

Original Research Article

Influence of COVID-19 Pandemic on health risk of heavy metals to the general public in Owerri, Nigeria via consumption of food crops and fruits

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Abstract

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Through various sources resulting from an increase in industrial pollution, man-made or natural activities, humans are exposed either knowingly or unknowingly to heavy metals. The COVID-19 pandemic has taken its toll on the global economic uncertainties and disruption of activities forcing a slowdown globally and lockdown in some countries including Nigeria. This study assessed the influence of COVID-19 on heavy metals that are persistent environmental pollutants namely: Cadmium (Cd), Nickel (Ni), and Lead (Pb), in fruits, food crops, and soil samples from Owerri environs in Nigeria, and estimated the potential public health risks. The samples were washed with deionized water, oven-dried at 70-80 °C for 24 h and ground to powder. The samples were digested with a gradient mixture of perchloric acid and nitric acid. Unicam Atomic Absorption Spectrophotometer was employed in heavy metals analyses. The concentration of Cd, Ni, and Pb in this study was within the maximum allowable concentrations for agricultural soil according to European Union (EU). Taken together, sampled food crops and fruits had 65% of non-detectable level of Cadmium; Lead, 40%, and Nickel, 35% of non-detectable levels. There were however, incidences of detectable levels of the heavy metals but not all of them exceeded the maximum allowable concentration recommended by relevant commissions. COVID-19 pandemic with the attendant lockdown of human activities in terms of industrialization and urbanization may have reduced heavy metal public health risk.

Keywords: COVID-19 Pandemic, Dietary intake, Food crops, Heavy metals, Risk assessment

INTRODUCTION

The pandemic of coronavirus disease 2019 (abbreviation as COVID-19) in Nigeria, had the first confirmed cases announced on February 27, 2020, following a test conducted on an Italian citizen in Lagos state which proved positive for the virus caused by SARS-COV-2 (Maclean and Dahir, 2020; Nigeria Centre for Disease Control (NCDC), 2020). This was followed by a Nigerian citizen who had contact with the Italian citizen in which on

March 9, the second case of the virus was reported in Ewekoro, Ogun state, Nigeria (PM News, 2020).

In every continent across the globe the COVID-19 outbreak has since spread to over 196 countries and territories; though the figure is increasing daily, as at 08 May, 2020, in Nigeria 3,526 cases have been confirmed in 35 out of 36 states (WHO Africa, 2020). Imo State of Nigeria was among the few states that recorded

low case of COVID-19 (2 only), ostensibly due to early lockdown of the entire state, hence Owerri, the state capital and its environs were chosen to assess the heavy metals health risk during the COVID-19 pandemic. The prevalence of heavy metals-prone ecosystem components, firstly, emanate from rapid industrial advances, increase in agricultural chemicalization, or cosmopolitan activities of human beings (Jan et al., 2015). Foods contamination by heavy metals has posed an inevitable challenge; and soil, water, and air pollution are contributing to availability of harmful metals including Cd, Ni, and Pb in foodstuff (Orisakwe et al., 2017). The ingestion of victuals contaminated by harmful metals are susceptible to diseases such as cancer, diabetes, infertility, neurotoxicity. Environmental pollution associated with heavy metals is even more severe in many developing countries where priority is given to the economy over safety and environmental effects (Wu, 2016). The entry of heavy metals into food chain leads to elevated susceptibility and exposure to metal poisoning of the human population. There is lack of data in Nigeria concerning food intake to monitor the intake of heavy metals and their levels in urine and blood. Legislation and enforcement is necessary in order to check heavy metal exposure to humans but it is advocated that such legislation should be based on proven scientific evaluation of the data available (Gidlow, 2004). Many heavy metals such as zinc, copper, manganese and iron when present in very small quantities, have physiological functions in the body. For instance, haemoglobin contains iron; zinc is a cofactor for several enzymatic reactions, protamine zinc is long-acting insulin; and vitamin B in its core has a cobalt atom. However, many other heavy metals are persistent to the environment with no known benefit for physiology of human. These include cadmium, nickel, lead and mercury (Tchounnwou et al., 2016).

MATERIALS AND METHODS

Sample materials and study area

Samples of some commonly and traditionally grown food crops and fruits were collected from three different sites in Owerri environs in late April, 2020. Owerri is the capital city of Imo state, South-Eastern Nigeria; and the center of industrialization, urbanization and preponderance of human activities, hence, informed the choice of study area; coupled with the fact that a Pre-COVID-19 investigation had been reported in 2012 (Orisakwe et al., 2012) in the same areas, providing opportunity for comparison of data and results.

Preparation of samples

The edible parts of the collected samples were separately

washed with deionized water to remove airborne pollutants. The samples were weighed and air-dried for a day for the purpose of reducing water content. Further, all the samples were oven-dried at 70-80 °C for 24 h to render them moisture-free. Using a pestle and mortar, the dried samples were separately powdered and sieved through Muslin cloth.

Digestion of samples

From each soil site, three (3) powdered samples were accurately weighed and placed in crucibles for each food crop giving three replicates for each samples. The ash was digested with a gradient mixture of perchloric acid and nitric acid (1:4) solution. The samples after cooling were made up to final volume of 25 ml with deionized water. Well-shaken, the hydrolyzed samples were transferred to a centrifuge tube and centrifuged at the rate of 3000 rpm to remove solid particles. To ensure homogeneity of the mixture, the resulting homogenized samples were thoroughly mixed before sub-samples then taken for analysis. Using Unicam Atomic Absorption Spectrophotometer (AAS) Model 929, the presence of cadmium, nickel, and lead were analyzed in samples at 228.8, 232.0 and 217.0 nm wavelength, respectively. Samples were analyzed in triplicates. With blank values reading 0.00 ppm for all the heavy metals in deionized water having electrical conductivity value of lower than 5 µS/cm, the detection limit for Cd, Ni, and Pb were all 0.001 ppm.

Precautionary and quality control measures

To ensure the reliability of the results, appropriate precaution and quality procedures were carried out. Analytical grades of reagents were used to calibrate the instrumentation. A spike-and-recovery analysis to assess the accuracy of the analytical techniques was performed. With varying amounts of the standard solutions of the different metals, post-analyzed samples were spiked samples and homogenized. By the dry ashing method, the spiked samples were processed for analysis and quality control measures were adopted to assess contamination as well as reliability of data. For precision of analysis, the coefficients of variation of replicate analysis were determined, and the variations were found to be less than ten percent.

Health risk assessment/Analyses of data

Based on the daily intake rate (DIR) (Chary et al., 2008), health risk index (HRI) (Jan et al., 2010), and the target hazard quotient (THQ) (Jan et al., 2010), the potential health risk of heavy metal consumption were assessed.

The DIR of heavy metals in this study was calculated, since:

$$\text{DIR} = \frac{C_{\text{metal}} \times C_{\text{factor}} \times C_{\text{food intake}}}{B_{\text{average weight}}}$$

Where: C_{metal} is Heavy metal concentration in plants (mg/kg)

C_{factor} is the conversion factor;

$C_{\text{food intake}}$ is the daily intake of vegetables (kg/person); and

$B_{\text{average weight}}$ is the average body weight considered to be 65 kg for this study (Oguntona, 1998), and the conversion factor, 0.085 (Adedokun et al., 2016).

The HRI was calculated as:

$$\text{HRI} = \frac{\text{DIR}}{\text{RFD}}$$

Where: RFD is the reference dose for heavy metals given as 0.001, 0.020, and 0.0035 mg/kg/day for Cadmium, Nickel, and Lead respectively (US-EPA IRIS, 2020).

The THQ was calculated as:

$$\text{THQ} = \frac{\text{EF} \times \text{ED} \times \text{FIR} \times \text{C}}{\text{RFD} \times \text{WAB} \times \text{TA}} \times 10^{-3}$$

Where ED is the exposure duration (equivalent to 54 years of the average life expectancy of the Nigerian population); EF is the exposure frequency (350 days/year); FIR is the food ingestion rate for adult Nigerian considered to be 65 g/person/day (Oguntona, 1998); C is the metal concentrations (mg/kg); WAB is the average body weight (65 kg) (Oguntona, 1998); and TA is the average exposure time for non-carcinogen (ED x 365 days/year). The exposure is most likely to cause obvious adverse effect if the THQ value is greater than 1.

RESULTS

The levels of Cadmium, Nickel and Lead in commonly consumed food crops and fruits in Nigeria are as shown in Tables 2 and 3, respectively. The range of various heavy metals in food crops were 0.00-0.90, 0.00-1.62, and 0.00-10.16 mg/kg for Cd, Ni, and Pb, respectively; while the range of various heavy metals in fruits was 0.00-0.24, 0.00-0.81, and 0.00-2.01 mg/kg for Cd, Ni, and Pb, respectively. The highest mean levels of Cd and Ni, in the food crops were detected in *Cucumis melo* (melon) 0.9 mg/kg and *Phaseolus vulgaris* (beans) 1.62 mg/kg, respectively; for Pb it was *Oryza sativa* (rice) 10.16 mg/kg. The highest mean levels of Cd, Ni and Pb in the fruits were detected in *Citrus reticulata* (tangerine), *Ananas comosus* (pineapple), and *Canarium schweinfurthii* (Local pear) at 0.14, 0.81, and 2.01 mg/kg respectively. Taken together, 13 out of the 20 sampled food crops and fruits had non-detectable levels of Cadmium representing 65%. For Nickel, 7 out of the 20 sampled food crops and fruits had non-detectable levels, representing 35%; 40% representing 7 out of the 20

samples for Lead. There are incidences of detectable levels of the heavy metals but not all of them exceeded the maximum allowable concentration as recommended by European Union (EU) and/or FAO/WHO joint codex Alimentarius Commission (Table 1). For Cadmium, only 2 (i.e. *C. melon* and *C. reticulata*, 0.90 and 0.24 mg/kg, respectively) out of the 20 food crops and fruits representing 10% violated the permissible limit of 0.20 mg/kg prescribed by EU maximum levels in foods, leaf vegetables, tubers, cereals and fruits (Table 1). For Nickel, 65% violated the limits; while 15% violated the limits for Lead, as three samples only (*Z. mays* (0.50), 0.3 mg/kg limit of *O. sativa* (10.16), and *C. schweinfurthii* (2.0) mg/kg) exceeded the FAO/WHO (2001) Joint Codex (Table 1). In the soil samples, the range of various heavy metals was 0.12-0.65, 0.00-2.50 mg/kg for Nickel and Lead, respectively, while Cadmium was non-detectable. The concentrations of Pb and Ni in the soil sample sites of Owerri (Municipal, North, and West local government areas) fall within the allowable concentrations for agricultural soil as recommended by Canadian Human Quality Health Soil Quality Guideline (Table 1).

The estimated DIR, HRI and THQ for all the heavy metals tested (Cd, Ni, and Pb) were as shown in Tables 5, 6, 7, and 8.

The calculated or the estimated DIR, HRI, and THQ of the heavy metals are as contained in Examples below:

DIR via *Manihot* spp. (Cassava) for:

$$\text{Cd} = \frac{0.05 \times 0.085 \times 65}{65} = 0.0042 \text{ mg person}^{-1} \text{ day}^{-1}$$

$$\text{Ni} = \frac{0.20 \times 0.085 \times 65}{65} = 0.017 \text{ mg person}^{-1} \text{ day}^{-1}$$

$$\text{Pb} = \frac{0.20 \times 0.085 \times 65}{65} = 0.017 \text{ mg person}^{-1} \text{ day}^{-1}$$

HRI via *Manihot* spp. (Cassava) for:

$$\text{Cd} = \frac{0.0042}{0.001} = 4.2$$

$$\text{Ni} = \frac{0.017}{0.020} = 0.85$$

$$\text{Pb} = \frac{0.017}{0.0035} = 4.857$$

THQ via *Manihot* spp. (Cassava) for:

$$\text{Cd} = \frac{350 \times 54 \times 65 \times 0.05}{0.001 \times 65 \times (54 \times 365)} = 0.0479 \times 10^{-3}$$

$$\text{Ni} = \frac{350 \times 54 \times 65 \times 0.20}{0.020 \times 65 \times (54 \times 365)} = 0.0095 \times 10^{-3}$$

$$\text{Pb} = \frac{350 \times 54 \times 65 \times 0.20}{0.0035 \times 65 \times (54 \times 365)} = 0.0547 \times 10^{-3}$$

Table 1. Guideline for safe limits of heavy metals

Sample	Standard	Cd	Pb	Ni
Soil, ug.g ⁻¹	Indian Standard Awashthi	3-6	250-500	75-150
	WHO/FAO, 2007	-	-	-
	European Union, 2002	3-0	300	75
Soil, mg.kg ⁻¹	Canadian human quality health soil quality guideline	14	140	
Plant, ug.g ⁻¹	Indian Standard Awashthi	15	2.5	1.5
	WHO/FAO, 2007	0.2	5.0	-
Leaf vegetables Tubers, cereals and fruits	European Union maximum levels in foods (mg.kg ⁻¹ wet weight)	0.20 ^x	0.3 ^y	
		0.050 ^x		
Stem vegetables, root vegetables, and potatoes		0.10 ^x		
Bran, germ, wheat, and rice, soyabean				

^xCOMMISSION REGULATION (EU) NO 420/2011 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs.

^yFAO/WHO (2002), Joint Codex Alimentarius Commission

Table 2. Cadmium, Nickel, and Lead levels (mg/kg) in commonly consumed food crops

S/N	Sample	Common name	Cd	Pb	Ni
1.	<i>Manihot spp</i>	Cassava	0.05	0.20	0.20
2.	<i>Musa Paradisiaca</i>	Plantain	0.05	0.60	Nd
3.	<i>Colocasia esculenta</i>	Cocoyam	Nd	0.22	0.10
4.	<i>Dioscoria rotundata</i>	Yam	0.05	0.30	Nd
5.	<i>Arachis hypogea</i>	Groundnut	Nd	0.10	0.11
6.	<i>Phaseolus vulgaris</i>	Beans	0.10	1.62	0.10
7.	<i>Ipomea batata</i>	Potato	Nd	0.91	Nd
8.	<i>Zea mays</i>	Maize	Nd	Nd	0.50
9.	<i>Cucumis melo</i>	Melon	0.90	0.21	Nd
10.	<i>Oryza sativa</i>	Rice	Nd	Nd	10.16

Table 3. Cadmium, Nickel, and Lead levels (mg/kg) in commonly consumed fruits

S/N	Sample	Common name	Cd	Pb	Ni
1.	<i>Musa spp</i>	Banana	Nd	Nd	0.16
2.	<i>Citrus sinensis</i>	Orange	Nd	0.10	Nd
3.	<i>Carica papaya</i>	Pawpaw	Nd	0.10	Nd
4.	<i>Ananas Comosus</i>	Pineapple	Nd	0.81	Nd
5.	<i>Canarium schweinfurthii</i>	Local pear	Nd	0.10	2.01
6.	<i>Psidium guajava</i>	Guava	Nd	Nd	0.18
7.	<i>Magnifera indica</i>	Mango	Nd	Nd	Nd
8.	<i>Citrus paradise</i>	Grape	0.04	0.05	0.11
9.	<i>Citrus reticulate</i>	Tangerine	0.14	Nd	0.19
10.	<i>Annona muricata</i>	Soursop	Nd	Nd	Nd

Table 4. Heavy metal concentrations (mg/kg) in soil samples of three (3) different sites in Owerri, Nigeria

Soil sample site	Cd	Pb	Ni
Owerri West	Nd	0.46	Nd
Owerri Municipal	Nd	0.12	0.15
Owerri North	Nd	0.65	2.50

Nd = Not detectable

Table 5. Daily intake rate (DIR) of heavy metals via consumption of food crops (mg person⁻¹ day⁻¹)

S/N	Sample	Common name	Cd	Pb	Ni
1.	<i>Manihot spp</i>	Cassava	0.0042	0.017	0.017
2.	<i>Musa Paradisiaca</i>	Plantain	0.0042	0.051	-
3.	<i>Colocasia esculenta</i>	Cocoyam	-	0.0187	0.0085
4.	<i>Dioscoria rotundata</i>	Yam	0.0045	0.0255	-
5.	<i>Arachis hypogea</i>	Groundnut	-	0.0085	0.0093
6.	<i>Phaseolus vulgaris</i>	Beans	0.0085	5.1377	0.0085
7.	<i>Ipomea batata</i>	Potato	-	0.0773	-
8.	<i>Zea mays</i>	Maize	-	-	0.0425
9.	<i>Cucumis melo</i>	Melon	0.0765	0.0178	-
10.	<i>Oryza sativa</i>	Rice	-	-	0.8636

Table 6. Daily intake rate (DIR) of heavy metals via consumption of fruits (mg person⁻¹ day⁻¹)

S/N	Sample	Common name	Cd	Pb	Ni
1.	<i>Musa spp</i>	Banana	-	-	0, 0136
2.	<i>Citrus sinensis</i>	Orange	-	0.0085	0.0935
3.	<i>Carica papaya</i>	Pawpaw	-	0.0085	-
4.	<i>Ananas Comosus</i>	Pineapple	-	0.0688	-
5.	<i>Canarium schweinfurthii</i>	Local pear	-	0.0085	0.1708
6.	<i>Psidium guajava</i>	Guava	-	-	0.0161
7.	<i>Magnifera indica</i>	Mango	-	-	-
8.	<i>Citrus paradise</i>	Grape	0.0034	0.0042	0.0935
9.	<i>Citrus reticulate</i>	Tangerine	0.0119	-	0.0161
10.	<i>Annona muricata</i>	Soursop	-	-	-

Table 7. Calculated values of health risk index (HRI) and target hazard quotient (THQ) for heavy metals via consumption of food crops

S/N	Sample	Common name	Cd		Pb		Ni	
			HRI	THQ	HRI	THQ	HRI	THQ
1.	<i>Manihot spp</i>	Cassava	4.2	0.0479	0.85	0.0095	4.857	0.0547
2.	<i>Musa Paradisiaca</i>	Plantain	4.2	0.0479	2.55	0.0287	-	-
3.	<i>Colocasia esculenta</i>	Cocoyam	-	-	0.935	0.0105	7.800	0.0273
4.	<i>Dioscoria rotundata</i>	Yam	4.2	0.0479	1.275	0.0143	-	-
5.	<i>Arachis hypogea</i>	Groundnut	-	-	0.425	0.047	8.600	0.0301
6.	<i>Phaseolus vulgaris</i>	Beans	8.5	0.0958	6.885	0.0776	7.800	0.0273
7.	<i>Ipomeabatata</i>	Potato	-	-	3.865	0.0436	-	-
8.	<i>Zea mays</i>	Maize	-	-	-	-	39.114	0.1369
9.	<i>Cucumis amelo</i>	Melon	76.5	0.8630	0.890	0.0100	-	-
10.	<i>Oryza sativa</i>	Rice	-	-	-	-	795.28	2.7835

Table 8. Calculated values of health risk index (HRI) and target hazard quotient (THQ) for heavy metals via consumption of fruits

S/N	Sample	Common name	Cd		Pb		Ni	
			HRI	THQ	HRI	THQ	HRI	THQ
1.	<i>Musa spp.</i>	Banana	-	-	-	-	3.885	0.04383
2.	<i>Citrus sinensis</i>	Orange	-	-	0.425	0.0047	26.71	0.0301
3.	<i>Carica papaya</i>	Pawpaw	-	-	0.425	0.0047	-	-
4.	<i>Ananas Comosus</i>	Pineapple	-	-	3.442	0.0388	-	-
5.	<i>Canarium schweinfurthii</i>	Local pear	-	-	0.425	0.0047	48.814	0.5506
6.	<i>Psidium guajava</i>	Guava	-	-	-	-	4.614	0.0493
7.	<i>Magnifera indica</i>	Mango	-	-	-	-	-	-
8.	<i>Citrus paradise</i>	Grape	3.4	0.0383	0.21	0.0023	26.714	0.0301
9.	<i>Citrus reticulate</i>	Tangerine	11.9	0.1342	-	-	4.614	0.0520
10.	<i>Annona muricata</i>	Soursop	-	-	-	-	-	-

Table 9. Recommendation of DI and UL of heavy metals (Food and Drug Administration, 2001; Garcia-Rico et al., 2007)

	Cd	Ni	Pb
DI (mg day ⁻¹ person ⁻¹)	0.000	0.50	0.00
UL(mg day ⁻¹ person ⁻¹)	0.064	1.00	0.240

DISCUSSION

The emphasis of this study was to access the levels of Cadmium, Nickel and Lead in commonly consumed food crops and fruits in Nigeria during the period of COVID-19 pandemic lockdown. We have made available data on heavy metals levels in ingested farm produce that are known to form the staple foods of Nigerians as well as soil levels in corresponding farmland with a view to comparing a similar work done in a Pre-COVID -19 era (Orisakwe et al., 2012). The heavy metal values are relatively higher in the sampled food crops and fruits compared to the soil samples. The soil samples collected

from different farmlands where fruits and food crops were harvested showed no presence of Cd; but Ni and Pb were all present except in Owerri-West where there was no presence of Pb. The concentration of Pb and Ni were highest in Owerri-North soil samples, yet lower than Canadian Human Quality Health Soil Quality Guideline (Table 1). Through their root systems, some plants are capable of assimilating Pb from soil, although this uptake does not appear to be appreciable (Agency for Toxic Substances and Disease Registry (ATSDR), 2007). A major source of essential nutrients, metabolites and antioxidants is via cereals consumption (Anita et al., 2010) but intake of toxic metal contaminated ones may

pose a human health risk. Environmental contaminations through various sources such as spillages, waste water irrigation, air deposition have been implicated for heavy metals bioaccumulation in plants (Adesuyi et al., 2015). In the present study, Cadmium was either not detected or within allowable concentrations for safe limit in both food crops and fruits except in *Cucumis melo* (0.90 mg/kg). The safety outcome may not be unconnected with the lockdown occasioned by COVID-19 pandemic as a similar study previously conducted in Pre-COVID-19 era (2012) reported that high percentage of food crops and fruits violated the permissible limit of Cadmium and Lead (Orisakwe et al., 2012). According to FAO/WHO (2001) and EU, the safety limit for Cd and Pb are 0.2 and 0.3 mg/kg, respectively (Table 1). Cadmium is a known heavy metal with high toxicity, a non-essential element in natural waters and foods which accumulates principally in kidneys and liver (Adesuyi et al., 2015). To further buttress that lockdown of activities during COVID-19 may be responsible for the low concentration of heavy metal, apart from the Pre-COVID-19 report by Orisakwe (2012), higher values also have been reported for vegetables cultivated along roadsides in Nigeria (Oluwole et al., 2013). The highest level of Ni and Pb in this study was recorded in *P. vulgaris* (1.62 mg/kg) and *O. sativa* (10.16 mg/kg), respectively. These concentrations of Ni and Pb should not diminish the fact of reduction in the same during COVID-19 lockdown, as many other food crops and fruits showed no-detection or concentration below safe limits as against a Pre-COVID-19 investigation where *P. vulgaris* and *O. sativa* showed 2.65 and 61.17 mg/kg for Ni and Pb, respectively (Orisakwe et al., 2012). The higher levels of Cd, Ni and Pb in Pre-COVID-19 pandemic documentations may probably be attributed to pollutant in farm, soil/site, irrigation water, or due to pollution from highways, traffic, urban and industrial activities (Wu et al., 2016; Adesuyi et al., 2015). The potential health risk of heavy metal consumption via food crops and fruits were assessed based on DIR, HRI and THQ. The results are presented in Tables 5, 6, 7, and 8. The DIR results in Tables 5 and 6 for food crops and fruits respectively, were compared with recommended daily intake (DI) and the upper level (UL) of daily intake of heavy metals (Food and Drug Administration, 2001; Garcia-Rico et al., 2007).

From the results and Tables, daily intake rate (DIR) of heavy metals in food crops for Cd (0.004-0.076mg/kg) and Pb (0.008-0.863 mg/kg) exceed the recommended daily intake and upper tolerable daily intake. However, Ni (0.008 – 0.137 mg/kg) is significantly lower than the recommended daily intake of metals as well as the upper tolerable daily intake level (UL). The HRI for food crops are more than 1 (>1) for Cd, Ni, and Pb in this study. The same applies to Pb in fruits. But the HRI are less than 1 (<1) in fruits except *A.comosus* (Pineapple) whose value is 3.4 Nickel; then *C. reticulate* (11.9) and *C. Paradise* (3.4) for Cd. Conventionally, HRI>1 indicates that

the exposed population is not safe of heavy metals health risk while HRI<1 means the reverse (Khan et al., 2008). The human population is therefore at risk of Cd, Ni, and Pb as corroborated by earlier reports (Isafe et al., 2012; Adedokun et al., 2016; Orisakwe et al., 2012). This study has proved lesser contamination of the environment due to COVID-19 Pandemic lockdown of activity compared with Pre-COVID-19 reports (Orisakwe et al., 2012; Oluwole et al., 2013). So a legislation to check exposure of heavy metals should be encouraged. The THQ values define the exposure duration and the potential risk within that period. In this study the values are shown in Tables 7 and 8. The THQ value in all the metals is less than 1 hence does not create health risk concern except lead in *Oryza sativa* (2.78). The exceptional case of lead is in agreement with a reported study (Zhou et al., 2016). There exist various sources of lead exposure to the environment in Nigeria. At the top rank of the list is leaded gasoline. Even, during the lockdown occasioned by COVID-19 pandemic, many individual homes resorted to the use of leaded gasoline to power their electric generators due to the glaring failure of the public-power-supply system. There was an attempt to reduce the Lead content of gasoline from 0.74 g/L to 0.15 g/L by the year 2002 in Nigeria yet recent realities suggest doubt that it was implemented (Clean Air Initiative Mobile Service, 2020). Lead exposure in addition to altering the metabolism of cholesterol thereby increasing the risk of cardiovascular diseases and atherosclerosis can cause still birth, miscarriage, premature birth and low birth weight plus minor malformations in pregnant women (Amadi et al., 2017). Lead is known to reduce the quality of spermatozoa in males (Offor et al., 2017). WHO on May 15, 2015 received a report from Nigeria, of a suspected case of lead poisoning which happened at UnguwanKawo and UnguwanMagiro communities in Rafi Local Government Area of Niger State. According to WHO (2015), artisanal gold mining and agriculture are the main occupations in the affected communities but in other cases of lead poisoning Durban, South Africa in 2012, Ayurvedic medicine was the implicated cause (Mathee et al., 2015).

CONCLUSION

In the present study, local food stuff commonly and readily available in Nigeria especially South-Eastern region may contribute no major heavy metal public health risk. This may not be unconnected with activity-lockdown occasioned by the COVID-19 pandemic; lying credence that human activities in terms of industrialization and urbanization are the greatest culprit in the global burden of heavy metals. Hence, there is need to legislate and regulate heavy metals exposure to humans.

Conflicts of Interest

No conflicts of interests have been declared by the authors.

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REFERENCES

- Adedokun AH, Njoku KL, Akinola MO, Adesuyi AA, Jolaoso AA (2016). Potential human health risk assessment of heavy metals intake via consumption of some leafy vegetables obtained from four markets in Lagos metropolis, Nigeria. *J. Appl Sci. Environ Manage.* 20 (3):530-539.
- Adesuyi AA, Njoku KL, Akinola MO (2015). Assessment of heavy metals pollution in soils and vegetation around selected industries in Lagos state, Nigeria. *J. Geosci Environ Protect* 3:11-19.
- Agency for Toxic Substances and Disease Registry (ATSDR) (2007). Toxicology profile for Lead. Atlanta, G.A: US Department of Health and Human Services, Public Health Service.
- Amadi CN, Igweze ZN, Orisakwe OE (2017). Lack of metals in miscarriages and stillbirths in developing nations. *Middle East Fertil Soc J.* 22:91-100.
- Amadi CN, Offor SJ, Frazzoli C, Orisakwe OE (2019). Natural antidotes and management of metal toxicity. *Environ Sci Pollut Res*, <https://doi.org/10.1007/s11356-019-05104-2>.
- Anita A, Rajesh KS., Madhoolika A, Fiona MM (2010). Health risk assessment of heavy metals via dietary intake of foodstuffs from the waste water irrigated site of a dry tropical area of India. *Food Chem Toxicol.*; 48:611-619.
- Asomugha RN, Udowelle NA, Offor SJ, Njoku CJ, Ofoma IV, Chukwuogor CC, Orisakwe OE (2016). Heavy metals hazards from Nigerian spices. *RoczPanstwZaklHig.* 67:309-314.
- Chary NS, Kamal CT., Raj DSS (2008). Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxicology and Environmental Safety*, 69:513-524.
- Clean Air Initiative Mobile Service (2020). Sub-Saharan Africa; Group Report, Nigeria & Neighbours. 2007. Available on-line at: <http://www.cleanairnet.org/ssa/1414/property value-13627.html>. Accessed on 04 May.
- FAO/WHO (2001). Report on the 32nd session of the Codex Committee on Food additives and Contaminants. ALINORM 01/12, Beijing, China, 20-24 March 2000. Joint FAO/WHO Food Standard Programme, Codex Alimentarius Commission, 24th session, 2-7 July, Geneva, Switzerland.
- FDA (Food and Drug Administration) (2001). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Report of the panel on micronutrients. National Academy Press, Washington DC. Food and Drug Administration, Dietary supplements, Centre for Food Safety and Applied Nutrition.
- Garcia-Rico L, Leyva-Perez J, Jara-Marini ME (2007). Content and daily intake of copper, Zinc, Lead, Cadmium and Mercury from dietary supplements in Mexico. *Food Chem. Toxicol*; 45:1599-1605.
- Gidlow DA (2004). Lead toxicity. *Occupational Medicine (Lond)* 54 (2):76-81.
- Isafe AI, Hassan LG, Sahabi DM, Alhassan Y, Bala BM (2012). Evaluation of heavy metals uptake and risk assessment of vegetables grown in Yargalma of Northern Nigeria. *J. Basic Applied Sci Res.* 2 (7):6708-6714.
- Jan AT, Azam M, Siddiqui K, Ali A, Choi I, Haq QMR (2015). Heavy metals and human health: Mechanistic insight into toxicity and counter defense system of antioxidants. *Int J. Mol. Sci*; 16:29592-29630.
- Jan FA, Ishaq M, Khan S, Ihsanullah I, Ahmad I, Shakirullah M (2010). A comparative study of human health risk via consumption of food crops grown on waste water irrigated soil (Peshawar) and relatively clean water irrigated soil (lower Dir). *J. Hazard Materials.* 179:612-621.
- Khan S, Lin A, Zhang S, Huc Q, Zhu Y (2008). Accumulation of polycyclic aromatic hydrocarbons and heavy metals in lettuce grown in the soils contaminated with long-term waste water irrigation. *J. Hazardous Mater.* 152:506-515.
- Maclean R, Dahir AL (2020). Nigeria responds to first coronavirus case in Sub-Saharan Africa. *The New York Time*, 28 February, <http://en.wikipedia.org/wiki/20>. (Accessed on 04/May/2020).
- Mathee A, Naicker N, Teare J (2015). Retrospective investigation of a lead poisoning outbreak from the consumption of an Ayurvedic medicine: Durban, South Africa. *Int J. Environ Res Public Health* 12:7804-7813.
- Nigeria Centre for Disease Control (NCDC) (2020). First case of coronavirus disease confirmed in Nigeria. 28 February, 2020. <http://en.wikipedia.org/wiki/20>. (Accessed on 04/May/2020).
- Offor SJ, Mbagwu HOC, Orisakwe OE (2017). Lack of beneficial effect of activated charcoal in lead induced testicular toxicity in male albino rats. *Middle East Fertil Soc. J.* 22:189-192.
- Oguntona T (1998). Green leafy vegetables in: Osagie AU and Eka OU (Eds). *Nutritional Quality of Plant Foods*. Post-Harvest Research Unit, Department of Biochemistry, University of Benin, Benin-city, Nigeria: pp 120-133 ISBN: 978-2120-02-2.
- Oluwole SO, Makinde OSC, Yusuf KA, Fajana OO, Odumosu AO (2013). Determination of heavy metal contaminants in leafy vegetables cultivated by the road side. *Int J. Engr. Res Dev.* 7 (3): 1-5.
- Orisakwe OE, Nduke JK, Amadi CN, Dike DO, Bede O (2012). Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South-Eastern Nigeria. *Chemistry Central Journal* 6:77.
- Orisakwe OE, Oladipo OO, Ajaezi GC, Udowelle NA (2017). Horizontal and vertical distribution of heavy metals in farm produce and livestock around lead-contaminated goldmine in Daret and Abare, Zamfara state, Northern Nigeria. *J. Environ Public Health*; 2017, 3506946.
- PM News (2020). Nigeria records second case of coronavirus. 09 March. <http://en.wikipedia.org/wiki/20>. (Accessed on 04/May/2020).
- Rehman K, Fatima F, Waheed I, Akash MSH (2017). Prevalence of exposure of heavy metals and their impact on health consequences. *J. Cell Biochem*, 1-28.
- Storelli MM (2008). Potential human health risks from metals (Hg, Cd, and Pb) and Polychlorinated biphenyls (PCBs) via seafood consumption. Estimation of target hazard quotients (THQs) and toxic equivalents quotients (TEQs). *Food Chemistry and Tox.* 46:2782-2788.
- Tchounnwou PB, Yedjon CG, Patlolla AK., Sutton DJ (2016). Heavy metal toxicity and the environment. *EXS* 101:133-164.
- US-EPA IRIS (2020). United States, Environmental Protection Agency, Integrated Risk Information System. <http://www.epa.gov/iris/sust2006>. Access on 04 May.
- WHO (2020). Lead Poisoning in Nigeria. World Health Organisation Regional Office for Africa, 2015. Available at www.afro.who.int/.../4637-lead-poisoning-in-Nigeria-15-May-2015. Html.2015.

- Accessed on 04 May.
- WHO Africa (2020). COVID-19 in Nigeria 08 May, 2020. www.afro.who.int (Accessed on 08/May, 2020).
- Wu H (2016). Heavy metals and chelation therapy. *J. heavy Met Toxicity Dis*, 1:1
- Wu X, Cobbina SJ., Mao G, Xu H., Zhang Z, Yang L (2016). A review of toxicity and mechanisms of individual and mixtures of heavy metals in the environment. *Environ Sci. Pollut. Res.* 23:8244-8259.
- Zhou H, Yang W, Zhuo X, Liu L, Gu JF, Wang WL, Zou JL, Tian T, Peng PQ., Liao BH (2016). Accumulation of heavy metals in vegetable species planted in contaminated soils and the health risk assessment. *Int. J. Environ Res. & Public Health.*;13:289-291.