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Evaluation of Lead and Cadmium Levels in Some Commonly Consumed Vegetables in the Niger-Delta Oil Area of Nigeria

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The Niger- Delta region in southern Nigeria has attracted and continues to attract the interest of many international oil and gas prospecting companies owing to its vast crude oil and natural gas reserves. The region accounts for about 98% of the foreign exchange earnings of the country (Ihonvbere and Falola 1991). Many oil and non-oil related industries have been established in this region amongst which are oil refineries and petrochemical, natural gas and steel processing industries. The activities of these industries have increased industrial emissions which have contributed to the pollution of the environment (Egborge 1994).

Cadmium which occurs naturally with lead (Cabrera et al. 1998) are amongst the heavy metals which are the most persistent and accumulative environmental pollutants arising from the mining processes in the Niger-Delta (Kakulu 1985; Omgbu and Kokogho 1993; Egborge 1994; Ataikiru 1997). In his study, Kakulu (1985) showed that the Nigerian crude oils are rich in lead, copper, zinc, mercury and iron. Oil exploration and processing in the Niger-Delta is associated with gas flaring and occasional oil spillages which results in acid rain and heavy metal contamination. Acidification of the soil and rain water run-off results in enhanced mobilization of heavy metals from soils (WHO 1992). With recorded high rainfall in the Niger-Delta, there is improved chance of run-off of these pollutants to other areas beyond the sources of the pollution. Heavy metals from the industrial emissions of these oil and non oil related industries can contaminate edible vegetables. Cadmium contamination of vegetables has been earlier reported in Seaweed (Robards and Worsfold 1991), and in leafy and root crops and fruits (Sherlock 1986). The ecotoxicity of heavy metals is mainly due to the fact that they are not biodegradable, accumulating in vegetables (Zurera et al. 1987) and when consumed, they also accumulate in human bodies producing illnesses (WHO 1992).

Studies have shown that soil samples from Ekpan (Omgbu and Kokogho 1993), Aladja (Ataikiru 1997) and Forcados (Omgbu 1992) have significantly high levels of some heavy metals. These towns are of high industrial activities in the Niger-Delta. To the best of our knowledge, there is no measurement of the accumulation of heavy metal in edible plants of the Niger-Delta of Nigeria. This makes the study of the levels of some heavy metals in edible shrubs commonly

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consumed by the communities in the Niger-Delta area imperative. *Vernonia amygdalina* (bitter leaf), *Talinum triangulare* (water leaf), *Amaranthus hybridus* (spinach) and *Telfaria occidentalis* (pumpkin leaf, locally called 'ogu') form a major component of most local diets consumed in the Niger-Delta of Nigeria.

The objective of this study is to investigate the levels of lead and cadmium contamination of some commonly consumed vegetables (*A. hybridus, T. occidentalis, V. amygdalina* and *T. triangulare)* obtained from farmlands in the western Niger-Delta area and to establish a base level of contamination to serve as a reference point for further studies.

MATERIALS AND METHODS

The leaves of four plant species viz (*V. amygdalina, T. occidentalis, A. hybridus* and *T. triagulare*) were used in this study. The leaves used were at least 6cm in length and 3cm in width and were at least four weeks post germination. The vegetables studied were obtained from 3 farms in each of the following towns in the Western Niger-Delta; Ekpan, Aladja, Forcados and Ekiadolor. The farms selected were the major sources of these vegetables in the local markets of each town. Ten leaves from each of 30 plants of the same species meeting the sampling size were harvested from each of 3 farms thus bringing the total number of plants harvested for study to 90 per species per town. The 10 leaves from a plant were pooled together as a sample and thoroughly washed with deionised water to remove dust and other particles. The samples obtained were packed into labeled polythene bags rinsed with nitric acid (1:3) and stored in a deep freezer at -10°C until required for analysis.

The vegetable leaves were dried at 50°C in an oven for 24 hours to a constant weight. The dried leaves from each plant were homogenized with a blender to a powdery form. One gramme of the sample was digested with 20ml HNO_3-$HClO_4$ mixture (4:1v/v) at100°C. Each sample was thereafter diluted to 100ml with distilled deionised water and analyzed for cadmium and lead with a Varian spectre AA10 Atomic absorption spectrophotometer with an air/acetylene flame equipped with an auto print out system and metal hollow cathode lamps. Wavelengths used for cadmium and lead were 228.8nm and 283nm respectively. Standard solutions for cadmium and lead ions (1000μg L^{-1}) were prepared from analytical grade of the following metal compounds: $3CdSO_4.8H_20$ and $PbNO_3$ manufactured by May & Baker limited, Dagenham, England. The working standards were prepared by serial dilution of the standard stock solutions and were used for the calibration of the instrument. The accuracy and precision of the analysis were evaluated using an International Atomic Energy Agency (IAEA) reference biological sample V-10 (Hays) with certified values of 0.029±0.004mg Cd/kg dry weight and 0.54±0.05mg Pb/kg dry weight. The results obtained for the reference sample were in agreement with the certified values (0.027±0.005mg Cd/kg dry weight and 0.58±0.04mg Pb/kg dry weight). In all the determinations, blanks were prepared to determine the effect of reagents purity on the metal levels. Before use, glassware and plastic utensils were washed using 10% HNO_3.

The values are reported as Mean ± S.E.M. Analysis of variance was used to test for differences in the groups. Duncan's multiple range test was used to test for significant differences between the means (Sokal and Rohlf 1969).

RESULTS AND DISCUSSION

The level of heavy metal in the soil of Ekpan, Aladja and Forcados which are towns of high industrial activities in the Niger-Delta region had previously been reported (Omgbu and Kokogho 1993; Egborge 1994). The use of plants as biomakers of heavy metal pollution has long been acknowledged, however the monitoring of heavy metals in edible vegetables in the Niger-Delta region is lacking.

The levels of cadmium and lead in the vegetables from the farms in the four towns are presented in tables 1 and 2. The study shows a higher level of lead than cadmium in the vegetables grown in all the study towns. The soils of the Niger-Delta are believed to arise from rocks of the Benue trough which are associated with lead-zinc mineralization (Ofoegbu and Odigi 1990). This may account for the higher level of lead in all the plants grown in the study towns including Ekiadolor (the control town) compared with the level of cadmium. Values obtained in this study show that the level of cadmium and lead recorded in the leaves of vegetables from the industrial areas of Aladja, Ekpan and Forcados were at least 10-fold (cadmium) and 5-fold (lead) higher than the levels recorded in the typical rural setting of Ekiadolor. Varying levels of cadmium and lead were recorded in the vegetables. Cadmium unlike lead has been reported to be transferred with ease from soil to plants and the transport is influenced to some extent by soil and plant species (Jackson and Alloway 1991; Zurera et al. 1987). As cadmium is more easily taken up by plants than lead, it may explain the ten fold uptake of cadmium compared with the five fold uptake of lead by the vegetables studied.

Table 1. The levels of cadmium in *V. amygdalina, T. occidentalis, A. hybridus and T. triagulare* from farms in towns of the Niger-Delta area of Nigeria

Town / Vegetable	Ekiadolor	Aladja	Ekpan	Forcados
V. amygdalina	0.006 ± 0.0003^{a}	0.05 ± 0.01^{b}	0.09 ± 0.01^{c}	0.11 ± 0.02^{c}
T. occidentalis	0.003 ± 0.0005^{a}	0.07 ± 0.02^{b}	0.10 ± 0.01^{b}	0.13 ± 0.04^{b}
A. hybridus	0.008 ± 0.0003^{a}	0.06 ± 0.01^{b}	0.20 ± 0.04^{c}	0.35 ± 0.04^{d}
T. triagulare	0.002 ± 0.0003^{a}	0.07 ± 0.01^{b}	0.08 ± 0.02^{b}	0.17 ± 0.05^{c}

Cadmium level is expressed as µg/g dry weight of sample. Values are means ± S.E.M. (n = 90). Means of the same row followed by different letters differ significantly ($P < 0.05$).

Earlier studies had reported increased cadmium and lead levels in plants due to increased industrial activities (Onianwa and Ajayi 1987; WHO 1992). Since the early 1960s, the discovery of large oil deposits in the Niger-Delta had led to tremendous increase in industrial activities and pollution. This was argued to have contributed to earlier observed increase in heavy metal levels in the soils of these areas (Omgbu and Kokogho 1993; Ataikiru 1997; Omgbu 1992). It is not surprising therefore that there were observed elevated cadmium and lead levels of the vegetables grown in these areas. Comparing the areas with industries, the highest level of cadmium in the vegetables was recorded in Forcados (table 1) while the highest level of lead was in Ekpan (table 2). Studies of heavy metals in various Nigerian crude oils have shown them to contain relatively high concentrations of heavy metals (Kakulu 1985). The sources of cadmium in Forcados are yet unclear however; spillages are a frequent occurrence because of the presence of an oil terminus for export. The frequent oil spillages may be one of the sources of cadmium contamination and may account for the high levels of cadmium in vegetables grown in this area. Also oil exploration and processing in the Niger-Delta is associated with gas flaring and acid rain. Acidification of the soil and prevalent rain water run-off would contribute to enhanced mobilization of cadmium from soils in Forcados.

Our results show that *A. hybridus* accumulated the highest amount of cadmium ($0.35\pm0.04\mu g\ g^{-1}$ in Forcados; $0.06 \pm 0.01\mu g\ g^{-1}$in Aladja; $0.20 \pm 0.04\mu g\ g^{-1}$ in Ekpan). *T. occidentalis* accumulated the highest lead ($4.91\pm0.43\mu g\ g^{-1}$ in Ekpan; $3.23 \pm 0.32\mu g\ g^{-1}$ in Forcados; $1.61 \pm 0.27\mu g\ g^{-1}$ in Aladja) as compared with the other vegetables. The ability of plants to accumulate heavy metals does not only depend on the level of environmental contamination but also on the species of plant (Chambers and Sidle 1991; Steinbörn and Breen 1999). Therefore the results obtained suggest that *A. hybridus* and *T. occidentalis* have a high ability for the accumulation of cadmium and lead respectively than the other vegetables.

Table 2. The levels of lead in *V. amygdalina, T. occidentalis, A. hybridus and T. triagulare* from farms in towns of the Niger-Delta area of Nigeria.

Town Vegetable	Ekiadolor	Aladja	Ekpan	Forcados
V. amygdalina	0.029 ± 0.003^{a}	1.62 ± 0.24^{b}	2.82 ± 0.22^{c}	2.95 ± 0.15^{c}
T. occidentalis	0.016 ± 0.001^{a}	1.61 ± 0.27^{b}	4.91 ± 0.43^{c}	3.23 ± 0.32^{d}
A. hybridus	0.031 ± 0.004^{a}	1.56 ± 0.23^{b}	3.13 ± 0.26^{c}	3.01 ± 0.42^{c}
T. triagulare	0.021 ± 0.002^{a}	1.78 ± 0.21^{b}	2.91 ± 0.22^{c}	2.10 ± 0.23^{d}

Lead level is expressed as µg/g dry weight of sample. Values are means ± S.E.M. (n = 90). Means of the same row followed by different letters differ significantly ($P< 0.05$).

The high levels of lead in the vegetables in Ekpan (table 2) may not be unconnected with the presence of an oil refinery and petrochemical company at Ekpan. Lead is discharged from the waste effluents of this company and may accumulate in ecological materials. Moreover, Ekpan is a more densely populated area with high traffic volume. Atmospheric pollution by lead would therefore be higher since the metal is an anti-knock additive in gasoline for automobiles. This would also have contributed to the higher levels of lead recorded in the vegetables grown in the contaminated sites with high vehicular traffic as compared to cadmium. The major industry in Aladja is the iron and steel plant which has seized operating since the late 80s thus the low level of cadmium and lead in the vegetables grown in this area in relation to the other industrial towns may be due to low industrial pollution.

The main risk of the heavy metals is that they can continuously accumulate in plants and when consumed can generate severe illnesses in humans with time. Thus the body burden of cadmium and lead primarily depends on the daily intake of the elements in food. Legislations are lacking in Nigeria for maximum tolerable heavy metal levels in foods, but in the United Kingdom (UK) the statutory limit for lead in dried or dehydrated vegetables is 2mg/kg (The Lead in Foods regulation, 1985). The results obtained for lead levels in the vegetables grown in Ekpan (2.82-4.91mg/Kg) and Forcados (2.10-3.23mg/Kg) are above the allowed limits for the UK (table 2). High levels of lead and cadmium have also been reported in vegetables grown in areas where there is high degree of environmental pollution such as in areas close to active volcanoes (Queirolo et al. 2000)

The cadmium and lead concentrations in commonly consumed vegetables in the industrial towns of the Niger-Delta were slightly high and may portend a health risk for the population which subsists on the vegetables. It is suggested that the monitoring of heavy metal in edible plants of these areas especially those contained in Nigerian crude oils be a continuous process. The values obtained in this study can also serve as a reference point, as no measurements of lead and cadmium levels in vegetables from these areas have been reported. There is also need to establish tolerable limits of these heavy metals in vegetables consumed in Nigeria. Further work is also required to establish a more precise relationship between the heavy metal levels in the vegetables grown in the Niger-Delta and the degree of environmental pollution.

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