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Assumptions on Health Risks in Consuming *Vermonia amygdalina* and Fruits (*Musa sp.*) in Koko, Nigeria

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ABSTRACT

The unified potential of plants to absorb nutrients from soil, air, and water, including their natural surrounding habitat, makes them efficient in translocating nutrients and absorbing pollutants to the leaves, fruits, and other edible parts. Composite soil and two plants, *Vermonia amygdalina* and *Musa sp.*, were selected from two areas (area 1 and area 2), respectively, in Koko, Nigeria. Both samples were analyzed using an atomic absorption spectrophotometer, gas chromatography, and a soxhlet extractor for heavy metals, polychlorinated biphenyls (PCBs), and dioxins, respectively. Techniques applied were arithmetic mean, contamination factor, potential ecological risk index, and toxicity equivalence. Results revealed high mean concentrations of cadmium for plants in Area 1 (5.9022 mg/kg) and Area 2 (5.0172 mg/kg), respectively. The contamination factor showed a higher value in plants for cadmium in area 1 (5.9022 mg/kg) than in area 2 (5.017 mg/kg). The same was observed in the ecological risk index, as cadmium was concentrated more in plants (1.1612 mg/kg) in area 1 than (0.84 mg/kg) in area 2. PCBs recorded a high amount of mean in plants (14.095 ppb) for area 1 and 14.91 ppb in plants for area 2. The contamination factor in PCBs was the same in both areas, with area 1 recording 1409.5 ppb in plants and area 2 recording 1491 ppb in soil. The ecological risk index for plants was 496.7 ppb in plants for area 1 and 555.8 ppb in soil for area 2. Toxicity in dioxins exceeded the World Health Organization maximum limits, with Polychlorinated dibenzo-para-dioxins having the highest toxicity of 42.88 ppb in *V. amygdalina* and 9.69 ppb in *Musa sp.* Anthropogenic sources of pollutants such as shipping, oil transportation, power plant facilities, bitumen production, and lubricants remain key driving stressors that contribute to the destruction of plant ecology in Koko. The knowledge of the compounds constituting the make-up of these products in both plants reflects the health risks and hazards in the town. Hence, awareness and ecological monitoring of the area need a continuous program to minimize health hazards in Koko.

Keywords: ecological, plants, pollutants, potential, risk.

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I. INTRODUCTION

The awakening consciousness of human interference in the ecosystem has long been an issue that seeks to be addressed as quickly as possible [1]. The ecocide from biological degradation, which emanates from anthropogenic activities, disrupts plants' uptake of nutrients from the soil [2]. Plant roots play a functional role in this uptake which transcend to stems, vascular bundles, branches, petioles and leaves [3]. The diversity of soil prompts specializations of key characteristics of plants to absorb nutrients as well as bio-accumulate and bio-concentrate pollutants since soil biodiversity is a commonly needed part that is crucial for plants, and it possesses unique qualities that can help to aid plant growth [4]. Depending on the nature and specific characteristic features of plants, some are able to withstand the harsh effects of climatic fluctuations and other environmental stressors [5]. Key factors in these plants' potential for absorption are their physiological traits and characteristics [1]. *Vermonia amygdalina*, a good edible perennial creeper and climber, with elliptical leaves otherwise known as bitter leaf, is a commonly used medical plant and has a complex active site-response ingredient in the human body [6]. It is a common home-grown vegetable in farmlands and houses for easy consumption because of its medicinal effects however, various research has established its potential of bio-accumulating and decontaminating soils polluted with hydrocarbons using animals as case study [7]. Increasing trend of industrial pollution and use of crude oil products including kerosene in homes results in serious health-defects to humans [8], [9]–[10]. *Musa sp.* is also another edible fruit in the form of banana and plantain, which is highly nutritious and, more so, an erect perennial plant with enormous benefit [11]. Numerous research has demonstrated these advantages along with antioxidant qualities that include anticancer, antifungal, and antibacterial [12]. Their physiological traits on the life cycle, plant geometry, and their nature, which happens to be a part of plant breeding, provide means to bio-accumulate pollutants from the area. Koko has been a recipient of pollutants; hence, a conserved approach is applied to this study on the risks and hazards that human activities from industries and surrounding agricultural activities portend for organisms and human health.

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II. MATERIALS AND METHODS

The study area is located at 5°44′ NE and 5°4′ 6″ NW in Koko, Niger Delta region of Nigeria, using Garmin-73 Global Positioning System (GPS). Composite soils were collected using a soil auger in both sampled areas (1 and 2). Musa specie was located in area 2 and Vermonia amygdalina in area 1. Both were sampled and analyzed based on their phenotypes using the Plank [4] method (Table I). The selected heavy metals were lead, cadmium, and chromium. These were analyzed using Microsoft Excel to calculate the arithmetic mean, an atomic absorption spectrometer (AAS-500) to determine heavy metal concentrations, and 28 PCBs and 17 dioxin compounds were analyzed with the aid of gas chromatography, while dioxin values were calculated using the Hakanson [13] method for soil and specified plants.

A. *Preparation*

The soil particles were air-dried and sieved with a mesh size of 0.05–2 mm. The leaves were air-dried for seven days in an oven at 60 °C. It was then ground to a fine powder.

B. *Metal Analysis*

Two grams of air-dried soil samples were weighed and mixed with 20 ml of distilled water, 1.0 ml of concentrated nitric acid, and 5.0 ml of concentrated hydrochloric acid. After cooling and filtering, another 20 ml of distilled water was added, and the digested sample was sent to an atomic absorption spectrometer (AAS) for analysis. The leaves were subjected to nitric and kjeldahl microwave digestion before being fixed into the AAS machine for heavy metal analysis. *Polychlorinated biphenyls (PCBs) and dioxin analysis*: potassium permanganate was used for cleaning the soil samples and leaves thereafter, which were placed in a dual gas chromatography system using a soxhlet extractor and a microwave extractor for analyses.

TABLE I: SAMPLING PROCEDURE FOR COLLECTING LEAF AND PLANT TISSUE FOR PLANT ANALYSIS

Stage of growth	Plant part to sample	No of plants to sample
Watermelon, muskmelon, cucumber, pumpkin, etc. Mature leaves near the base portion of plant on main stem	Early growth prior to fruit set	20-30
Leafy greens (palak, spinach, etc.) Youngest mature leaf	Mid-growth	30-40

Source: Plank [13].

III. MATH

Techniques involved in the study were:

1) *Statistics*

Mean values were calculated using Microsoft Excel 16.0.

Mean is defined as the average data set, and it is denoted by the following:

$$\bar{x} = \left(\frac{\sum x}{n}\right) \tag{1}$$

where x = each observation and n = number of observations.

2) *Determination of contamination factor (CF)*

Determination of contamination factor (CF) is the quantification of the degree of contamination that is relative to the measured background values from similar uncontaminated areas. It is given by:

$$CF = C_s^i / C_n^i \tag{2}$$

where C_s^i is the concentration of each toxic substance in subsurface soils, C_n^i is the reference value for toxic substance that was defined by the background value (BV) of the toxicant in natural soil.

3) *3. Computation of Potential ecological risk index (PERI)*

Computation of Potential ecological risk index (PERI) determines the potential risk of pollutants in soils and sediments and provides information on their toxicity and effects in the overall assemblage of pollutants. It is expressed as follows:

$$C_f^i = C_s^i / C_n^i \tag{3}$$

$$E_f^i = \sum E_r^i = \sum T_r^i \times C_f^i \tag{4}$$

where C_f^i is calculated in the same way as CF,

E_r^i is the monomial potential ecological risk factor,

T_r^i is the substance toxic response factor.

IV. RESULTS AND DISCUSSION

The ethnomedicinal, antimicrobial, and phytochemical properties of banana, plantain, and bitterleaf are widely known; however, the drawbacks from the environmental associations in which they are grown make them unhealthy and a threat to consumers along the food chain [5], [6], [11]. Active points of production that chiefly release hazardous pollutants in the area include paint and lubricant, road tar, oil sludge, petroleum wastes with limitless transmission facilities, a seaport [2], etc. Among these products, significant concentrations of lead (pb) and cadmium (cd) were produced, with chromium (cr) in little quantity, which is correlated with studies in the Niger Delta [2], [14], and [15]. This led to the following observed analysis, as shown in Tables II and III.

TABLE II: MEAN, CONTAMINATION FACTOR AND ECOLOGICAL RISK INDEX OF SOIL AND PLANTS IN AREA 1

Elements	Mean		Contamination factor (CF)		Potential ecological risk index (PERI)	
Heavy metals (mg/kg)	Soil	Plants	Soil	Plants	Soil	Plants
Lead (Pb)	4.11492	4.8832	0.059	0.0698	0.049	0.0682
Cadmium (Cd)	4.40562	5.9022	4.406	5.9022	0.65	1.1612
Chromium (Cr)	0.16992	0.0212	0.0019	0.00024	0.00016	0.0000025
PCBs (ppb)	7.74	14.095	774	1409.5	149.8	496.7

TABLE III: MEAN, CONTAMINATION FACTOR AND ECOLOGICAL RISK INDEX OF SOIL AND PLANTS IN AREA 2

Elements	Mean		Contamination factor (CF)		Potential ecological risk index (PERI)	
Heavy metals (mg/kg)	Soil	Plants	Soil	Plants	Soil	Plants
Lead (Pb)	4.48664	2.9968	0.064	0.0428	0.057	0.0257
Cadmium (Cd)	4.22102	5.0172	4.221	5.017	0.594	0.84
Chromium (Cr)	0.13688	0.0328	0.0015	0.00036	0.000103	0.0000059
PCBs (ppb)	14.91	8.96	1491	896	555.8	200.7

According to the World Health Organization, the background levels of heavy metals and PCBs were exceeded in both soil and plants in the sampled areas [2], [15], showing a significant amount of health risk in the area. For dioxins, there are no stipulated values to calculate the contamination factor and potential ecological risk; hence, the toxicity equivalence factor was used as an assessment of toxicity levels in the area and compared with the safe and tolerable dose using WHO [16]. Dioxin is a globally known persistent, toxic, non-degradable, hydrophobic, and lipophilic pollutant that travels far from its source of production and has adverse effects on human health, including kidney disease, skin disorders, neurological disease, and so many others, as recorded in Tuyet-Hanh [17]. The maximum toxicity for Dioxins was exceeded in all its congeners, as shown in Table 5, except for OCDD in Table IV.

TABLE IV: TOXICITY EQUIVALENCE (TEQ) FOR *V. AMYGDALINA*

Dioxins (ppb)	Maximum allowable limits	Soil	Plants
2,3,7,8-TCDF	0.1	0.042	0.177
2,3,7,8-TCDD	1	ND	ND
1,2,3,7,8-PCDF	0.05	0.127	0.026
2,3,4,7,8-PCDF	0.5	0.37	0.02
1,2,3,7,8-PCDD	1	5.9	42.88
1,2,3,4,7,8-HxCDF	0.1	0.3	0.038
1,2,3,6,7,8-HxCDF	0.1	2.74	0.027
2,3,4,6,7,8-HxCDF	0.1	0.2	0.592
1,2,3,4,7,8-HxCDD	0.1	3.7	0.018
1,2,3,6,7,8-HxCDD	0.1	1.1	0.009
1,2,3,7,8,9-HxCDD	0.1	0.2	0.01
1,2,3,7,8,9-HxCDF	0.1	3.71	0.107
1,2,3,4,6,7,8-HpCDF	0.01	0.17	0.0014
1,2,3,4,6,7,8-HpCDD	0.01	0.08	0.001
1,2,3,4,7,8,9-HpCDF	0.01	0.04	0.0422
OCDD	0.0001	0.002	0.000013
OCDF	0.0001	0.0002	0.000022

TABLE V: TOXICITY EQUIVALENCE (TEQ) FOR *MUSA SP.*

Dioxins (ppb)	Maximum allowable limits	Soil	Plants
2,3,7,8-TCDF	0.1	0.382	0.124
2,3,7,8-TCDD	1	ND	ND
1,2,3,7,8-PCDF	0.05	0.057	0.014
2,3,4,7,8-PCDF	0.5	0.115	1.015
1,2,3,7,8-PCDD	1	1.41	9.69
1,2,3,4,7,8-HxCDF	0.1	0.103	0.606
1,2,3,6,7,8-HxCDF	0.1	0.206	0.54
2,3,4,6,7,8-HxCDF	0.1	0.101	0.019
1,2,3,4,7,8-HxCDD	0.1	0.023	0.015
1,2,3,6,7,8-HxCDD	0.1	0.037	0.006
1,2,3,7,8,9-HxCDD	0.1	0.64	0.008
1,2,3,7,8,9-HxCDF	0.1	0.014	0.013
1,2,3,4,6,7,8-HpCDF	0.01	0.0025	0.0095
1,2,3,4,6,7,8-HpCDD	0.01	0.0076	0.0032
1,2,3,4,7,8,9-HpCDF	0.01	0.0021	0.0611
OCDD	0.0001	0.000029	0.000025
OCDF	0.0001	0.000046	0.000041

The results of these plants revealed their viability, viscosity, and toxicity to organisms and humans. Although the inhabitants are knowledgeable to an extent about the deleterious effect of products from industries in the area, which has prompted the ban on live fish consumption from their surrounding rivers [18], the indigenous settlers constantly consume home-grown fruits and vegetables, which have the ability to accumulate pollutants [6], [11]. These pollutants are distributed across ecological systems through ecosystem processes (natural and man-made) [18], [19]. Their movements cut across environmental components, thus compromising the health status of the community dwellers [14]. With shared information on arochlors of persistent organic pollutants, which states that the higher the compound, the more site-specific action it performs on organs in organisms and humans [3], [19], [17], the contamination and ecological risk hit a critical point in ecosystems. Assessing the likelihood of neurological and death-trap sickness and diseases caused upon consuming V. amygdalina and Musa sp. from previous research [5], [3]–[6], reveals loopholes in health infrastructure programs as well as the potency of these pollutants to cause outbreaks of infectious diseases in oil-rich areas like Koko.

V. CONCLUSION

The contradictory potential of Musa and V. amygdalina species to harness environmental contaminants remains a concern to both living things and humans despite their demonstrated ability to be useful materials for pharmaceutical uses. On the environmental health public chart, undermining the hazards and consequences on gullible people in Koko is least likely since agricultural yield is evenly dispersed around the nation. While Musa sp. concentrated more PCBs than V. amygdalina did, Musa sp. contained more heavy metals and dioxins. The largest quantities of dioxins in both plants were polychlorinated dibenzo-para-dioxins, which have been linked to ill effects on human health. In order to prevent ecological harm to the environment, species, and humans, it is necessary to provide a safe environmental strategy and environmental monitoring of pollutants in the area. Additionally, it would help in reducing the continual generation of hazardous wastes and their disposal, as well as aiding in the fight against climate change problems by reducing the manufacturing of items that contain persistent organic pollutants.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of the manuscript.

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