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Survey of heavy metal contaminations of cassava mash and maize corns dried along the highways in some selected states in northern part of Nigeria

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ABSTRACT

Heavy metal concentrations were determined in some of the crops (cassava mash and maize grains) dried along highways "express" in selected states (Benue, Nasarawa and Taraba) in Northern part of the country (Nigeria). The results of chemical analysis indicated that the heavy metal contents of the food crops (cassava mash and maize grains) dried along the highways were higher than the heavy metal contents of food crops (cassava mash and maize grains) from the control areas. The overall ss ranged from 0.210-0.410µg/g, 11.120-18.120 µg/g, 10.200-17.010 µg/g, 0.680-0.920 µg/g 0.350-0.660 µg/g and 9.520-21.330 µg/g for Cd, Cu, Mn, Ni, Pb and Zn in the cassava mash samples, while in the maize grains the heavy metal concentrations ranged from 0.180-0.350 µg/g, 5.780-9.880 µg/g, 7.850-12.250 µg/g, 0.521-0.880 µg/g, 0.310-0.450 µg/g and10.990-16.550 µg/g for Cd, Cu, Mn, Ni, Pb and Zn respectively. Cd concentrations were above WHO/FAO (2007) and Commission regulation (EU 2006) safe limits and Pb above Commission regulation (EU 2006) but below the WHO/FAO (2007) safe limits. Regular monitoring of heavy metals in the food crops dried along the highways is also necessary.

Keywords: heavy metal, contamination, maize and cassava.

INTRODUCTION

For many decades public health authorities have considered mineral contamination of foods and water as a matter of concern [1]. Although some metals are essential for life, all metals are toxic at sufficiently high concentrations; for there is a narrow window between what is essential and what is toxic [2]. Because many biological systems exist naturally on the margin of metal toxicity, the physical and geochemical redistribution of toxic metals in environments by human activities has a strong potential to disrupt ecosystem [3].

The exposure of people to the increasing levels of pollutant metals in various compartments of their environment represents a growing health hazard that has yet to receive due attention. What is worrisome is that many people may be more susceptible to environmental metal poisoning because of their lifestyle and living conditions [4]. The narrow streets and overcrowding in urban areas, the helter-skelter location of polluting industries, the vibrant outdoor lifestyle, the open type of dwellings, the endemic dusty environment, the prevalence of the contaminated dusts outdoor as well as indoor, poor nutrition and health, poor hygienic practices can combine to increase the level of exposure and susceptibility to lead and other metal poisoning [5]. Highly elevated Pb concentrations have been reported in roadside soils and vegetation in Nigeria[6,7,8]. The monthly average dust concentrations at street level in Ibadan (Nigeria) were reported to be 48-76mgm^3 are among the highest anywhere in the world [9]. The estimated Pb levels in Ibadan exceed the recommended ambient air guideline of 1.5µg/m3. The exceptional Pb concentration is due to the heavy leads of contaminated dusts in the air of a very crowded city. Pollution from automobiles has risen sharply in Nigeria. Measurements made in 1976 at Baguada, a rural site in Northern Nigeria, found that the concentrations of trace and major elements in the atmosphere were an order of magnitude higher in the dry season when the air is of Saharan origin than in the rainy season when maritime tropical air dominate [10]. Thus, during the harmattan season, the dust concentrations in many parts of West Africa exceed the WHO recommended guideline values of 60-90ng/m^3. The major highways in country especially cities carry tens of thousands of vehicles per day but during the rush hour traffic, the travelling speeds typically decrease to 0-10 km/h for most roads within the cities [11]. The poor maintenances of the vehicles, their mode of operation, the longer driving times in narrow and crowded roads and the perennial traffic jams often result in a larger fraction of the metals especially lead in gasoline being released to the air and deposited on the food crops dried on the road. Furthermore, as the vehicles plow through the dusty roads, they cause the pre-released lead and other toxic metals to be wafted back up into air. Dust mobilization due to automobiles has been estimated to be 6.5g/vehicle-kilometer for paved roads and 61.5g/ (veh.Km). For unpaved roads in Nigeria, compared to only 0.1g/ (veh.km) for the streets in London, England [11]. Although the metals flux from this source is small on the wide scale, the recycling of pollutant lead can be a problem in urban areas where the vehicles are concentrated.

The discharge of large quantities of toxic metals into the air, water and soils inevitably results in the transfer of pollutant metals to the human food chain. An assessment of environmental metal poisoning in African especially Nigeria is thus made difficult by the multiplicity of sources in any given areas. Food processing, preservation and storage are one of the major problems facing most farmer in developing countries especially in African countries where there isn't enough technological development to processes and preserves their farm produce. Most of African farmers resort to various methods of processing and preserving of their food products. The most common and widely used method is drying food crops along the highways; especially in the Northern part of the country where food crops such as cassava, maize corns, millets, guinea corns and varieties of vegetables are produced in large quantities. As local residents consumed these food crops continuously or sold in the markets, this may possibly have adverse effects on human health. The objective of this research is to investigate the influence of automobile exhausts, dusts and associated waste materials on the heavy metal contaminations of selected food crops (cassava mash and maize corns) dried along the major highways in some selected states “Nassarawa, Benue and Taraba” in Northern part of the country where these food crops are produced in large quantities.

MATERIALS AND METHODS

Cassava mash and maize corns were gotten from the cassava mash and maize corns dried along the highways in the study areas ‘’ Nassarawa, Benue and Taraba”, while the control samples were purchased from farmers at home before taken to the highways for drying. Samples were oven dried at 80 ^{O} C to constant weight. The dried samples were ground, passed through a 2mm sieve and stored at room temperature before analysis.

Heavy metal analysis

A portion (1g) of prepared food crop samples were weighed into 125 cm^3 conical flask using the USEPA 3050 method [12]. 10 cm^3 of HNO_3 was added and the mixture was heated for 30 minutes on a water bath at 100^0 C. The digest was allowed to cool and another 5 cm^3 of HNO_3 was added and heating continued for 1 hour at 100^0C. The volume of the digest was reduced by boiling in the water bath and this was allowed to cool. 5 cm^3 of deionized water was added when effervescence subsided, 10 cm^3 of H_2O_2 (60%) was added and heating continued for another 30 mins. The final digest was allowed to cool and filtered. The final volume of digest was made up to 50 cm^3 with deionized-distilled water and was analyzed for the required heavy metal by flame atomic assumption spectrophotometer. Standards were prepared with serial dilution techniques within the range of each metal determined. The standard used was analar grade; the instrument was first calibrated with stock solutions of the prepared standards before analyzed using flame atomic absorption spectrophotometer. After every five samples analyzed using AAS, the first sample was repeated for quality check. Only when the result was within 10% of earlier readings did the analysis proceed further. The data obtained in the study were analyzed using Pearson correlation analysis.

RESULTS AND DISCUSSION

The results of heavy metal concentrations in the crop samples (Cassava mash and Maize grains) dried along the highways are presented in (Tables 1-8). The samples (Cassava mash and Maize grains) from high ways in the study areas revealed elevated levels of these heavy metals (Cd, Cu, Mn, Ni, Pb, and Zn). The mean concentrations of heavy metals obtained from the control samples were lower than those obtained from the samples dried along the highways. This reflects a contamination of these crops (Cassava mash and Maize grains) dried along the highways by heavy metals. Out of the heavy metals considered, lead and cadmium show the highest contamination in the crops under considerations.

The overall results ranged from 0.21-0.41μg/g, 11.12-18.12 μg/g, 10.20-17.01 μg/g, 0.68-0.92 μg/g 0.35-0.66 μg/g and 9.52-21.33 μg/g for Cd, Cu, Mn, Ni, Pb and Zn in the cassava mash samples, while in the maize grains,the heavy metal concentrations ranged from 0.18-0.35 μg/g, 5.78-9.88 μg/g, 7.85-12.25 μg/g, 0.52-0.88 μg/g, 0.31-0.45 μg/g and10.99-16.55 μg/g for Cd, Cu, Mn, Ni, Pb and Zn respectively.

Table 1: Trace heavy metal contents (µg/g) in Cassava mash along the Highways in Benue State.

Sites	Cd	Cu	Mn	Ni	Pb	Zn
A	0.24	12.11	10.20	0.85	0.52	19.55
B	0.22	12.50	12.50	0.75	0.35	21.33
C	0.28	17.01	17.01	0.77	0.45	18.55
D	0.29	13.15	14.25	0.68	0.62	13.52
E	0.28	12.50	11.89	0.69	0.54	19.52
F	0.21	12.35	13.08	0.88	0.44	9.52
G	0.28	14.21	11.89	0.75	0.51	17.66
H	0.27	12.55	13.56	0.72	0.46	16.87
I	0.26	13.55	12.98	0.81	0.44	18.36
J	0.24	12.35	14.53	0.91	0.65	19.85
Mean	0.26	13.23	13.19	0.78	0.50	17.47
S.D	0.03	1.48	1.84	0.08	0.09	3.50
Control 1	0.05	10.05	10.05	0.77	0.09	10.22
Control 2	0.04	9.15	9.15	0.73	0.08	9.52
Control 3	0.06	10.55	10.55	0.65	0.08	11.21
Mean	0.05	9.92	9.92	0.72	0.08	10.32
S.D	0.01	0.71	0.71	0.06	0.01	0.85

Table 2: Trace heavy metal contents (µg/g) in maize corn along the Highways in Benue State.

Sites	Cd	Cu	Mn	Ni	Pb	Zn
A	0.22	8.25	12.25	0.65	0.35	15.25
B	0.21	6.69	11.51	0.56	0.32	13.45
C	0.22	7.55	10.05	0.68	0.41	13.25
D	0.23	8.56	10.09	0.59	0.33	12.22
E	0.21	7.66	11.23	0.63	0.42	11.16
F	0.19	8.55	12.23	0.75	0.35	13.21
G	0.22	6.78	9.89	0.66	0.34	14.44
H	0.20	9.63	10.26	0.77	0.37	13.22
I	0.21	8.55	11.56	0.62	0.38	12.95
J	0.22	7.32	10.05	0.65	0.34	11.05
Mean	0.21	7.95	10.91	0.66	0.36	13.02
S.D	0.01	0.92	0.95	0.07	0.03	1.30
Control 1	0.05	6.55	8.89	0.55	0.07	11.21
Control 1	0.04	6.82	9.55	0.59	0.07	10.33
Control 1	0.04	7.12	8.95	0.57	0.06	9.85
Mean	0.04	6.83	9.13	0.57	0.07	10.46
S.D	0.01	0.29	0.37	0.02	0.01	0.69

Table 3: Trace heavy metal contents (μg/g) in Cassava mash along the Highways in Nassarawa State.

Sites	Cd	Cu	Mn	Ni	Pb	Zn
A	0.36	12.15	11.25	0.85	0.52	20.123
B	0.32	12.66	13.23	0.88	0.42	22.12
C	0.31	18.12	17.01	0.77	0.45	19.55
D	0.35	13.15	14.22	0.71	0.62	14.23
E	0.37	13.22	13.22	0.72	0.54	19.52
F	0.33	12.35	12.55	0.88	0.54	10.58
G	0.38	15.11	15.22	0.75	0.66	17.66
H	0.39	12.66	11.25	0.81	0.46	18.22
I	0.41	13.55	14.11	0.79	0.54	18.36
J	0.38	13.33	12.85	0.77	0.65	20.12
Mean	0.36	13.63	13.49	0.79	0.54	18.05
S.D	0.03	1.78	1.76	0.06	0.08	3.34
Control 1	0.09	10.05	10.05	0.77	0.09	10.22
Control 2	0.08	10.11	11.25	0.69	0.08	10.59
Control 3	0.07	10.55	10.55	0.65	0.06	11.21
Mean	0.08	10.24	10.62	0.70	0.08	10.67
S.D	0.01	0.27	0.60	0.06	0.02	0.50

Table 4: Trace heavy metal contents (μg/g) in Maize corn along the Highways in Nasarawa State

Sites	Cd	Cu	Mn	Ni	Pb	Zn
A	0.26	8.25	11.98	0.62	0.41	14.55
B	0.27	6.69	11.05	0.65	0.31	13.55
C	0.27	7.55	10.05	0.86	0.39	13.25
D	0.29	9.22	10.09	0.64	0.33	12.55
E	0.35	7.66	9.58	0.521	0.32	11.61
F	0.28	8.55	12.23	0.57	0.34	12.13
G	0.31	5.78	7.85	0.76	0.42	14.54
H	0.31	9.63	10.26	0.88	0.37	13.26
I	0.28	9.88	10.56	0.63	0.32	13.05
J	0.26	7.32	10.55	0.56	0.45	10.99
Mean	0.29	8.05	10.42	0.67	0.37	12.95
S.D	0.03	1.31	1.24	0.12	0.05	1.16
Control 1	0.05	6.23	8.89	0.65	0.08	10.21
Control 2	0.07	6.28	8.55	0.59	0.12	10.22
Control 3	0.06	7.55	8.95	0.58	0.09	9.85
Mean	0.06	6.69	8.80	0.61	0.10	10.09
SD	0.01	0.75	0.22	0.04	0.02	0.21

Table 5: Trace heavy metal contents (µg/g) in Cassava Mash along the Highways in Taraba State.

Sites	Cd	Cu	Mn	Ni	Pb	Zn
A	0.21	11.12	11.22	0.76	0.45	19.06
B	0.23	11.95	11.98	0.85	0.43	20.05
C	0.25	14.55	16.88	0.65	0.48	19.55
D	0.26	13.15	13.15	0.75	0.45	14.67
E	0.24	13.05	11.95	0.71	0.54	20.67
F	0.25	13.55	12.35	0.85	0.55	15.87
G	0.25	13.95	15.21	0.73	0.51	16.66
H	0.26	12.55	13.05	0.69	0.45	15.87
I	0.21	13.55	13.55	0.87	0.43	17.98
J	0.22	11.98	13.22	0.92	0.66	18.88
Mean	0.24	12.94	13.26	0.78	0.50	17.93
SD	0.02	1.04	1.68	0.09	0.07	2.04
Control 1	0.06	9.95	9.95	0.67	0.08	10.55
Control 2	0.05	9.88	9.85	0.73	0.07	9.55
Control 3	0.05	11.05	10.05	0.72	0.07	10.55
Mean	0.05	10.29	9.95	0.71	0.07	10.22
SD	0.01	0.66	0.10	0.03	0.01	0.58

Table 6 : Trace heavy metal contents (µg/g) in Maize corn along the Highways in Taraba State.

Sites	Cd	Cu	Mn	Ni	Pb	Zn
A	0.22	8.75	11.66	0.75	0.34	16.55
B	0.23	6.55	11.55	0.65	0.31	14.22
C	0.21	7.25	10.55	0.72	0.42	12.55
D	0.24	8.62	10.09	0.69	0.35	12.06
E	0.21	7.03	11.23	0.65	0.31	11.55
F	0.18	8.75	12.23	0.68	0.37	12.89
G	0.22	7.02	10.23	0.77	0.34	14.55
H	0.21	8.98	11.22	0.78	0.37	12.66
I	0.21	8.95	11.56	0.82	0.38	13.04
J	0.21	8.55	10.53	0.71	0.41	11.22
Mean	0.21	8.05	11.06	0.72	0.36	13.13
SD	0.02	0.96	0.70	0.06	0.04	1.59
Control 1	0.06	6.33	9.44	0.65	0.08	11.77
Control 2	0.05	6.21	8.55	0.61	0.08	11.55
Control 3	0.05	7.55	9.76	0.62	0.09	10.55
Mean	0.05	6.70	9.25	0.63	0.08	11.29
SD	0.01	0.74	0.63	0.02	0.01	0.65

Table 7: Summaries of the total metal contents in cassava mash dried along highways in study areas.

States	Metals						
Benue		Cd	Cu	Mn	Ni	Pb	Zn
Ranges		0.21-0.29	12.11-17.01	10.20-17.00	0.68-0.88	0.35-0.65	9.52-21.33
Mean±Sd		0.26□0.03	13.23□1.48	13.19□1.81	0.78±0.08	0.50±0.90	17.47±3.50
Nassarawa							
Ranges		0.31-0.41	12.15-18.12	11.25-17.01	0.71-0.88	0.42-0.66	10.58-20.12
Mean±Sd		0.36±0.03	13.63±1.78	13.49±1.76	0.79±0.01	0.54±0.08	18.05±3.33
Taraba							
Ranges		0.21-0.26	11.12-14.55	11.22-16.88	0.69-0.92	0.43-0.66	14.67-20.67
Mean±Sd		0.24±0.01	12.94±1.04	13.26±1.68	0.78±0.09	0.50±0.07	17.93±2.04

Table 8: Summaries of the total metal contents in maize corn dried along highways in study areas

States	Metals						
Benue		Cd	Cu	Mn	Ni	Pb	Zn
Ranges		0.19-0.23	6.69-9.63	9.89-12.25	0.56-0.77	0.32-0.42	11.05-15.25
Mean□SD		0.21±0.01	7.95±0.92	10.91±0.95	0.66±0.07	0.36±0.03	13.02±1.30
Nassarawa							
Ranges		0..26-0.35	5.78-9.88	7.85-12.23	0.52-0.88	0.31-0.45	10.99-14.55
Mean□SD		0.29±0.03	8.05±1.31	10.42±1.24	0.67±0.12	0.37±0.05	12.95±1.16
Taraba							
Ranges		0.18-0.24	6.55-8.98	10.09-12.23	0.65-0.82	0.31-0.42	11.22-16.55
Mean□SD		0.21±0.02	8.05±0.96	11.09±0.70	0.72±0.06	0.36±0.04	13.13±1.59

Table 9: Transfer factor of trace heavy metals studied (Cassava mash)

States	Metals					
	Cd	Cu	Mn	Ni	Pb	Zn
Benue	5.14	1.33	1.33	1.09	5.98	1.69
Nasarawa	4.50	1.33	1.27	1.13	7.01	1.69
Taraba	4.49	1.26	1.33	1.10	7.07	1.75

Table 10: Transfer factor of trace heavy metals studied (Maize corn)

States	Metals					
	Cd	Cu	Mn	Ni	Pb	Zn
Benue	4.95	1.17	1.20	1.15	5.39	1.24
Nasarawa	4.80	1.20	1.18	1.10	6.54	1.28
Taraba	4.04	1.21	1.20	1.15	4.34	1.16

Table 11: Interelemental correlation of elements in cassava mash.

State	Metals					
	Cd	Cu	Mn	Ni	Pb	Zn
Benue		0.49	0.49	-0.70	0.38	0.10
			0.94*	-0.19	-0.16	0.07
				-0.26	-0.17	-0.00
					0.07	-0.07
						-0.06
Nasarawa		-0.30	-0.32	-0.32	0.44	0.09
			-0.24	-0.39	-0.05	0.17
				0.49	0.00	-0.78
					-0.54*	-0.01
						-0.32
Taraba		0.51*	0.36	-0.58*	-0.04	-0.56*
			0.78*	-0.36	-0.02	-0.23
				-0.40	0.02	-0.08
					0.35	0.03
						0.12

Table 12: Interelemental correlation of elements in maize corn

State	Metals					
	Cd	Cu	Mn	Ni	Pb	Zn
Benue		-0.37	-0.51*	-0.61*	-0.11	-0.01
			0.15	0.56*	0.13	0.00
				-0.02	-0.09	0.30
					0.25	0.14
						-0.46
Nasarawa		-0.02	-0.57*	-0.00	-0.32	-0.14
			0.42	0.02	-0.38	-0.18
				-0.35	-0.19	-0.14
					0.22	0.52*
						0.11
Taraba		-0.27	-0.57*	-0.04	-0.37	0.20
			0.22	0.49	0.42	-0.06
				-0.06	-0.22	0.30
					0.38	0.28
						-0.37

Table 13: Guideline for safe limits of Heavy metals in crop plant (µg/g)

	Metals					
	Cd	Cu	Mn	Ni	Pb	Zn
W.H.O/F.A.O (2007)	0.20	40.00	-	-	5.00	60.00
Commision regulation (EU,2006)	0.20	-	-	-	0.30	-

Generally, in the crop samples (cassava mash and maize grains) studied, the concentrations of the heavy metals were high especially Pb and Cd. This is an indication that these heavy metals are the primary contaminant in the food crops dried along the highways which was also reflected in the low level of these heavy metals obtained from the control crop samples in comparison with those obtained from the samples along the highways. Also, the degrees of heavy metals contamination of these crops (cassava mash and maize grains) dried along the highways which hwere determined by its "transfer factors" which were also high. From the mean results and transfer factors, there is a clear indication that Pb and Cd are the great contaminants in these crops dried along the highways where exhaust from vehicles and gasoline combustion primarily cause air pollution with the heavy metals especially lead particles reaching these crops dried along the highways [13]. Studies have shown that motor vehicles constitute principal source of these metals [14,15]. The major highways in the country carry tens of thousands of vehicles per day but during the rush hour traffic, the traveling speeds typically decrease to 0-10km/h for most roads within the cities [11]. The poor maintenance of the vehicles, their mode of operation, the longer driving times in narrow and crowded roads and perennial traffic jams often result in a larger fraction of the lead in gasoline being released to the air. Furthermore, as the vehicles plow through the dusty roads, they cause the pre-released lead and other toxic metals to be wafted back up into the air. Although the Pb flux from this source is small on a wide scale, the recycling of polluted lead can be problems in areas were the vehicles are concentrated. The sources of Cd to the environment are motor oils, car tyres, zinc compounds and phosphorus fertilizers. The correlations were established among the various metals under consideration (Table 11-12). Generally the correlations among the metals were very poor, there was positive correlation between pair of Cu/Mn in cassava mash sample, which may mainly reflects the natural occurrence of these metals in plants.

The transfer factors for Cu, Mn, Ni and Zn varied between 1.09-1.75 and 1.10-1.28 for cassava mash and maize grains (Table 9), which indicates that samples (cassava mash and maize grains), were not contaminated by these trace heavy metals. Although these metals "Cu, Mn,Ni and Zn have transfer factors somewhat higher than unity (Table 10), the result of this study indicates that these metal levels are generally below the trigger concentration and fall the safe limits [16],and commission regulation [17] (Table 13).The results of "transfer factors" showed that Cd and Pb contamination in cassava mash and maize grains dried along the highways had potential to pose health risk to the local population since these food items can be consumed directly without any other treatment. Dietary intake of heavy metals through contaminated foods may lead to various chronic diseases. Many researchers have suggested that biotoxic effects of heavy metals depend on the concentrations and oxidation states of heavy metals, kind of sources and mode of deposition [18].Severe exposure of Cd may result in pulmonary effects such as emphysema, bronchiolitis and alveolitis. Renal effect may also result due to sub-chronic inhalation of Cd [19]. Pb toxicity causes reduction in the haemoglobin synthesis, disturbance in the haemoglobin synthesis, disturbance in the functioning of kidney, joints, reproductive and cardiovascular systems and chronic damage to the central and peripheral nervous systems [20].

CONCLUSION

The results obtained from the analysis of food crops (cassava mash and maize grain) dried along the highways in the selected states (Benue, Nasarawa and Taraba) in northern part of the country (Nigeria) indicated that the concentrations of the metals determined (Cd, Cu, Mn, Ni, Pb and Zn) were higher than those of control crop samples (cassava mash and maize grains) metal contents. The degrees of contamination determined through the "transfer factors" were very high for Pb and Cd. Other metals such as Cu, Mn, Ni and Zn showed little degree of contamination in crop samples under consideration. From this reason, it could be predicted that the sources of contamination of these metals especially Pb and Cd are probably from anthropogenic sources. Cd concentrations were above WHO/FAO [16] and Commission regulation safe limits and Pb above Commission regulation[17] but below the WHO/FAO safe limits [16]. Cd and Pb contamination in the test samples (cassava mash and maize grains) had potential for human health risk due to consumption of these crops. Consumption of these crops with elevated levels of heavy metals may lead to high level of body accumulation causing related health disorders. Thus regular monitoring of heavy metal concentration in the food crops dried along the highways is necessary and consumption of contaminated food crops should be avoided in order to reduce the health risk caused by taking the contaminated crops.

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