants is of considerable importance, since they might constitute a possible toxicological hazard. Heavy metals, when concentrated in living organisms beyond acceptable limits should be regarded as toxins towards mammals and particularly humans (Kalagbor, 2014).

From this study therefore awareness will be created amongst the populace of the study area and fill existing gaps on the concentrations of heavy metals and PAHs in some edible vegetables cultivated along some major roads around Port Harcourt. The aim of this study is to evaluate the levels of Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals in some edible vegetables along roadsides in Port Harcourt metropolis.

II. Materials And Methods

Study Area

The study areas are located in Port Harcourt, Eleme, Ikwerre and Obio/Apor Local Government Areas of Rivers State, Nigeria. Rivers state is located in the Niger Delta region of Nigeria's South-South Geo-political Region. Port Harcourt city lies between longitude 07^{o} 1' East and latitude 4^{o} 5'North on an elevation of 20meters (60 feet above sea level) (Ideriah *et al*., 2018). The sampling areas were selected based on their traffic density.



Location of sampling

Fig. 1 Map showing the sample collection areas around Port Harcourt

Table 1 Identification and description of sampling location

SAMPLE	LOCATION	GPS Longitude	GPS Latitude
Bitter Leaf	Eleme-Okrika Road	007^{o},006',59^{s}, East	04^{o}, 47',0.8^{s} North
Pumpkin	Eleme –Okrika Road	007^{o},06',52.7^{s}, East	04^{o},46',5.8^{s} North
Bitter Leaf,	Eneke-Igwuruta road	007^{o}, 01', 31.6^{s}, East	04^{o}, 53,2', 39^{s} North
Pumpkin,	Eneke-Igwuruta road	007^{o}, 05', 58.7^{s}, East	04^{o},43' ,5.8^{s} North
Bitter Leaf	Igwuruta- Omagwa road,	007^{o}, 0', 25^{s}, East	04^{o}, 57',28.2^{s} North
Pumpkin,	Igwuruta- Omagwa road,	007^{o}, 07', 2.7^{s}, East	04^{o},44', 8^{s}.0 North
Bitter Leaf	PABOD Road(Oginigba)	007^{o}, 02.8'.3^{s}, East	04^{o},49', 38.9^{s} North
Pumpkin,	PABOD Road(Oginigba)	007^{o},02,5',6.6^{s}, East	04^{o},49',36.7^{s} North
Bitter Leaf	Eagle Island(Redeem Road),	006^{o},58', 37.5^{s} , East	04^{o}, 47', 044^{s} North
Pumpkin,	Eagle Island (Redeem Road)	006^{o}, 49, 52.7^{s}, East	04^{o},47,5.2^{s}. North

Only vegetable farms located 10-50meters from the roadside were considered for the study but the control area was 80-100meters from the road.

Determination of Traffic Density in the Study Areas

AL Sayed & Mousa (2016) method of traffic density determination was applied in determining the traffic densities of the selected study areas. Four young men were recruited for the exercise. One stood at ordinance junction in Obio/Akpor LGA to take count of vehicular traffic along PABOD road at Oginigba, one stood at Iloabuchi to Eagle Island Junction to take count of vehicular movement at Eagle Island road in Port Harcourt LGA, one stood at Igwuruta Round-about to take count of vehicular movement along Igwuruta – Omagwa road, one stood at the "C-4-I" police check point to take count of vehicles plying the Eneka-Igwuruta road in Ikwerre LGA and the last stood at the refinery junction to take count of vehicles along the Eleme-Okrika road.

GSM phones were given to the young men and alarm set for counting to start simultaneously between the hours of 7:00am to 9:00am and 4:00pm to 8:00pm. These are considered the peak periods of traffic (Motorcycle, Tricycle, Vans, Buses and Trucks) flow within Port Harcourt and its environs. Vehicle count was made at every 10mins intervals irrespective of the direction, speed, size and type of vehicle and the average was calculated. The process was repeated on Mondays, Wednesdays and Fridays for three weeks in the month of October 2019. The month of October was chosen because it is an active schooling period from primary to tertiary in addition to other commercial and secular activities. Eagle Island road was used as the control. The result of traffic densities is tabulated in chapter four.

Sample Collection

Edible parts of Bitter Leaf and Pumpkin were collected in duplicate at a distance between 10-50m from the roadside wherever they were found along the selected routes using thoroughly washed stainless kitchen knife into Polyethene bags and taken to the laboratory for preservation, processing and analysis. A total of 10 (ten) samples were collected. A control sample from a less busy traffic area in Eagle Island, Port Harcourt was also collected.

Samples Analysis

The standard procedure described by the Association of Official Analytical Chemists (AOAC, 2002) was used in the sample analysis.

1) A Clean, dry and Ignite Silica dish was covered at 500^{o}C for 30minutes in a furnace. It was then cooled in a desicator and weighed and the process was repeated until a constant weight was obtained.

2) Accurately 5g of the sample was then weighed into the dish, burn, slightly opening the cover for escape of gases at 500^{o}C, checking periodically for complete ashing i.e. when a white residue remains in the silica dish.

The process was repeated for the two vegetable samples, Bitter Leaf and Pumpkin

Calculation.

$$\%\ Ash\ content = \frac{weight\ of\ ash}{weight\ of\ sample}\ x\ 100$$

Polycyclic Aromatic Hydrocarbons (PAHs)

Crushed Leaf sample 2g each was acidified by adding 1:1 HCl to 5ml of the acidified 2g sample. The acidified sample was filtered using Whatman filter paper no 1. With the aid of forceps, the filter paper was transferred to a watch glass. The entire filtrate containing samples was fitted into an extraction thimble. Before then, the thimble was dried in a hot-air oven at 103^{o}C for 30min and filled with wool. The extraction flask was weighed and oil was extracted in a Soxhlet apparatus at the rate of 20cycles/h for 4h.

Calculation:

Milligram of oil (PAH)/L = (A-B) x 100/ml sample,

where A is the initial weight of sample and B is the final weight of sample.

Metal Contamination Indices and Potential Ecological Risk.

The under listed contamination indices were adopted to evaluate the level of contamination of the vegetable samples collected from the different locations around Port Harcourt.

(i) Degree of contamination (CD); (ii) modified degree of contamination (mCD); (iii) Contamination factor (Cf); Metal Pollution index(MPI) (iv). It is calculated as the geometric mean of concentration of all metals in edible part of plant in the different sample location (Benson *et al*., 2016 and Usero *et al.* 1998). The CD was calculated as the overall impact of the study metals on the sampled locations around Port Harcourt using the formula developed by (Hakanson,1998), CD = Cfi,

$$CD = \sum_{i=1}^{n} Cfi$$

$$Cf_i = \left[\frac{C^i mconc}{C^i bkg}\right]$$

Where Cfi is contamination factor of metal i, $C^i{}_{mconc}$ is mean concentration, and $C^i{}_{bkg}$ is background value of individual metal. The degree of contamination is classified into low degree of contamination (CD ≤6), moderate degree of contamination (6<CD ≤ 12), considerable degree of contamination (12< CD ≤24), and very high degree of contamination (CD > 24). (Benson *et al*., 2016). The Cf is derived by dividing the concentration of selected trace metal by the background value. The gradation of Cf is as follows: (Cf <1) indicates low degree of contamination; (1≤Cf <3) indicates moderate contamination; (3≤Cf <6) indicates considerable contamination; and (Cf ≥6) shows very high degree of contamination.(Benson *et al*., 2016)

Metal Pollution Index

The MPI was employed to make comparison between the total metal concentrations of the sampled vegetables with permissible limits. MPI is classified as follows according to the contamination degree: unpolluted (0<MPI≤1), unpolluted to moderately polluted (1<MPI≤2), moderately polluted (2<MPI≤3), moderately to highly polluted (3<MPI≤4), highly polluted (4<MPI≤5), or very highly polluted (MPI>5), using the formula;

MPI (mg/kg) = $(C_1 \times C_2 \times C_3 \times \cdots \times C_n)$ /1_n (Chen *et al*., 2015).

where n is the number of metals and C_n is the concentration of metal in the vegetable samples on dry weight basis.

III. Results And Discussion

Eleme-Okrika road had an average of 105 vehicles in every 10mins, Eneka-Igwuruta had approximated average of 86 vehicles per every 10mins, Igwuruta Omagwa had average of 105 vehicles in every 10mins, PABOD road gave approximated average of 75 vehicles in every 10mins while Eagle Island recorded approximate average of 50 vehicles every 10mins.

The results of the analysis of the concentration of heavy metals and PAHs in the selected vegetable samples along traffic routes at the different locations around Port Harcourt are presented in Figures 4.1 to 4.26.

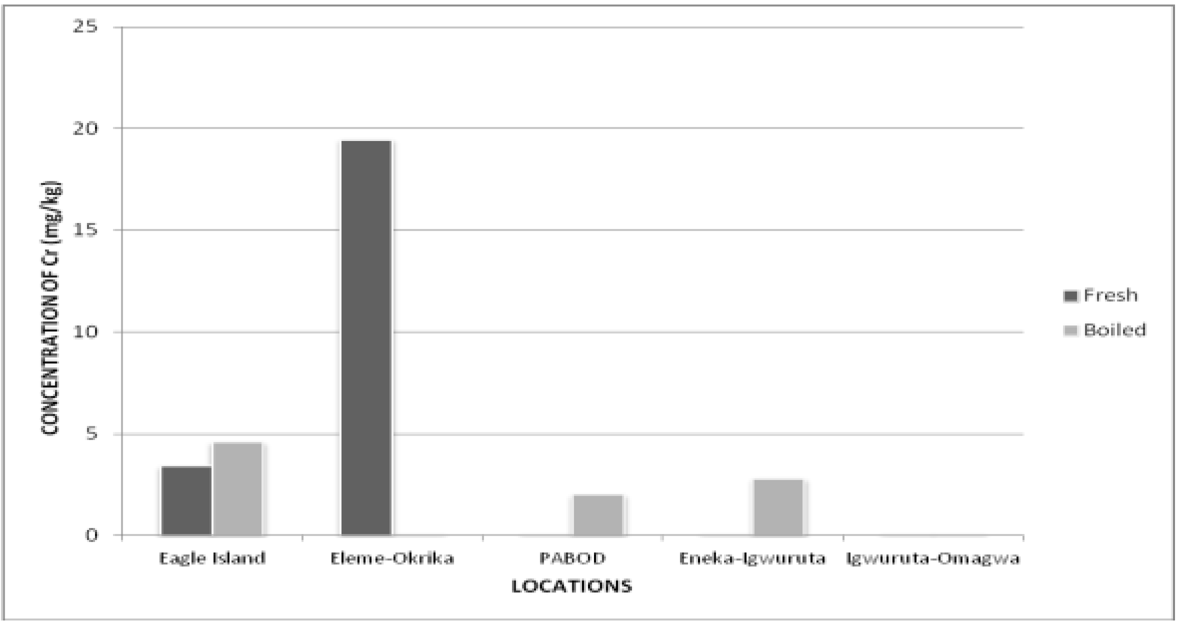


Figure 1: Comparison of concentrations of Chromium in Fresh and Boiled Pumpkin leaf

Figure 1 shows that the highest concentration of Chromium in fresh Pumpkin was recorded along Eleme-Okrika followed by the sample from Eagle Island road; samples collected from PABOD, Eneke-Igwuruta and Igwuruta-Omagwa roads were below detection limits (<0.001mg/kg). However in boiled pumpkin leaves, Cr was below detection limits in samples from Eleme-Okrika and Igwuruta –Omagwa roads, while concentrations of 4.598 mg/kg, 2.79 mg/kg and 2.00 mg/kg were obtained from Eagle Island road, PABOD and Eneka-Igwuruta road respectively. Analysis of Variance (ANOVA) showed that there was no significant difference in the concentrations of Cr between sampling locations (p=0.557361), as well as between boiled and fresh samples.

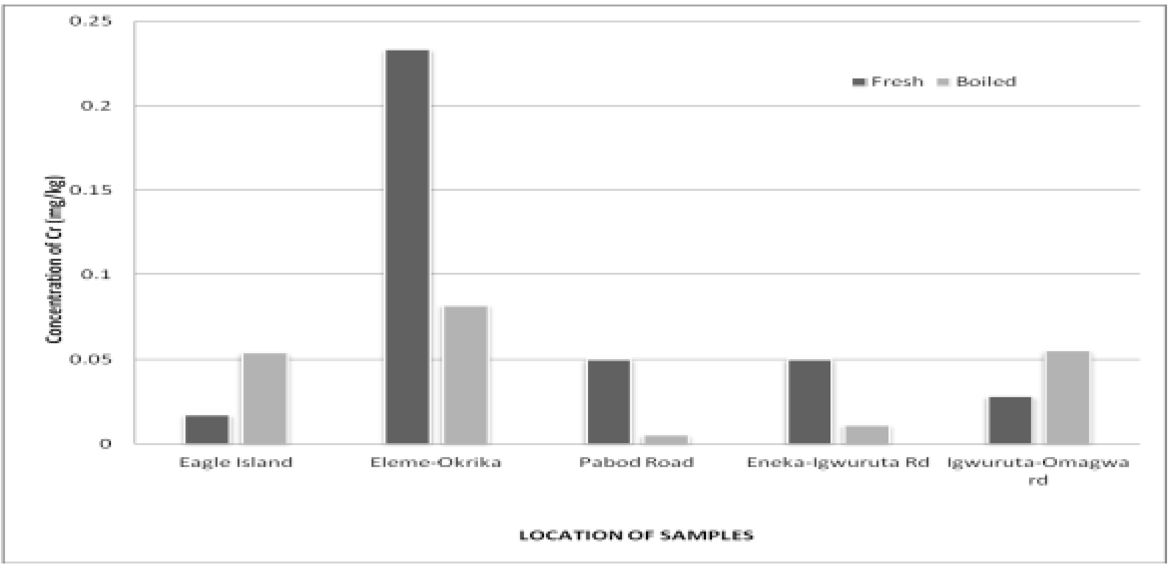


Figure 2: Comparison of concentration of Cr in Fresh and Boiled Bitter leaf

In Fig. 2, it can be seen that Eleme-Okrika, PABOD and Eneka-Igwuruta roads have higher concentration of Cr in fresh Pumpkin compared with Eagle Island and Igwuruta – omagwa roads.

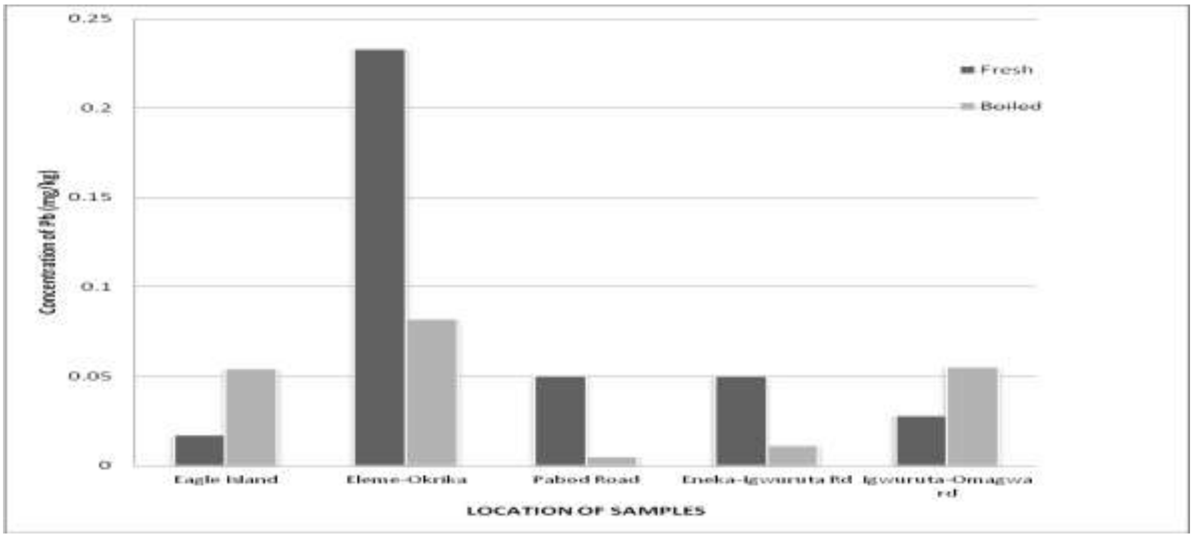


Figure 3: Comparison of concentration of Pb in Fresh and Boiled Pumpkin

From Fig 3 there is equally a significant presence of Pb in fresh Pumpkin at Eleme-Okrika, PABOD and Eneka-Igwuruta roads when compared with other locations. Boiling reduced the concentration of Pb in Samples collected from Eleme-Okrika, PABOD and Eneka-Igwuruta while there was increase in concentration of Pb in boiled samples collected from Igwuruta-Omagua and Eagle Island road. It can also be seen that there is a higher level of Pb in Pumpkin samples collected from Eleme-Okrika when compared with that collected from Eagle Island.

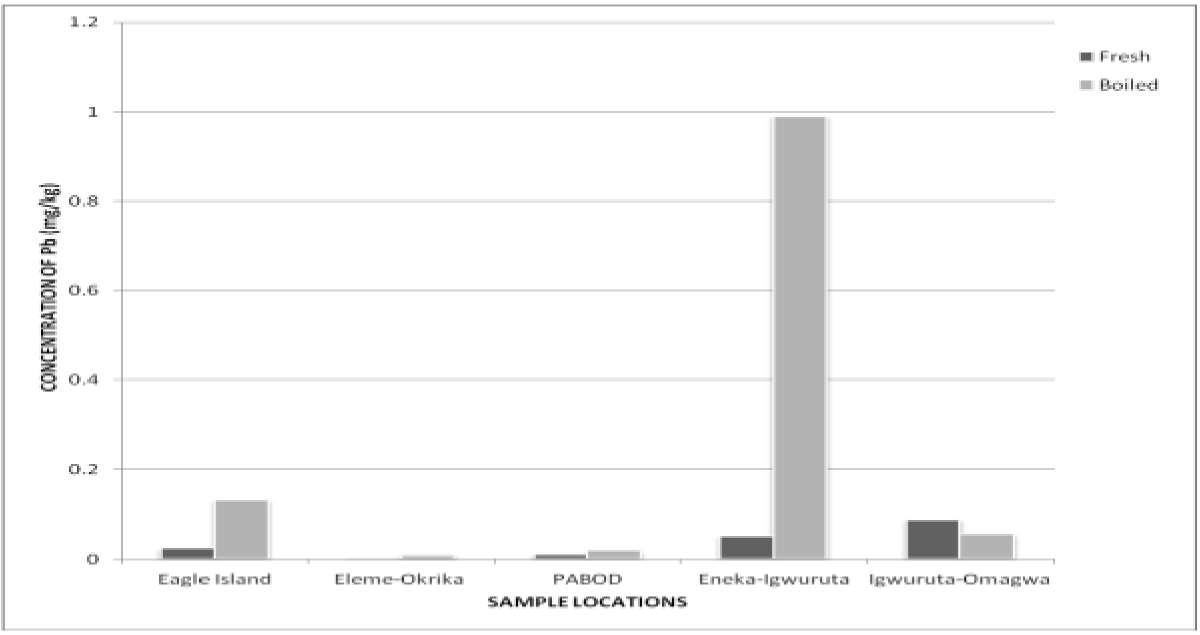


Figure 4: Comparison of concentration of Pb in Fresh and Boiled Bitter Leaf

From Fig 4, Pb shows a higher concentration in boiled Bitter Leaf at Eneka-Igwuruta road when compared with other locations. When boiled, the metal content in Bitter Leaf increased in all the sample locations except for Igwuruta-Omagwa road. Also Bitter Leaf showed a higher concentration of Pb at Eagle Island when compared with Eleme-Okrika.

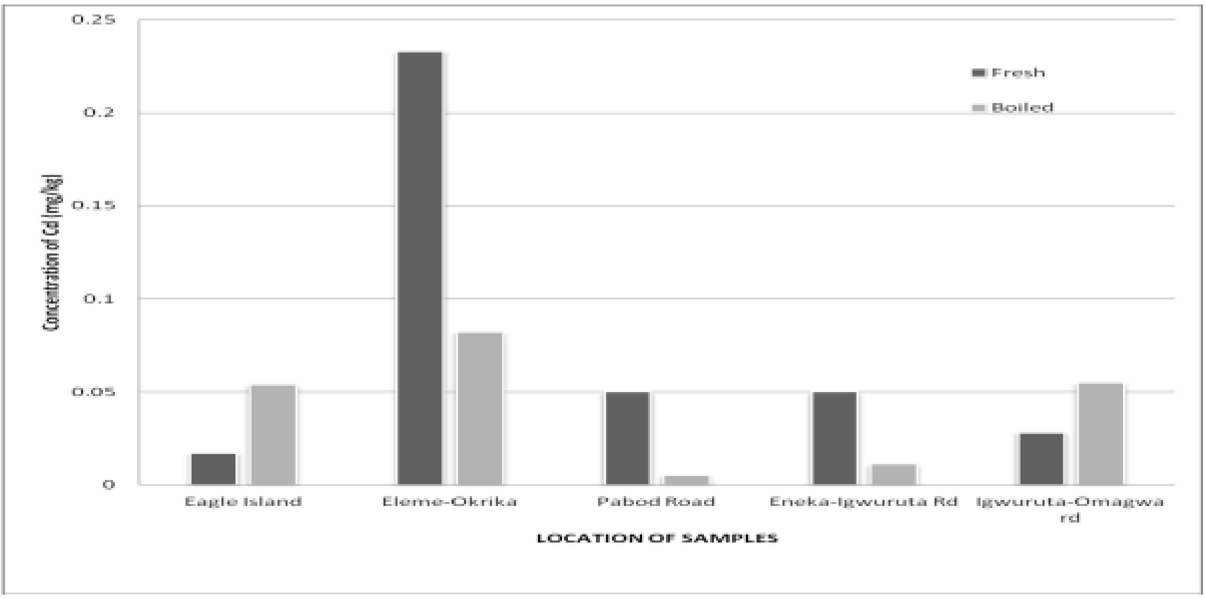


Figure 5: Comparison of concentration of Cd in Fresh and Boiled Pumpkin

From Fig 5, boiling increased the concentration of Cd in Pumpkin as seen at Eagle Island and Igwuruta-Omagwa. But at Eleme-Okrika, PABOD and Eneka-Igwuruta roads Cd showed lower concentration when boiled. Comparing Eleme-Okrika and Eagle Island, Cd had a higher concentration at Eleme-Okrika than Eagle Island.

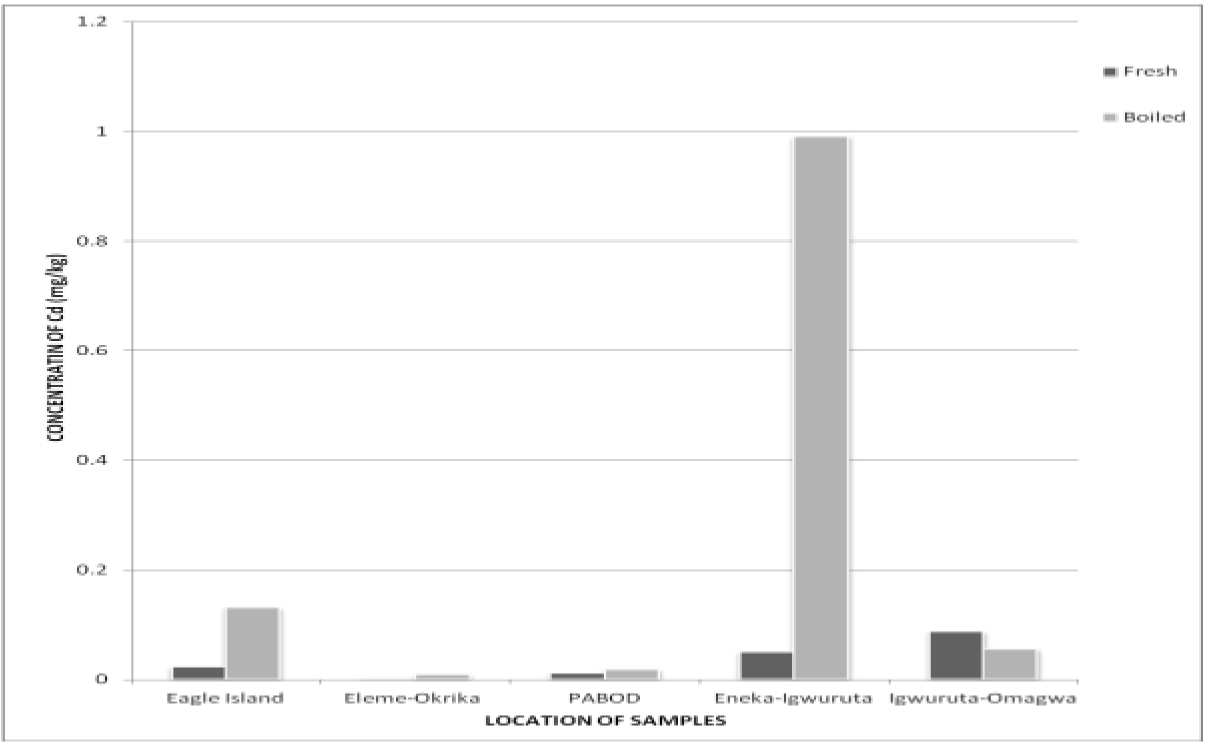


Figure 6: Comparison of concentration of Cd in Fresh and Boiled Bitter Leaf

From Fig 6, Bitter Leaf when boiled increased the concentration of Cd in all the sample locations except for Igwuruta-Omagwa road. But comparing Eleme-Okrika and Eagle Island road, Cd is higher in fresh Pumpkin from Eagle Island even when boiled.

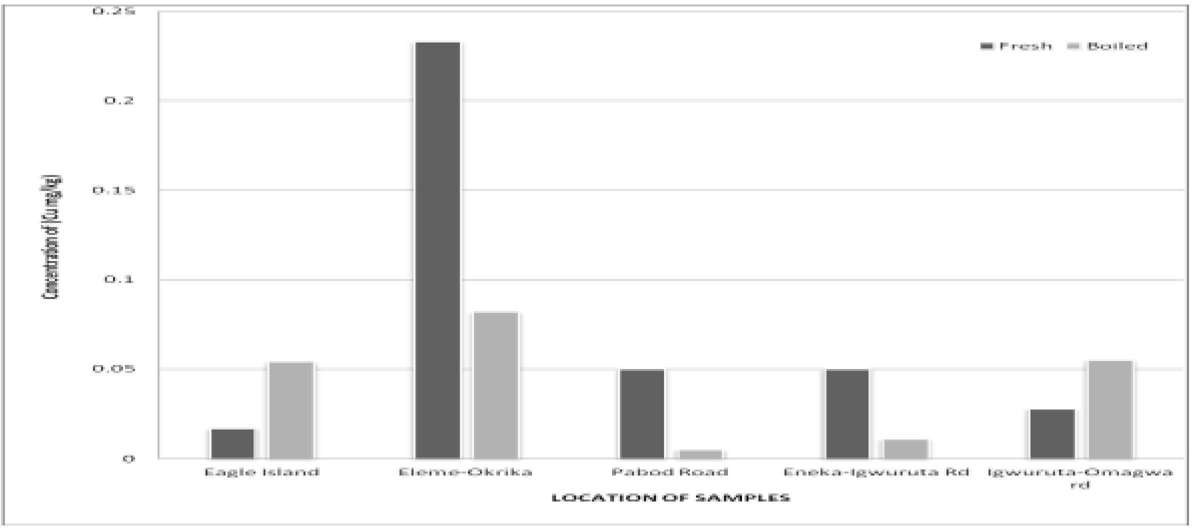


Figure 7: Comparison of concentration of Cu in Fresh and Boiled Pumpkin

In Fig 7, the concentration of Cu increased in boiled Pumpkin at Eagle Island and Igwuruta-Omagwa, but at Eleme-Okrika, PABOD and Eneka-Igwuruta there was a higher concentration of Cu in fresh Pumpkin as can be seen from the above graphical presentation. There was also a considerable higher level of Cu in Pumpkin Samples collected from Eleme-Okrika road than Eagle Island road.

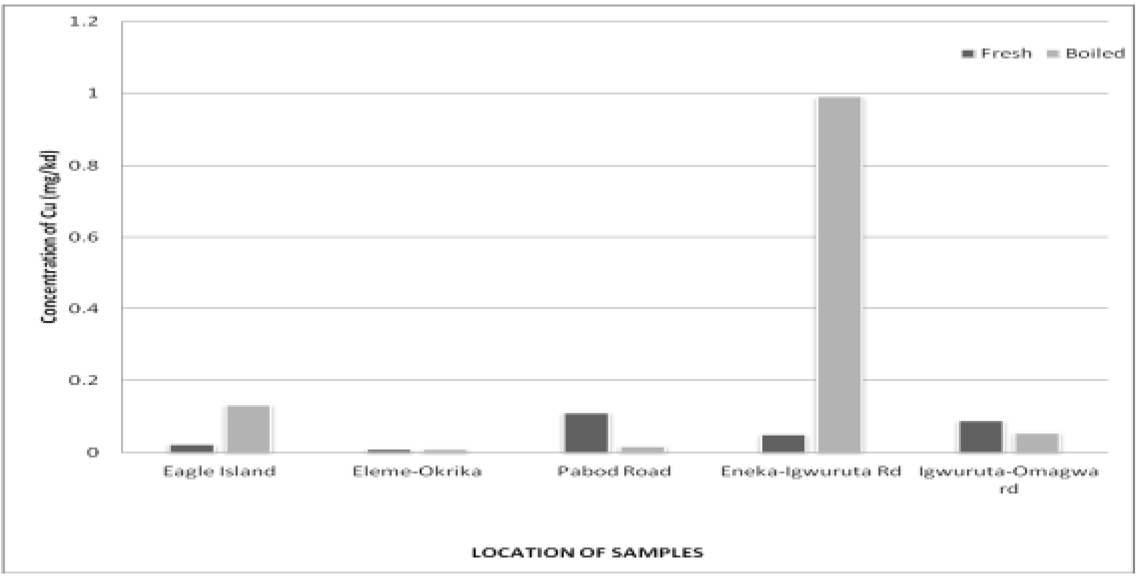


Figure 8: Comparison of concentration of Cu in Fresh and Boiled Bitter Leaf

From Fig. 8, the trend of Bitter Leaf showing increase in metal concentration when boiled continued here as can be seen in the above chart. Samples collected from Eagle Island and Eneka-Igwuruta roads are typical examples, but the case was not the same for samples collected from Eleme-Okrika, PABOD and Igwuruta-Omagwa roads as these showed a higher concentration of Cu in the fresh Pumpkin. But Bitter Leaf Samples collected from Eagle Island recorded a high level of Cu in comparison with Eleme-Okrika.

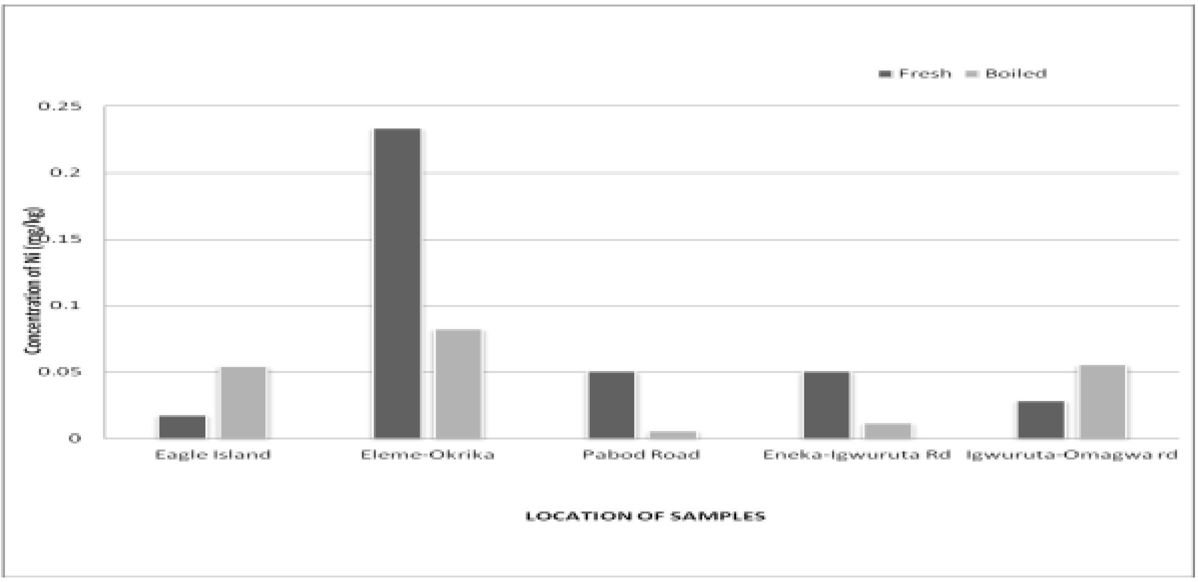


Figure 9: Comparison of concentration of Ni in Fresh and Boiled Pumpkin

From Fig 9 the effect of boiling on Ni concentration is also seen in Eleme-Okrika, PABOD and Eneka-Igwuruta roads that it recorded a lower concentration while Eagle Island and Igwuruta-Omagwa showed a higher concentration of Ni when boiled. Both fresh and boiled Pumpkin in samples collected from Eleme-Okrika road showed a higher level of Ni compared with Eagle Island.

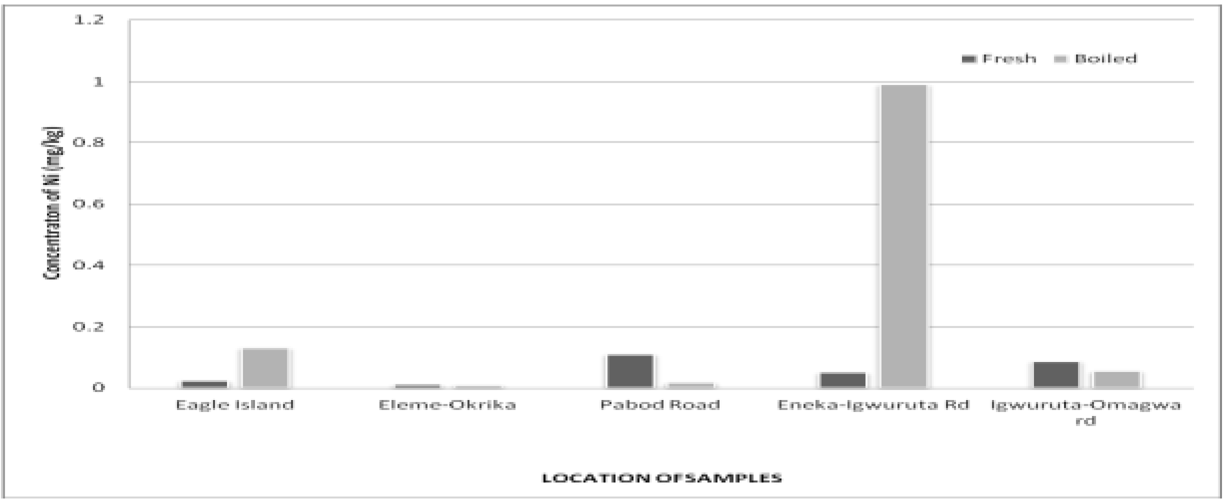


Figure 10: Comparison of concentration of Ni in Fresh and Boiled Biter Leaf

In Fig. 10 the concentration of Ni in boiled and fresh Bitter Leaf (0.009mg/kg and 0.01mg/kg respectively) was almost the same at Eleme-Okrika as can be seen from the chart above, however, the average concentration showed that Ni had a higher concentration in boiled Bitter Leaf at Eagle Island, Eneka-Igwuruta, but fresh Bitter Leaf had a higher level of Ni in samples taken from PABOD and Igwuruta-Omagwa road. However, comparing Eleme-Okrika and Eagle Island, there is a slightly higher concentration of Ni in Samples collected from Eagle Island than Eleme-Okrika road.

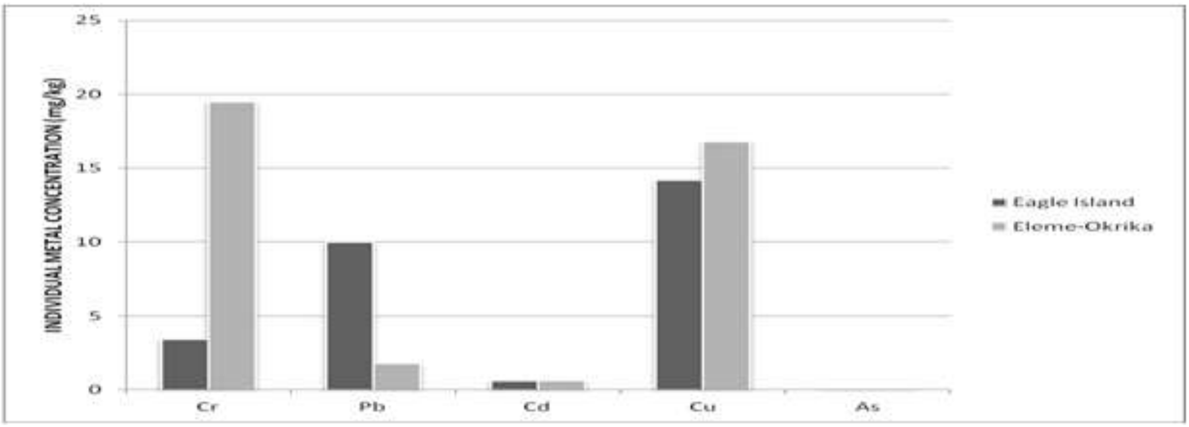


Fig. 11 Comparison of concentration Heavy Metals in Fresh Pumpkin leaf at Eleme-Okrika and Eagle Island area.

From Fig. 11 it can be seen that Pb showed a different characteristics being that it's the only heavy metal with a higher concentration at Eagle Island whereas Cr, Cd and Cu showed higher concentration in fresh pumpkin samples from Eleme-Okrika road than Eagle Island. Arsenic however remained below detection limit at both locations.

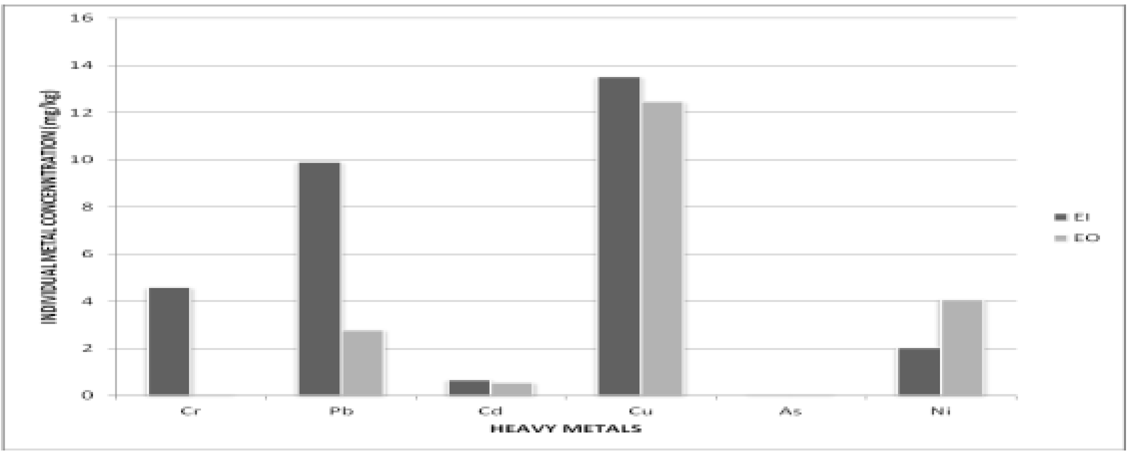


Fig. 12 Comparison of concentration Heavy Metals in Boiled Pumpkin leaf at Eleme-Okrika and Eagle Island area.

In boiled Pumpkin leaf all heavy metals but Ni recorded a higher concentration in samples collected from Eleme-Okrika road than Eagle Island road as can be seen in Fig. 12.

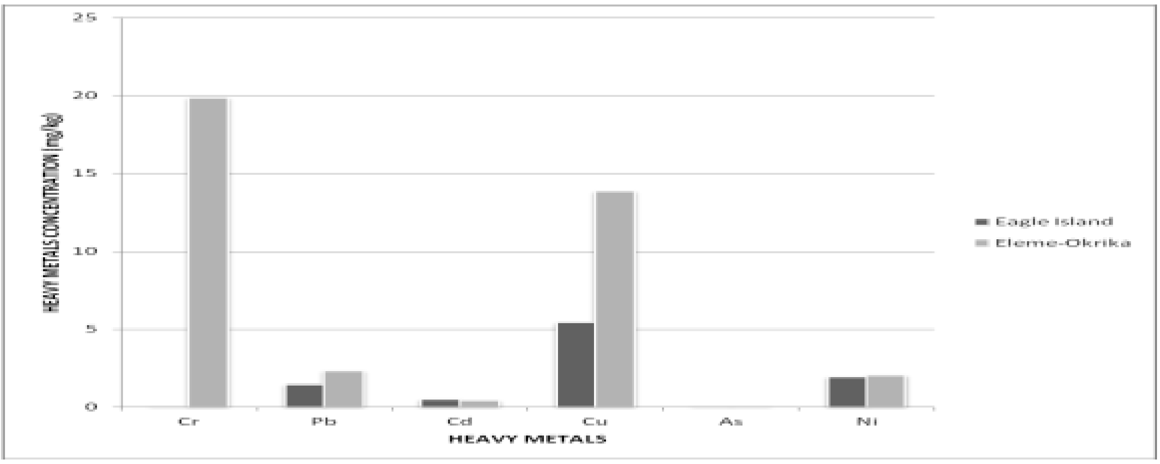


Fig. 13 Comparison of concentration of Heavy Metals in Fresh Bitter leaf from Eleme-Okrika and Eagle Island

Fig. 13 shows metals concentration is higher in fresh Bitter leaf from Eleme-Okrika road than Eagle Island. Only Cd presented a slightly higher concentration at Eagle Island.

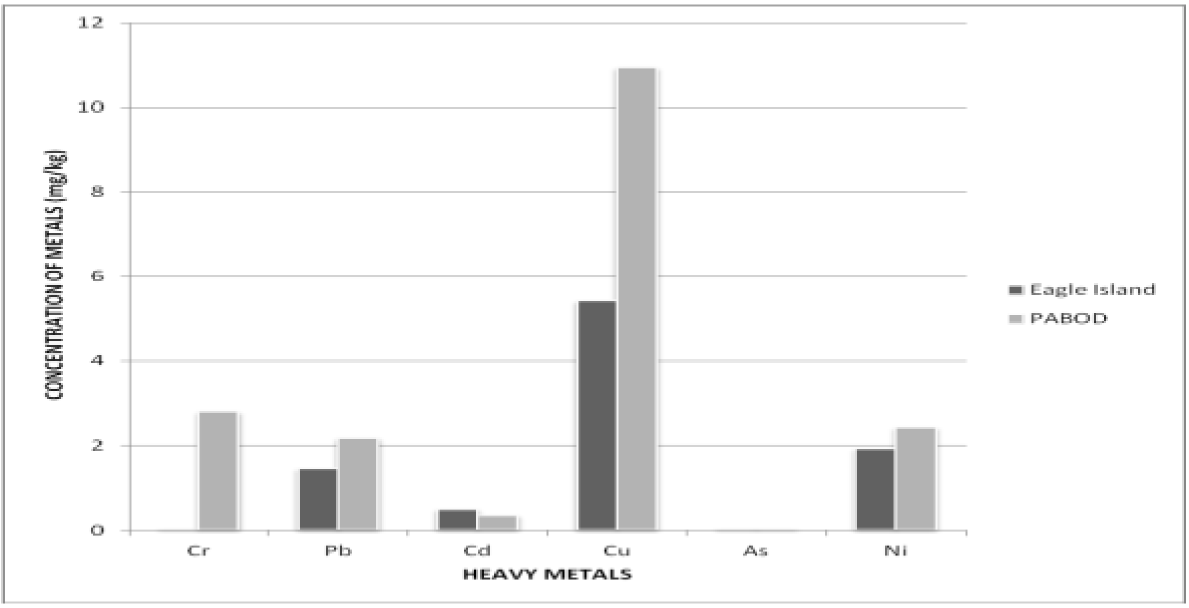


Fig. 14 Comparison of concentration Heavy Metals in Fresh Bitter leaf at PABOD road and Eagle Island road

From Fig. 14 all but Cd metal showed a higher concentration in fresh Bitter leaf at PABOD road when compared with Eagle Island sample.

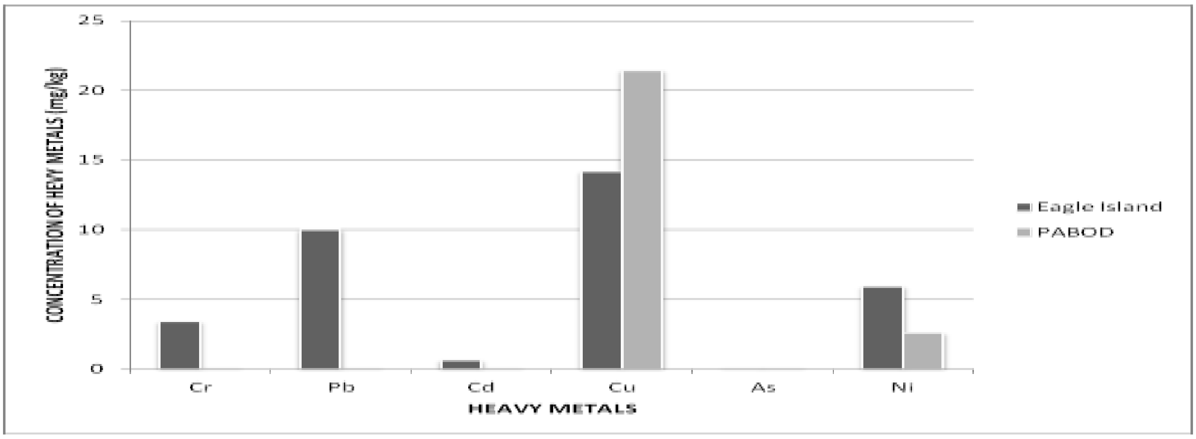


Fig. 15 Comparison of concentration of Heavy Metals in Fresh pumpkin at PABOD and Eagle Island road

From Fig. 15 Cu presents a more significantly higher level of concentration in fresh Pumpkin at PABOD road while other study metals are lower than the control area.

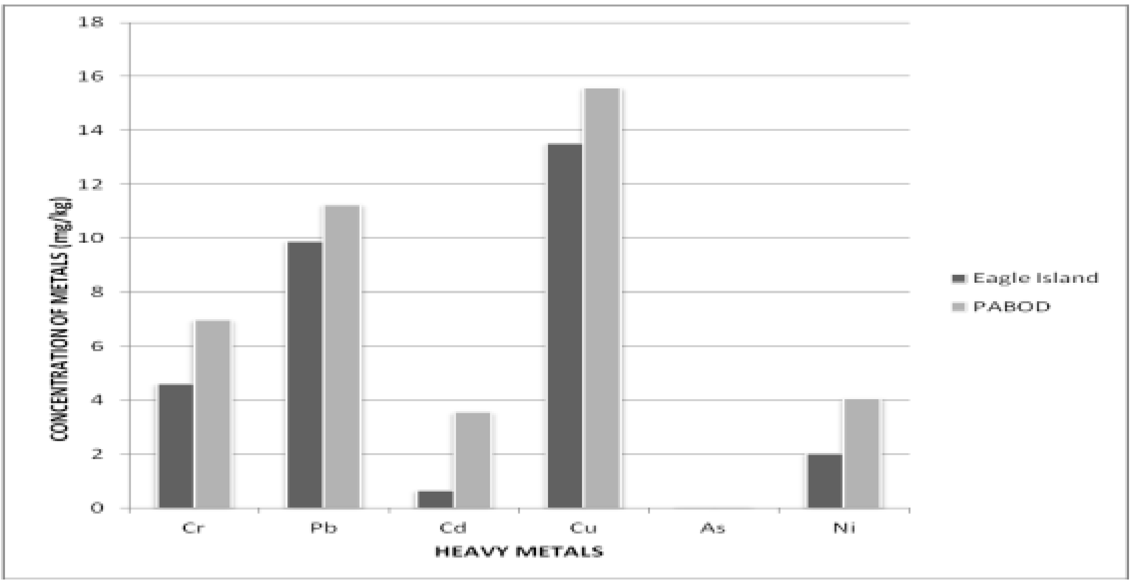


Fig. 16 Comparison of concentration of Heavy Metals in Boiled Pumpkin leaf at PABOD and Eagle Island

When boiled, Fig. 16 shows that the metals' concentrations are higher in samples collected from PABOD road than Eagle Island with Cu recording the highest concentration.

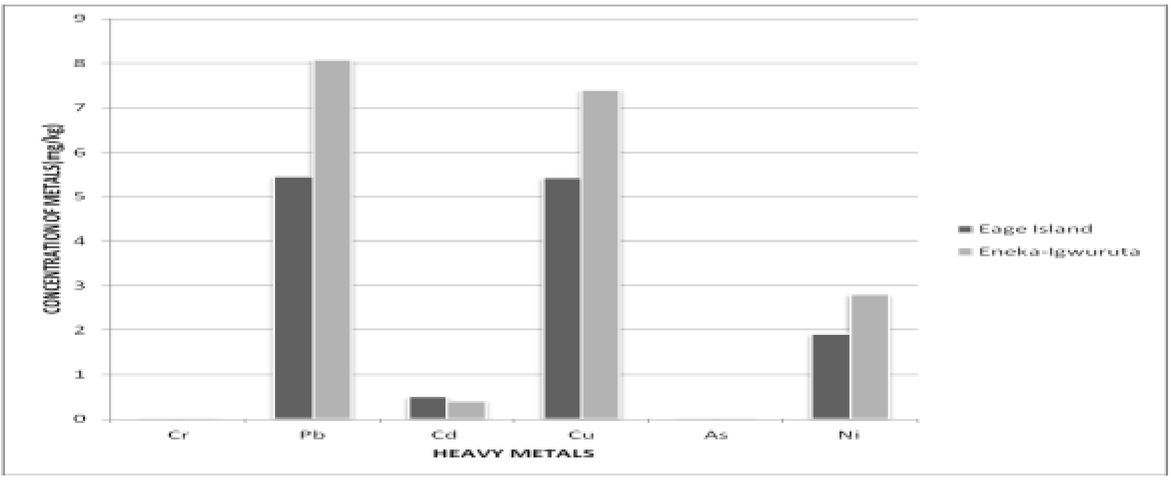


Fig. 17 Comparison on concentration of metals in Boiled Bitter leaf from Eneka-Igwuruta and Eagle Island

Figure 17 also showed that the trend is the same. Heavy metals showed higher concentration in boiled Bitter leaf from Eneka-Igwuruta road when compared with samples from Eagle Island except for Cd.

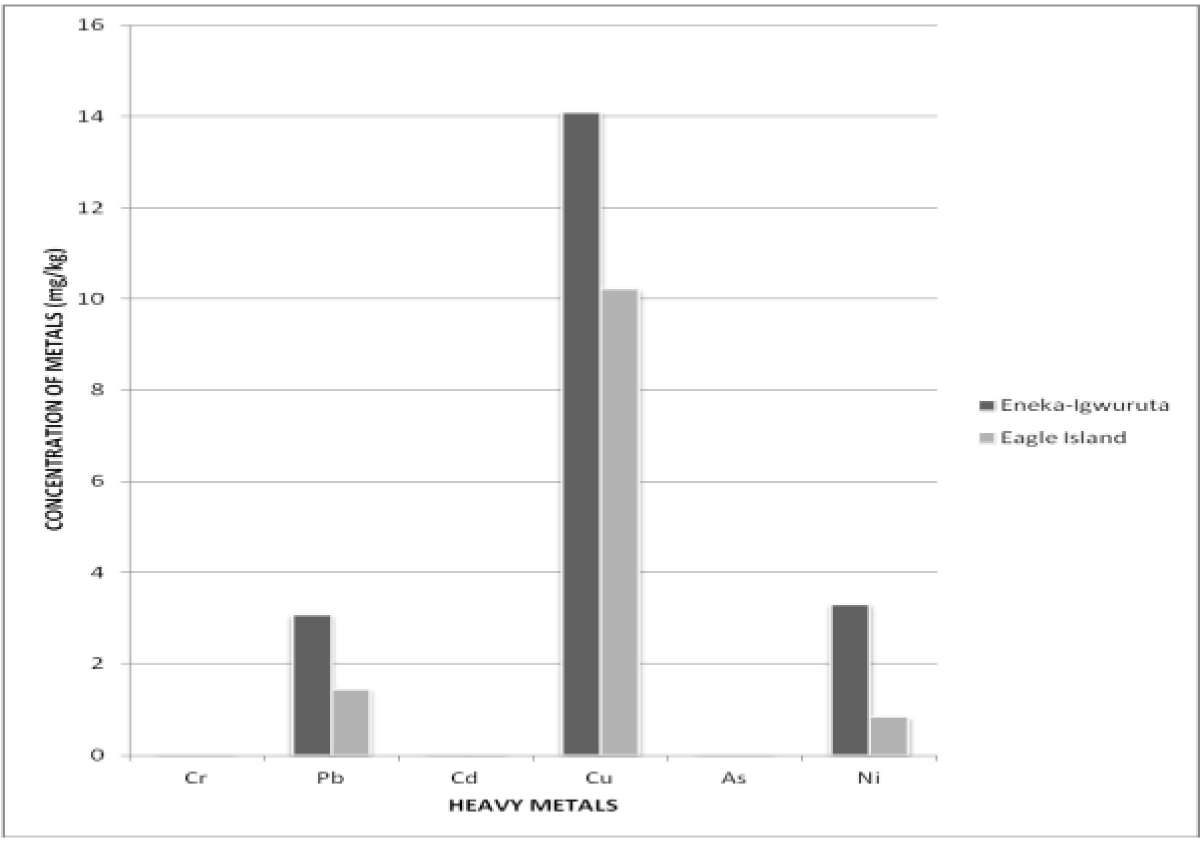


Fig. 18 Comparison of concentration of heavy metals in Fresh Bitter leaf from Eneka-Igwuruta and Eagle Island

Figure 18 shows that fresh Bitter leaf samples from Eneka-Igwuruta road contains higher concentration of heavy metals than the samples from Eagles Island road

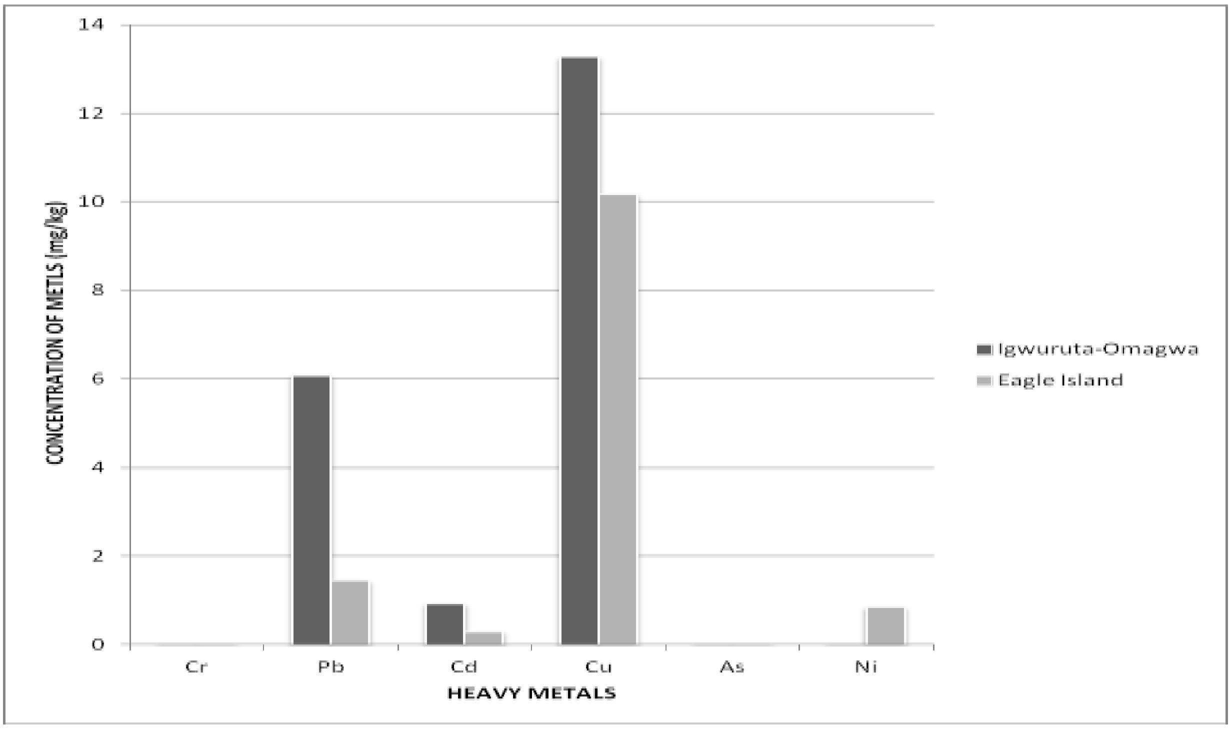


Fig. 19 Comparison of concentration of metals in Boiled Bitter leaf from Igwuruta-Omagwa and Eagle Island

Figure 19 shows that when boiled, Bitter leaf samples from Igwuruta-Omagwa road contains higher concentration of heavy metals than sample from Eagle Island area

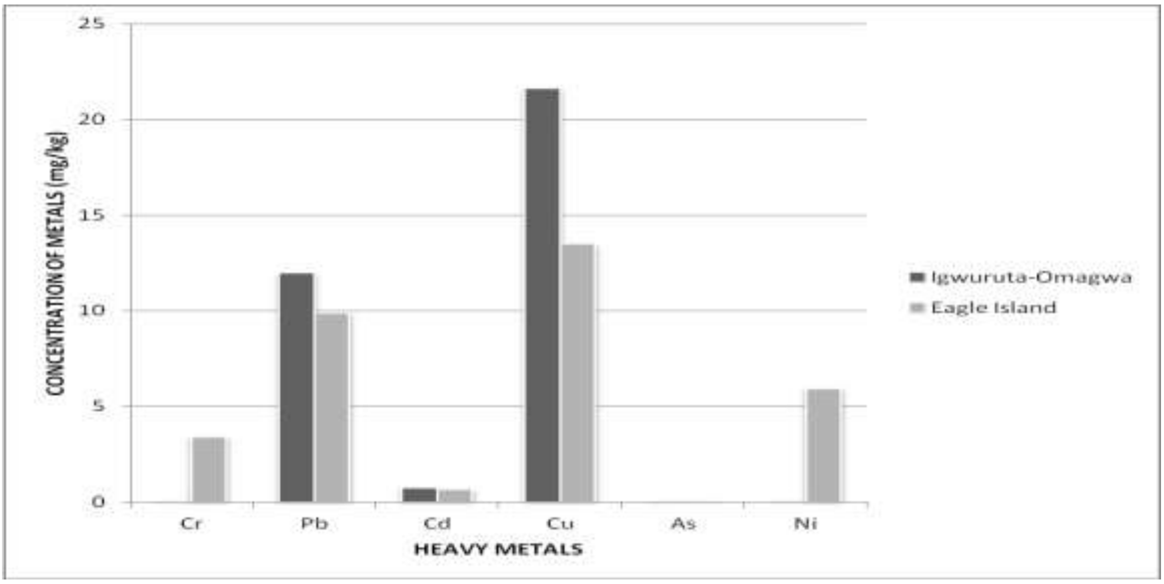


Fig 20 Comparison of concentration of heavy metals in Fresh Bitter leaf from Igwuruta-Omagwa and Eagle Island.

From Fig. 20 Pb, Cd, and Cu showed higher concentration in fresh Bitter leaf collected along Igwuruta-Omagwa road than samples collected from Eagle Island except for Ni and Cr that are both higher at Eagle Island.

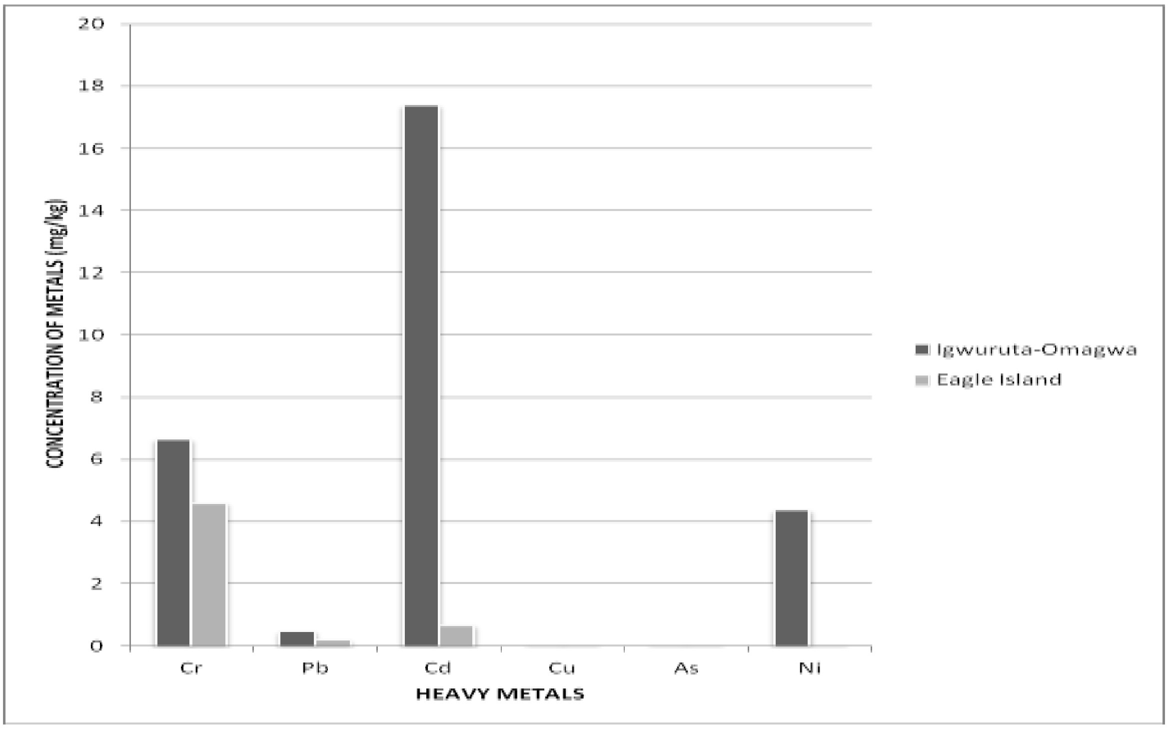


Fig. 21 Comparison of concentration of heavy metals in Boiled Pumpkin leaf from Igwuruta-Omagwa and Eagle Island

Figure 21 shows that when boiled, metals' concentration maintained higher values in Pumpkin sample from Igwuruta-Omagwa than Eagle Island.

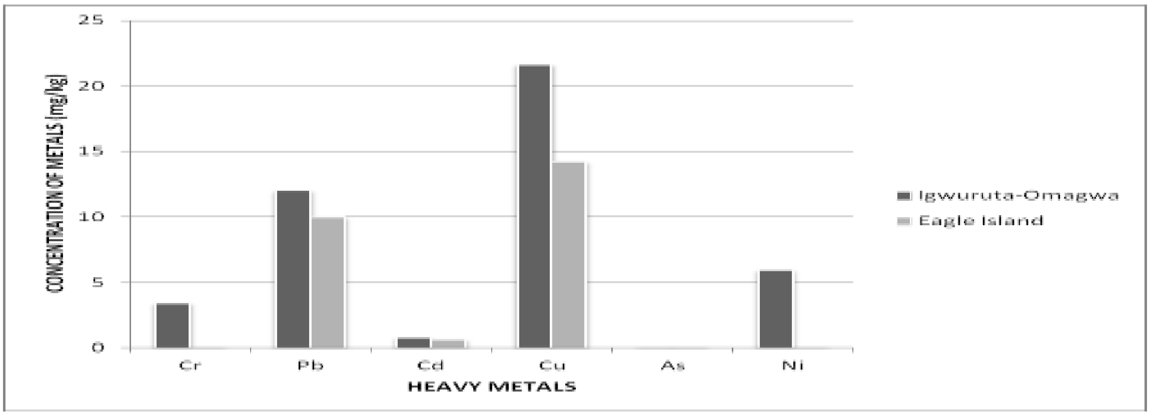


Fig. 22 Comparison of concentration of heavy metals in Fresh Pumpkin leaf from Igwuruta-Omagwa and Eagle Island.

Figure 22 also presents higher levels of heavy metals in samples collected from Igwuruta-Omagwa road. Igwuruta-Omagwa road is quite some distance away from Eagle Island and has higher traffic density when compared with Eagle Island area.

Table 1. Pollution indicators for heavy metals from the sample locations

Pollution indices		Samples Sites(**Pumpkin Fresh**)					Samples Sites(**Pumpkin Boiled)**				
		EI	**E-O**	**PAB**	**E-IG**	**IG-OMG**	**EI**	**E-O**	**PAB**	**E-IG**	**IG-OMG**
Cf	**Cr**	1.70	9.73	0.00	0.00	0.00	1.70	9.73	0.00	0.00	0.00
	Cu	7.09	8.40	10.72	10.72	10.81	7.09	8.40	10.72	10.72	10.81
	Cd	0.31	0.30	0.00	0.00	0.38	0.31	0.30	0.00	0.00	0.38
	Pb	5.00	0.87	0.00	0.00	6.00	5.00	0.87	0.00	0.00	6.00
	Ni	2.72	2.31	1.27	1.27	0.00	2.72	2.31	1.27	1.27	0.00
	As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PAH	0.001	0.12	0.03	0.03	0.04	0.001	0.12	0.03	0.03	0.04
CD		17.08	21.73	12.02	12.02	17.20	15.43	9.97	8.13	8.45	15.85
mCD		2.44	3.10	1.71	1.71	2.46	2.20	1.42	1.16	1.20	2.26

Table 2. Pollution indicators for heavy metals from the sample locations

Pollution indices		Samples Sites(**Bitter leaf -Fresh)**					Samples Sites(**Bitter Leaf- Boiled)**				
		EI	**E-O**	**PAB**	**E-IG**	**IG-OMG**	**EI**	**E-O**	**PAB**	**E-IG**	**IG-OMG**
Cf	**Cr**	0.00	9.93	1.40	9.90	0.00	0.00	0.00	0.90	0.00	0.00
	Cu	2.71	6.92	5.47	3.50	10.82	5.11	8.98	4.49	9.04	8.69
	Cd	0.25	0.22	0.18	0.18	0.37	0.14	0.34	0.11	0.00	0.46
	Pb	2.72	1.15	1.09	4.00	17.92	0.72	0.00	0.49	1.53	3.04
	Ni	0.96	1.01	1.21	0.15	1.01	0.42	0.55	0.87	1.69	0.00
	As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PAH	0.01	0.00	0.05	0.03	0.01	0.01	0.04	0.02	0.05	0.03
CD		6.65	12.29	9.40	17.76	31.13	6.40	9.91	6.88	12.31	12.22
mCD		2.44	3.10	1.71	1.71	2.46	0.91	1.42	0.98	1.76	1.75

EI= Eagle Island, E-O = Eleme-Okrika, PAB = PABOD, E-IG = Eneka – Igwuruta, I-OMG = Igwuruta -Omagwa

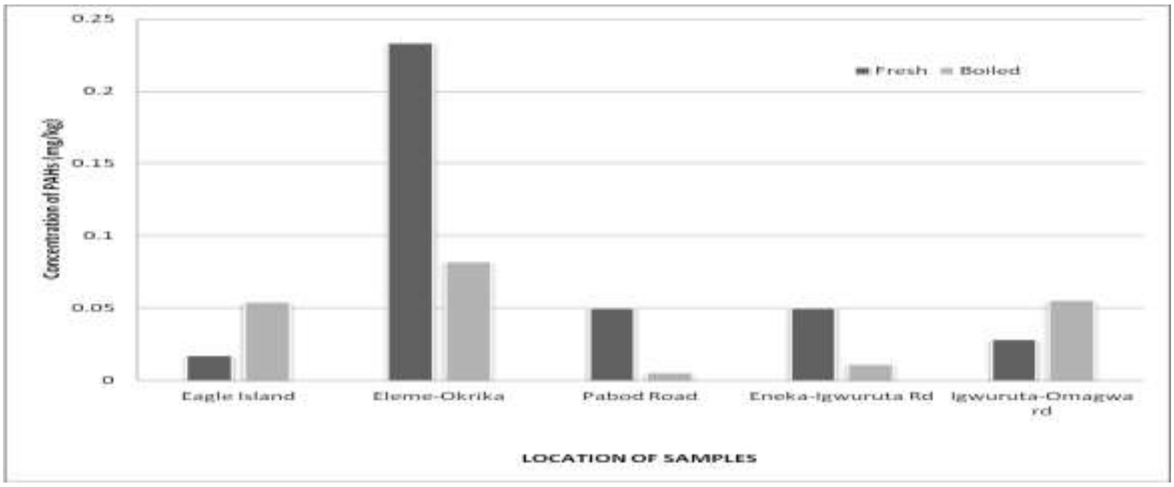


Figure 23: Comparison of concentration of PAHs in Fresh and Boiled Pumpkin

Figure 23 shows lower concentration of PAHs in boiled than fresh Pumpkin samples collected from Eleme-Okrika, PABOD and Eneka-Igwuruta roads except for samples collected from Eagle Island and Igwuruta-Omagwa road that showed higher concentration of PAHs in boiled samples. Again the PAHs level is higher in fresh pumpkin samples collected from Eleme-Okrika road when compared with the samples collected from the control area, Eagle Island.

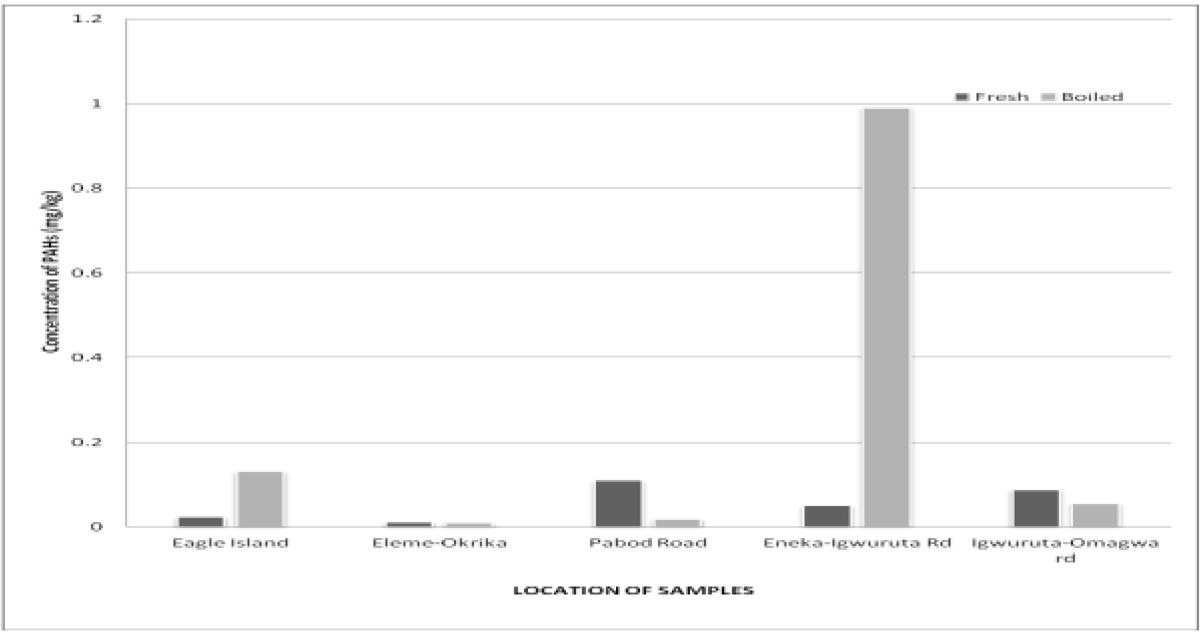


Figure 24: Comparison of concentration of PAHs in Fresh and Boiled Bitter Leaf

Figure 24 shows the levels of PAHs found in fresh and boiled Bitter Leaf. The average concentration for all the locations showed that boiling increased the concentration of PAHs. Eneka-Igwuruta road recorded the highest concentration of PAHs in boiled Bitter Leaf while higher level of PAHs was recorded in fresh Bitter Leaf sample from PABOD road.

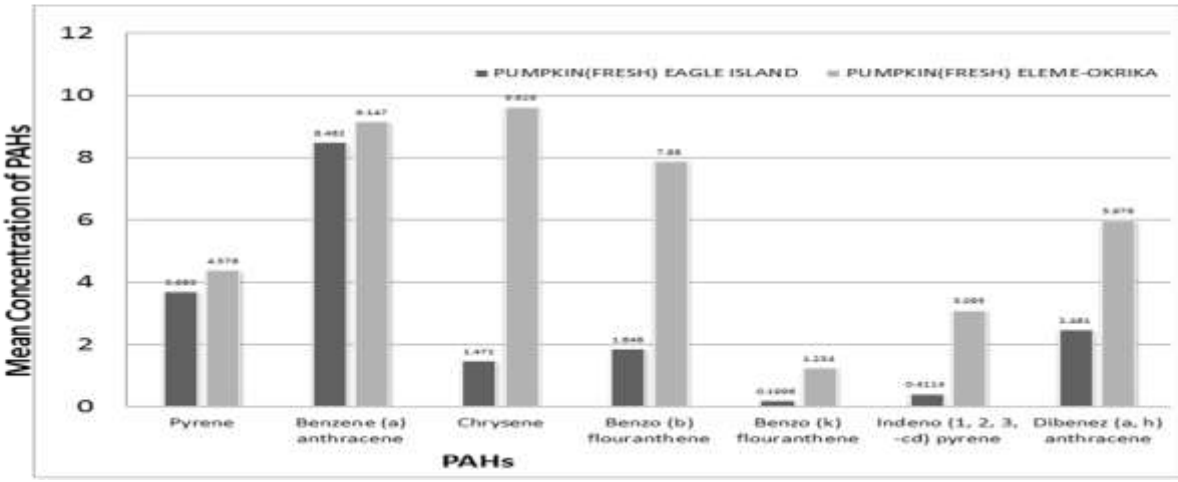


Figure 25: Comparison of concentration of PAHs in fresh Pumpkin at Eagle Island and Fresh Pumpkin at Eleme-Okrika road.

From Fig 25 Fresh Pumpkin samples collected from Eagle Island showed a tremendously lower concentration of PAHs than Pumpkin samples collected from Eleme-Okrika road that has a higher traffic density. Chrysene recorded higher concentration in fresh pumpkin from Eleme-Okrika road, but when considering fresh samples, Benzene(a) anthracene recorded a higher concentration at Eagle Island.

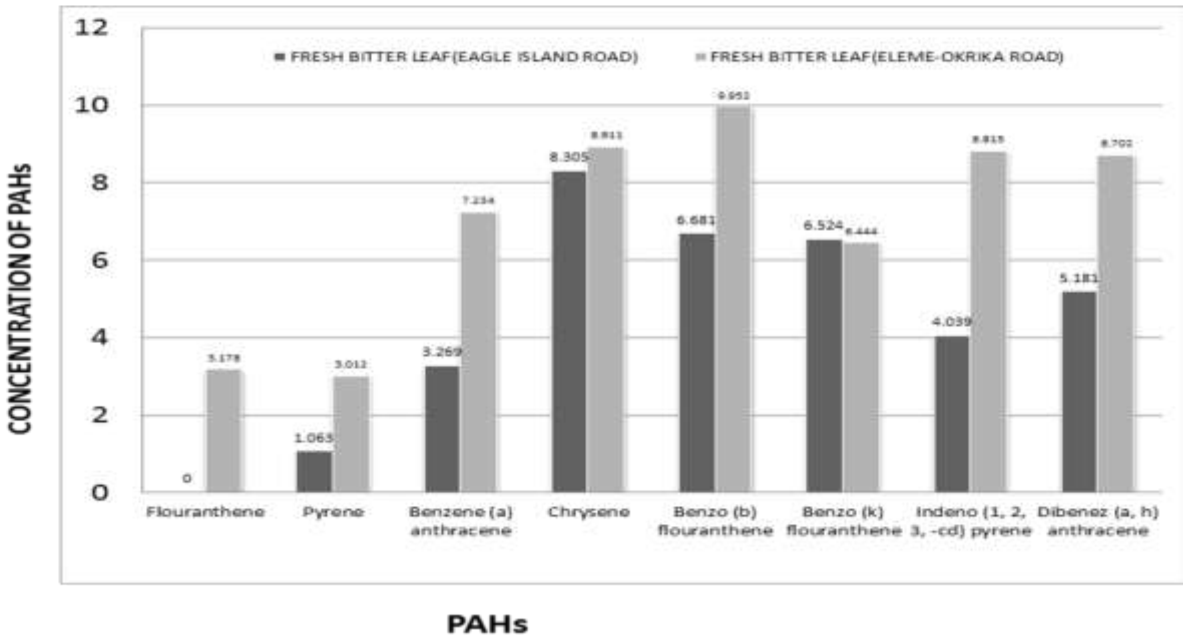


Figure 26: Comparison of concentration of PAHs in fresh Biter Leaf at Eleme-Okrika and Eagle Island Road.

Figure 26 shows Fresh Bitter samples collected from Eleme-Okrika road equally recorded a higher concentration of PAHs when compared with samples from the control location, Eagle Island.

Chromium (Cr) in Pumpkin Leaf

The concentration of Cr in Pumpkin leaf collected along some traffic routes around Port Harcourt ranged from <0.001mg/kg at Eleme –Okrika road to 19.455 mg/kg at Igwuruta-Omagwa road with an average concentration of 5.715mg/kg ± 0.25. The average concentration of Cr in Fresh Pumpkin sample collected from these locations is above the US EPA permissible limit of 0.04mg/kg/day. The general metals' pollution is in the order Cu>Pb>Ni>Cr>Cd>As. However there is a slight variance in concentration of Cr presenting 3.405mg/kg in fresh Pumpkin and 4.595mg/kg in the same pumpkin sample when boiled. The concentration of the heavy metals in boiled Pumpkin sample is also in the same order Cu>Pb>Ni>Cr>Cd>As. From graphical presentation in Figure 4.1, it can be seen that Cr showed highest concentration in fresh Pumpkin samples collected from Eleme-Okrika road while the concentration of Cr along Eneka-Igwuruta road is below detection limit. These results agree with the views of Aloysius *et al*.(2013), Mobofu and Bahemuka(1999) on the impact of traffic on the heavy metals concentration in vegetables grown along traffic routes. Eleme-Okrika road had higher traffic density compared with Eneka-Igwuruta and by extension, Eagle Island.

Statistical analysis showed there is no significant difference in concentrations of Cr in the boiled and fresh sample as ($p > 0.05$), however the average concentration of Cr in all the study areas showed a difference, Fresh (4.5726mg/kg) and boiled (1.8776mg/kg) (Appendix 1). This result suggests that boiling reduces the concentration of Cr in pumpkin. Similarly, the concentration of Cr in fresh and boiled samples at Eagle Island road was slightly higher than Eneka-Igwuruta but no significant difference ($p > 0.05$), but the levels of Cr at Eneka-Igwuruta road, PABOD road, Igwuruta-Omagwa road fell below detection limit. Also the concentration of Cr in all the study locations is above US EPA acceptable daily dosage limit of 0.04mg/kg/day. The difference in geological formation of the soil in the study areas could account for the difference in the Cr concentration in the vegetable samples.

The result of metal pollution index showed that fresh pumpkin is highly polluted with Cr ($4< MPI \leq 5$), but when boiled, the result showed moderate pollution of Pumpkin ($1< MPI \leq 5$) Appendix 23, thus agreeing with the assumption that boiling reduces the metal pollution in fresh pumpkin leaf. The Contamination factor (Cf) for boiled pumpkin collected from Eagle Island showed moderate contamination with Cr($1\leq Cf <3$), but fresh pumpkin from the same location is highly contaminated with Cr ($Cf > 6$) while PABOD, Eneka – Igwuruta and Igwuruta –Omagwa roads recorded low degrees of contamination($Cf < 1$) (Table 1).

Considering other pollution parameters such as degree of contamination (CD) and minimum degree of contamination (mCD), fresh Pumpkin sampled from all the sampled locations around Port Harcourt had considerable degrees of contamination ($12< CD \leq 24$) (Table 4.2).

The heavy industrial activities coupled with high traffic movement along these routes accounts for this level of Cr contamination in fresh Pumpkin leaves in the sampled locations. Comparing these results with the studies of Kalagbor *et al*. (2014), Ideriah *et al*. (2018) it can be agreed that there is a significant environmental pollution of edible vegetables in Port Harcourt and its environs and the pollution is due to anthropogenic activities. The health implications of consuming Cr above its permissible daily dosage limit are respiratory track irritation, nasal and sinus cancer (Bhardwaj *et al.,* 2019).

Chromium in Bitter Leaf

The concentrations of Cr in fresh and boiled Bitter Leaf range from <0.001 mg/kg to 19.802mg/kg and <0.001 mg/kg to 1.790 mg/kg respectively. In the study areas the concentration of heavy metals in Bitter Leaf is in the order Pb>Cu>Ni>Cd>Cr>As. The general average concentration of Cr at the five locations in boiled Bitter Leaf is 0.358 ± 0.08 while the general average concentration of Cr in fresh Bitter Leaf is 8.491 ± 0.18. From this result it can also be seen that boiling Bitter Leaf vegetable reduces the Cr content in it.

These results also agree with the views of Aloysius *et al*., (2013), Mobofo and Bahemuka (1999) on the impact of heavy traffic on the heavy metals concentration in vegetables grown along traffic routes. It implies that there is a more health risk of Cr poisoning in consuming raw Bitter Leaf either as chewing stick, raw leaves or drank as juice than when it is boiled. Statistical analysis of Cr content in fresh and boiled Bitter Leaf at Eleme-Okrika road showed no significant difference as ($P > 0.05$). The data also revealed that the concentration of Cr in boiled and fresh Bitter Leaf is above the US EPA permissible limit for Cr in vegetables.

Fresh Bitter leaf sampled in and around traffic routes in Port Harcourt are "very highly polluted" with Cr ($MPI>5$) whereas when boiled the result states unpolluted ($0< MPI \leq 1$). The contamination factor (Cf) for fresh Bitter leaf in all the locations indicates that PABOD had a moderate contamination of Cr($1\leq Cf <3$), Eagle Island and Igwuruta-Omagwa road samples had low Cr contamination ($Cf < 1$), but Eleme-Okrika and Eneka-Igwuruta road samples had high Cr contamination ($Cf \geq 6$). Traffic density and or the geological formation of these locations could account for the difference in levels of Cr contamination.

The degree of contamination CD for fresh Bitter leaf showed Eagle Island and PABOD had "moderate degrees" of contamination ($6 < CD \leq 12$), but Eneka-Igwuruta and Eleme-Okrika all had "considerable degrees" of contamination ($12 < CD \leq 24$), but Igwuruta –Omagwa had "high degree" of contamination ($CD > 24$). However, when boiled the result showed "considerable degrees" of contamination for all the locations. Table 1.

It implies consuming Bitter leaf over and above the WHO and US EPA acceptable daily permissible dosage predisposes individuals to respiratory tract diseases and cancer of the sinus.

Lead in Pumpkin Leaf

The concentrations of Pb in fresh and boiled Pumpkin leaf range from 19.802mg/kg to <0.001mg/kg and 1.790mg/kg to 0.001mg/kg respectively. The average concentration of Pb in boiled Pumpkin leaf is 0.358 ± 0.8 while the average concentration of Pb in fresh Pumpkin leaf is 3.816 ± 0.6. From this study it can be seen that boiling Pumpkin vegetable reduces the Pb content in it thus presenting a more health risk of Pb poisoning when raw Pumpkin leaf is chewed or the juice drank than when it is boiled (Appendix 3). Statistical analysis however, showed an elevated level of Lead concentration in boiled and fresh Pumpkin leaf at Eleme-Okrika road, fig 2, an area with a higher traffic density, but ANOVA reveals no significant difference as ($P > 0.05$). The data also revealed that the concentration of Pb in boiled Pumpkin leaf is above the US EPA permissible dosage limit for Pb in vegetables (0.04mg/kg/day). The same views held by (Ogundele *et al*.,2015, Mustapha & Adeboye, 2014).

The contamination factor (Cf), showed that fresh pumpkin sample collected from Eneka-Igwuruta, Eleme-Okrika and PABOD roads had low contamination (Cf <1), Eagle Island samples had moderate contamination while Igwuruta-Omagwa had considerable contamination, but boiling altered the contamination factor for pumpkin vegetable from the locations given it low contamination (Cf <1) (Table 2). Also the metal pollution index of fresh pumpkin leaf from all the sampled location around Port Harcourt showed that both fresh and boiled pumpkin leaf are highly polluted with Pb ($4<MPI\leq5$) (Table 2).

Lead in Bitter Leaf

The concentrations of Pb in fresh and boiled Bitter Leaf range from 35.836mg/kg to <0.001mg/kg and 9.885mg/kg to 0.001mg/kg respectively. The average concentration of Pb in boiled Bitter Leaf is 4.52 ± 0.8 while the average concentration of Pb in fresh Bitter Leaf is 10.29 ± 0.4 in all the study areas. This finding showed that boiling Bitter Leaf vegetable reduces the Pb content in it. This result went further to show that boiling reduces the level of Pb in Bitter Leaf hence there is more health risk of Pb poisoning in consuming raw Bitter Leaf than when it is boiled. However, statistical analysis showed an elevated concentration of Pb in boiled Bitter Leaf at Eneka-Igwuruta when compared with other stations but with no significant difference as ($P > 0.05$). The data also revealed that the concentration of Pb in fresh and boiled Bitter Leaf falls outside the US EPA permissible daily dosage limit for Pb in vegetables (0.04 mg/kg/day) (Table 2).

In Table 2, the contamination factor indicated Pumpkin samples from Eleme –Okrika, PABOD and Eneka – Igwuruta have low Pb contamination (Cf <1) while Igwuruta –Omagwa and Eagle Island roads have moderate contamination ($3\leq Cf<6$).

Cadmium (Cd) in Pumpkin Leaf

The concentrations of Cd in fresh and boiled Pumpkin leaf ranged from <0.001mg/kg to 0.755mg/kg and <0.001mg/kg to 0.670mg/kg respectively. The average concentration of Cd in boiled Pumpkin leaf is 0.5 ± 0.8 while the mean concentration of Cd in fresh Pumpkin leaf is 0.36 ± 0.4. Cd showed a different characteristic here compared with Chromium and Lead as it recorded a higher concentration when Pumpkin along Eleme-Okrika road was boiled. This showed that when pumpkin is boiled, the concentration of Cd increases as can be seen from the average concentration. It therefore, implies that fresh Pumpkin cultivated along the roadsides have lower risk of Cd pollution than when boiled. But Statistical analysis showed no significant difference as ($P > 0.05$). The data also revealed that the concentration of Cd in boiled and fresh Pumpkin leaf is above the US EPA permissible dosage limit for Cd in vegetables (0.001mg/kg/day, table 2) thus agreeing with the findings of Mustapha and Adeboye (2014), Maninno *et. al*.(2017). The contamination factor of Cd in all of the sampled vegetables showed low contamination (Cf <1)

Cadmium in Bitter Leaf

The concentration of Cd in fresh and boiled Bitter Leaf ranged from <0.001mg/kg to 0.739mg/kg and 0.001mg/kg to 0.912mg/kg in fresh and boiled better leaf respectively. The average concentration of Cd in boiled Bitter Leaf is 0.415 ± 0.06 while the average concentration of Cd in fresh Bitter Leaf is 0.476 ± 0.7. The study only showed a slight difference in concentration of Cd in fresh and boiled Bitter Leaf. Hence boiling Bitter Leaf vegetable had no significant impact in Cd levels in vegetables along Eneka-Igwuruta, and Eagle Island road as they both show higher levels of Cd when boiled compared with the fresh sample. Statistical analysis showed no significant difference as ($P > 0.05$). The data also revealed that the concentration of Cd in boiled and fresh bitter is above the US EPA permissible limit for Cd in vegetables (0.001mg/kg/day, Table 2) as stated by Okunola (2019). There is also a low contamination of fresh Pumpkin leaf with Cd from all the sampled locations as Cf < 1. (Table 2).

Copper (Cu) in Pumpkin Leaf

The concentration of Cu in fresh and boiled Pumpkin leaf ranged from 21.442mg/kg to 14.185mg/kg and 19.802mg/kg to 7.0mg/kg in fresh and boiled Pumpkin leaf respectively. The average concentration of Cu in boiled Pumpkin leaf is 13.05 ± 0.02 while the average concentration of Cu in fresh Pumpkin leaf is 19.09 ± 0.44. This analysis also revealed that boiling Pumpkin leaf vegetable reduces the Cu content in it as the general mean concentration of Cu in fresh Pumpkin is 17.02 while that of boiled Pumpkin is 12.00.

This analysis agrees with the views of (Ogundele *et al.*, 2015*)* which asserted that vehicular traffic results in the pollution of vegetables with heavy metals. However, the study also reveals that boiling has a significant ability to reduce the Cu content in Pumpkin vegetables. It means that there is more health risk of Cu poisoning in consuming Pumpkin leaf in its raw form than when boiled. Statistical analysis showed no significant difference in Cu content between boiled and fresh Pumpkin as ($P > 0.05$). The data also revealed that the concentration of Cu in boiled and fresh Pumpkin leaf is above the US EPA permissible limit for Cu in vegetables (0.04mg/kg/day, Table 2) thus supporting the views of (Olajide and Ayodele, 1997) .

The contamination factor showed a high contamination of Pumpkin vegetable sample collected from all the locations with Cu ($Cf \geq 6$). The metal pollution index for Cu in both fresh and boiled Bitter leaf all proves that the samples are very highly polluted with Cu ($MPI \geq 5$) (Table 2).

Cadmium in Bitter Leaf

The concentrations of Cu in fresh and boiled Bitter Leaf ranged from 21.642mg/kg to 7.00mg/kg and 18.080mg/kg to 8.976mg/kg respectively. The average concentration of Cu in boiled Bitter Leaf is 13.7 ± 0.002 while the average concentration of Cu in fresh Bitter Leaf is 10.00 ± 0.013. It goes further to show from this study that Bitter Leaf had a different biochemical composition when compared with Pumpkin as boiling produces insignificant changes in concentration of Cu. It implies there is more health risk of Cu poisoning in consuming boiled Bitter Leaf than when eaten in its raw form which is a common practice in the Nigerian Niger Delta where this study was carried out. However statistical analysis showed no significant difference between boiled and fresh Bitter Leaf as ($P > 0.05$). The data also revealed that the concentration of Cu in boiled and fresh Bitter Leaf falls above the US EPA daily permissible dosage limit for Cu in vegetables (0.04mg/kg/day, Table 2).

The contamination factor for Cu in the Bitter leaf sample from Eagle Island is low, moderate at PABOD and Eneka- Igwuruta road, but considerably high at Eleme-Okrika and Igwuruta –Omagwa roads. The metal pollution index revealed a highly polluted Bitter leaf sample at all the locations. Excess Cu intake can lead to nausea, vomiting, stomach cramps and kidney damage which might result into eventual death (Bhardwaj *et al.,* 2019)

Nickel (Ni) in Pumpkin Leaf

The concentrations of Ni in fresh and boiled Pumpkin leaf that ranged from 4.072mg/kg to <0.001mg/kg and 5.940mg/kg to 0.001mg/kg in fresh and boiled Pumpkin leaf respectively. The average concentration of Ni in boiled Pumpkin leaf is 2.164 ± 0.04 while the average concentration of Ni in fresh Pumpkin leaf is 3.13 ± 0.014. This result agreed with the trend of other metals investigated previously in this study where heavy metals showed reduced concentration in the sampled vegetables when boiled. From this study it could be seen that the average concentration of Ni in Pumpkin when boiled is less than when fresh. Similarly, Eleme-Okrika road showed an elevated concentration of Ni in fresh Pumpkin when compared with other locations of the study. The result further agreed with the findings of (Ogundele *et al*., 2015) that high traffic activities deposit heavy metals on roadside vegetables. It further implies that boiling Pumpkin leaf vegetable reduces the Ni content in it meaning that to reduce Ni content in Pumpkin leaf, then it is better boiled than eaten raw. Statistical analysis also showed no significant difference as ($P > 0.05$). The data also revealed that the concentration of Ni in boiled Pumpkin leaf is above the US EPA daily permissible dosage limit for Ni in vegetables (0.06mg/kg/day).

The contamination factor indicated Pumpkin leaves sampled from Igwuruta-Omagwa road had low contamination with Ni ($Cf < 1$) while other locations recorded moderate Ni contamination. Similarly the metal pollution index indicated both fresh and boiled pumpkin leaves from all the locations had moderate pollution with Ni.

Nickel in Bitter Leaf

The concentration of Ni in fresh and boiled Bitter Leaf ranged from 2.418mg/kg to 1.914mg/kg and 3.389mg/kg to 0.001mg/kg respectively. The average concentration of Ni in boiled Bitter Leaf is 1.413 ± 0.097 while the general mean concentration of Ni in fresh Bitter Leaf is 1.33 ± 0.014. ANOVA revealed that boiling raises the concentration of Ni in Bitter Leaf when compared with fresh Bitter Leaf. This study revealed that boiling Bitter Leaf vegetable does not reduce the Ni content in it rather increases its content. The chelating strength of Nickel in the biochemical composition of Bitter Leaf seems to be enhanced by heat. It means that there is more health risk of Ni poisoning in boiling Bitter Leaf than when eaten fresh. Also the position of Ni relative to other metals in the electrochemical series could account for why heat has less effect on its biochemical bonding when heated. Statistical analysis showed a more level of concentration of Ni in Eneka-Igwuruta road when compared with other locations in the study but with no significant difference as ($P > 0.05$). The data also revealed that the concentration of Ni in boiled Bitter Leaf is above the US EPA daily permissible dosage limit for Ni in vegetables (0.06mg/kg/day). The contamination factor of Bitter leaf with Ni is low at Eagle Island and Eneka-Igwuruta, moderately high at the remaining locations. Similarly the metal pollution index showed the Bitter leaf samples are moderately polluted with Ni (Table 2).

Poly Aromatic Hydrocarbon (PAHs) in Pumpkin leaf

From Fig 11 the study showed the presence of Poly Aromatic Hydrocarbons in the vegetable Samples collected from the study locations. Eleme-Okrika road recorded the highest concentration of PAHs in fresh pumpkin. Naphthalene, Acenaphthylene, Acenaphthene , Flourene and Phenanthrene were below detection limits (BDL) while Anthracene, Flouranthene, Pyrene Benzene (a) anthracene, Chrysene Benzo (b) flouranthene, Benzo (k) flouranthene, Indeno (1, 2, 3, -cd) pyrene, Dibenez (a, h) anthracene all showed significant presence in the vegetable samples at different concentration. The average concentration of PAHs in fresh and boiled Pumpkin showed a higher level of PAHs in boiled Pumpkin when compared with fresh samples. This trend agrees with the heavy metals concentration as previously shown. The evaporation of the dissolved water (Inorganic) content of the vegetables during boiling leaves the samples with more concentration of the PAHs(organic).

Polycyclic Aromatic Hydrocarbons in Bitter Leaf

The study showed the presence of Poly Aromatic Hydrocarbons in the Bitter leaf sample collected from the study locations, Eneka-Igwuruta road recorded the highest concentration of PAHs in boiled Bitter leaf than other sampled locations. As was seen in Pumpkin leaf, Naphthalene, Acenaphthylene, Acenaphthene , Flourene and Phenanthrene were below detection limits (BDL) while Anthracene, Flouranthene, Pyrene Benzene (a) anthracene, Chrysene Benzo (b) flouranthene, Benzo (k) flouranthene, Indeno (1, 2, 3, -cd) pyrene, Dibenez (a, h) anthracene all showed significant presence in the sampled vegetables with different levels of concentration. The average concentrations of PAHs in fresh and boiled Bitter leaf showed a higher level of PAHs in fresh Bitter leaf when compared with boiled samples. This trend agrees with the heavy metals concentration as previously shown. But statistical analysis showed no significant difference between fresh and boiled Bitter Leaf in all the study areas.

However, in comparing the impact of traffic density on PAHs pollution of Pumpkin and Bitter Leaf, Eagle Island with the least traffic density among the sampled locations was compared with samples taken from Eleme-Okrika road that had the highest traffic density, it was discovered that all PAHs ranging from Naphtalene to Dibenez (a, h) anthracene showed lower concentration at Eagle Island than Eleme-Okrika road. The same can be said of heavy metals when results from Eagles Island were compared with results from Eleme-Okrika road.

Naphthalene, Acenaphthylene & Flourene

The concentrations of Naphthalene, Acenaphthylene & Flourene were below detection limit in all the sampled locations for both fresh and boiled Bitter Leaf and Pumpkin. Acenaphthene was only detected in boiled Pumpkin with a concentration of 9.383×10^{-3}ppm

Phenanthrene: Phananthrene showed its presence in boiled Pumpkin, fresh Bitter leaf at PABOD, Eleme-Okrika Road and Eagle Island road.

Anthracene’s highest concentration was recorded in boiled Bitter leaf at Eagle Island road and lowest in boiled Bitter leaf at Eleme-Okrika road. Flouranthene recorded highest concentration in boiled Bitter leaf along Eneka-Igwuruta road and the lowet in boiled Bitter leaf along Igwuruta- omagwa road, but other locations were beyond detection limits. Pyrene’s highest concentration was recorded in boiled Pumpkin at Eagle Island and the lowest in boiled Pumpkin along Eleme-Okrika road. Benz[a] anthracene showed highest concentration in fresh Pumpkin at Eleme-Okrika road and the lowest in boiled Bitter leaf at Eagle Island road, but below detection limit in fresh bitter leaf at Eneka-Igwuruta road. Chrysene’s highest concentration was recorded in fresh Pumpkin at Eneka-Igwuruta and the lowest in fresh pumpkin at Eagle Island. Benzo[b]fluoranthene’s highest level was recorded in fresh Bitter leaf at Eleme-Okrika while the lowest was recorded in fresh Bitter leaf at Eagle Island. Benzo[k]fluoranthenen had highest level recorded in fresh Pumpkin at Eleme-Okrika road and the lowest recorded in fresh Pumpkin at Eagle Island road. Indeno [1,2,3-cd]pyrene showed highest level in fresh Bitter leaf at Eleme-Okrika while the lowest was recorded in Fresh Pumpkin at Eagle Island. Dibenz[a,h]anthracene had more significant level in fresh Pumpkin along Eleme-Okrika road while the lowest was recorded in fresh Pumpkin at PABOD road.

The results here gave clear indications that the density of traffic has significant contribution in the pollution of vegetables cultivated along traffic routes around Port Harcourt (Figures 13). Statistical analysis showed a significant difference between the concentration of PAHs in both Fresh Pumpkin and Fresh Bitter Leaf at Eleme-Okrika road and Eagle Island road as ($P<0.05$).

Arsenic

In all the samples analyzed, As concentration was below detection limit. This showed a low level of Arsenic contamination in vegetables cultivated along traffic routes in the study areas around Port Harcourt. Analysis revealed all the samples are unpolluted with As, hence no significant health risk from As in consuming bitter leaf and Pumpkin cultivated along traffic routes in Port Harcourt and its environs (Cf < 1) and (MPI < 1). Tables 1 & 2.

IV. Conclusion And Recommendations

Conclusion

There was general increase in the concentration of heavy metals and PAHs in the samples from the higher traffic density locations. However, there was no significant difference in the boiled and fresh samples. The sampled vegetables, Pumpkin and Bitter leaf are at risk of being polluted with heavy metals over and above the US EPA and WHO permissible daily dosage limits. However, boiling the vegetables will reduce the heavy metals concentration.

Eleme-Okrika road with a higher traffic density had the highest level of metal and PAHs concentration when compared with Eagle Island road that is found to have a lower traffic density.

The same comparison was made of heavy metals' and PAHs concentration in samples collected from other locations with samples from Eagles Island which as the control location and all samples proved that the higher the traffic density, the higher the pollution of vegetables cultivated along such routes

Recommendations

Based on the findings of this study the following recommendations are made; Further studies should be undertaken on the effect of boiling on the heavy metals and PAHs concentration in vegetables along traffic routes around Port Harcourt.

Citizens could be advised through advocacy programmes to consider vegetable farming far away from high traffic routes to avoid heavy metals and PAHs pollution.

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