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Bark of Neem Tree (*Azadirachta indica*) as Bio-indicator for Monitoring Environmental Pollution in Katsina Township, Nigeria

Fowotade SA[1*], Abdullah SA[2], Umar AA[3], Saleh I[2], Oladeji SO[3] and Otokiti MJ[3]

[1]*Department of Science Laboratory Technology, College of Science and Technology, Ota, Nigeria*

[2]*Department of Pre-ND College of Foundation Studies and Entrepreneurship Education, Hussaini Adamu Federal Polytechnic, Kazaure, Nigeria*

[3]*Department of Polymer Technology, College of Science and Technology, Ota, Nigeria*

[*]**Corresponding author:** Fowotade SA, Department of Science Laboratory Technology, College of Science and Technology, Ota, Nigeria, Tel: +2348036570430; E-mail: fowotades14@gmail.com

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Abstract

The bark of neem tree (*Azadirachta indica*) was used in this study as bio-indicator to monitor heavy metal pollution in Katsina Township. Barks were sampled from four sites in Katsina Township, which include; Katsina Steel Rolling Company Round-about (Site A), Kofar Kwaya Round-about (Site B), Kofar Yandaka Round-about (Site C) and Nigeria Army Barrack, Natsinta (Site D). The samples were analyzed for Iron (Fe), Manganese (Mn), Copper (Cu), Lead (Pb), Cobalt (Co), Chromium (Cr), Nickel (Ni) and Zinc (Zn) using Atomic Absorption Spectrophotometry (AAS).

The results obtained revealed Fe (52.50 μgg^{-1}-196.25 μgg^{-1}), Mn (19.50 μgg^{-1}-34.25 μgg^{-1}), Zn (2.41 μgg^{-1}-8.43 μgg^{-1}), Cr (<1.00 μgg^{-1}-18.75 μgg^{-1}), Co (3.01 μgg^{-1}-11.50 μgg^{-1}), Pb (<1.00 μgg^{-1}-3.50 μgg^{-1}), Ni (1.00 μgg^{-1}-4.25 μgg^{-1}) and Cu (0.13 μgg^{-1}-2.75 μgg^{-1}) across the four sites. The order of metal concentration from each site is site A (Fe>Mn>Cr>Co>Zn>Ni>Pb>Cu), site B (Fe>Mn>Co>Zn>Ni>Pb>Cr>Cu), site C (Fe>Mn>Zn>Co>Pb>Ni>Cu>Cr) and site D (Fe>Mn>Co>Cu>Zn>Ni>Cr>Pb). The heavy metal burdens from site A are the highest while those from site D are the least. The result also indicated a correlation between the heavy metal concentrations and distance of each site from the source of contamination with the exception of Cu, Pb and Zn concentrations. Amidst the heavy metal analyzed Fe has the highest level while Cu has the least. From this study the heavy metal load does not pose any immediate health risk to the inhabitants and other lives in Katsina Township.

Keywords: Biocrude; Hydrocarbon plantation; Latex-producing plants; FT-IR

Introduction

Interests in trace metals in urban centres have rapidly increased as a result of the high levels of contamination measured in some cities and the associated potential health risks [1]. Recent studies have shown the feasibility of using natural vegetation as a monitoring agent for the determination of atmospheric metallic fall-out [2].

Reports of metal contamination of plants in cities and industrial areas have shown levels of some micro-nutrients especially Cu and Zn far in excess of the plant requirements [3,4]. A lot of geochemical investigation into the trace metal contamination of the environment had been undertaken via soils and street dust sampling [5]. Inhalation of suspended particles and ingestion of dust and soils (especially in the case of children) are among the possible routes through which people can be exposed to these elevated levels of trace elements [5].

The environment of urban areas is a decisive factor influencing both the quality of life and the health of people living in it. A report estimates that nearly all the population growth in the next 30 years will be concentrated in the urban areas of the world. In industrial centres the load of environmental pollution is often elevated, and the impact of the urban environment has even been increased by careless industrial activities [6].

The urban environment is also a source of varying concentrations of heavy metals from a vast array of anthropogenic sources such as traffic, fossil fuel combustion, mining, metallurgical and other industrial activities [7]. Particulate pollutants may be composed of metallic elements such as Cu, Zn, Fe, Pb, Cr [8]. Pb aerosols are usually absorbed on mushrooms, trees, juice of ripe fruits and even the skin of animals causing lead poisoning [9]. Pb as air pollutant in the urban areas may also come from manufacturing sources, pesticides, combustion of coal, refuse incineration and leaded gasoline [8]. The usefulness of Pb content of lichens as a gauge of traffic Pb deposition has also been established [10].

There are many other environmental factors which affect plant sensitivity to air pollutant not normally considered in the interpretation of survey results. Edaphic factors influence plant response to air pollutants [11]. It is reported that higher concentration of Zn, Cu and Fe were found in white clover than in Paspalum when both herbs were analyzed [12]. The entry of pollutants into the urban atmosphere can occur in the form of gases, particles or as aerosols [13].

The use of residual water for the irrigation of the vegetables as well as the use of certain fertilizers constitutes the principal source of Cadmium pollution in vegetables [14]. It is reported that Cu may originate from a number of sources including emissions from auto-mobiles, industries and soils [15]. On this note, it can be said that heavy metal contamination has received a much meticulous attention with regard to accumulation in soils, uptake by plants and contamination of water [16]. The urban centres are furnished with most industrial operations, domestic activities and traffic which are major sources of trace metal contributors to the atmosphere. It is therefore pertinent to determine if the levels of heavy metals in the Neem tree bark planted in Katsina Township can be attributed to such activities. On this note, the objectives of this study are:

(i) To determine the concentration of heavy metals in the bark of Neem trees as a measure of environmental pollution.

(ii) To compare the metallic load among the sites with their probable sources.

Area of study

Katsina Township is latitude 12.9978°N and longitude 7.5994°W. Katsina town is bounded by the following local government: Batagarawa, (West), Mashi (East), Mani (South East), Jibia (North), Kaita (North East), Rimi (South), Batsari (North West). Katsina town can boast of Dana Steel Rolling Company and Tarbiyyah Integrated Chalk and tiles making factories. As usual of urban centres, lots of vehicular movements are witnessed. Many domestic activities are also evident including open roasting and sales of chicken, meat and fish are carried out in the town.

The studied area includes Dana steel Rolling Company Round-about, site A. This Round-about has in its close proximity, the Katsina state ecological garden consisting of Neem tree plants. This site is very busy with vehicular movement in and out of the township. In its neighborhood there located the Dana Steel Rolling Company. Another industry close by is the Integrated Chalk Company, maker of tarbiyyah chalk. So the Neem tree plantation appears to the first recipient of industrial effluents from these industries. It is quite unfortunate that site A, where we undertook this present study in now extinct due urbanization. This site now harbours Katsina Peoples Democratic Party (PDP) National secretariat, the construction of which started in 2008 is in progress till date (Figure 1).

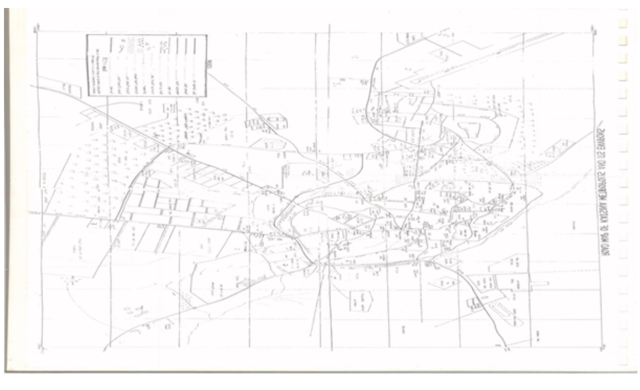

Figure 1: Shows the sampling sites used for the present study.

Site B is Kofar Kwaya Round-about. This is located within the township unlike site A that is somewhat at the outskirt. This site harbours a Neem tree plantation outfit as well in an unfenced landmass belonging to the Katsina state ministry of agriculture and environment, veterinary unit. This is the busiest site for vehicular movement among the four sites. Other activities obtainable in here include, road side frying of yam, beanscake, plantain, roasting of meat which is popularly called Balangu and vulcanizing activities. Neighboring to this site is the ELF filling station.

Site C is Kofar Yandaka Round-about, which is also located within the township. This site Harbours the Katsina state government day secondary school where the Neem tree plantation is situated. The activities in this site are much similar to those of site B but at reduce frequency. Neighboring to this site are two filling stations namely; Mobil and Conoil.

Site D is a beautiful Neem tree plantation in the Nigerian Army barrack, Nassinta, along Jibia road. This site is a complete sub urban region compared to other sites. It is used as a control site in this present study. This site witnessed the least industrial disturbances and vehicular motion is greatly reduced, so also are other aforementioned activities that may necessitate environmental pollution. Environmentally this is the least spontaneous site.

Samples of bark were collected during the months of April, May and June 2004, from four sites, in Katsina Township. These sites are: site A (Neem plantation, ecological and environment commission, Katsina about 10 m from the Dana Steel Rolling Company) round about; Site B (State Ministry of Agriculture and Natural Resources Veterinary area office, about 15 m from Kofar Kwaya round about), site C the compound of Government Day Secondary School, Kofar Yandaka about 50 m from Kofar Yandaka round about Neem tree plantation along Jibia road adjacent and site D (New tree plantation along Jibia Road, Adjacent Nigeria Army Barrack, Nasinta).

Materials and Methods

Samples from each site were collected from Neem trees at varying distance from one another. These were collected in plastic bags and transported to the laboratory where they were sorted and the dregs discarded. The fine samples were air dried in the laboratory, grounded into powder and sieved to obtain fine powder. 15 g of each sample were weighed into 100 cm^3 beaker of known weights and oven dried at a temperature of 105°C until a constant weight is reached. Each sample was stored in an air light container. Sample solution was prepared by digesting 10 g of each sample which has been ashed at 550°C using 10 cm^3 of 6 M nitric acid solution. The mixture is filtered into 50 cm^3 volumetric flasks and de-ionized water was added up to the mark [17]. The solutions were analyzed for Mn, Zn, Pb, Cr, Co, Ni, Cu and Fe, using AAS model Perkin Elmer 3110. A procedural blank and a set of standard for each element were determined each time a series of samples were run. Average reading of the samples was corrected with the blank reading and a calibration curve was constructed for each standard solution. The concentrations of each element under investigation in Parts Per Million (PPM) were determined from the curve of its standard by interpolation.

Results

Results of heavy metal levels assayed are presented in Table 1.

Site	A	B	C	D
Heavy metal	Mean and SD (μgg^{-1}) Range (μgg^{-1})	Mean and SD (μgg^{-1}) Range (μgg^{-1})	Mean and SD (μgg^{-1}) Range (μgg^{-1})	Mean and SD(μgg^{-1}) Range (μgg^{-1})
Fe	196.25 ± 21.36	122.50 ± 25.98	78.75 ± 54.98	52.50 ± 26.30
	210.00-165.00	150.00-90.00	135.00-20.00	90.00- 30.00

Mn	34.25 ± 2.66	32.75 ± 2.25	16.75 ± 3.59	19.50 ± 2.08
	37.00-31.50	36.00-31.00	20.00-12.00	22.00-17.00
Zn	5.50 ± 2.87	8.43 ± 4.15	5.88 ± 3.15	2.41 ± 1.02
	9.50-3.00	12.50-4.70	10.50-3.50	3.75-1.50
Cr	18.75 ± 10.31	1.00 ± 0.05	<1.00	<1.00
	30.00-10.00	4.00-0.00	0.00-0.00	0.00-0.00
Co	11.50 ± 5.51	9.39 ± 7.81	4.75 ± 4.17	3.01 ± 0.82
	18.00-6.00	18.00-2.55	10.00-0.50	4.00-2.00
Pb	3.50 ± 1.00	1.75 ± 0.50	2.75 ± 2.71	<1.00
	5.00-3.00	2.00-1.00	4.00-2.00	0.00-0.00
Ni	4.25 ± 1.26	4.00 ± 1.63	1.25 ± 0.96	1.00 ± 0.25
	6.00-3.00	6.00-2.00	2.00-0.00	2.00-0.00
Cu	1.73 ± 0.63	0.75 ± 0.15	0.13 ± 0.04	2.75 ± 0.65
	2.00-1.00	3.00-0.00	0.50-0.00	3.50-2.00

Table 1: Distribution of heavy metal in four sites across the Katsina Township, Neem tree bark (μgg^{-1}), showing the mean, range and standard deviation.

In Table 2, the concentration of metals across the four sites is presented with the WHO permissible limit. Mean, standard deviation and range results of heavy metals concentration in Neem tree (bark) from four sites in Katsina Township in μgg^{-1}.

Metal	Fe	Mn	Zn	Cr	Co	Pb	Ni	Cu
Range(μgg^{-1})	210.00-20.00	37.00-12.00	12.50-1.50	30.00-0.00	18.00-0.50	5.00-0.00	6.00-0.00	3.50-0.00
WHO	425	500	100	2.3	NS	0.3	NS	40

Table 2: Shows the concentration range (μgg^{-1}) range for the metals over the four sites and the WHO permissible limit.

Discussion

The results obtained in Neem tree bark sampled from four sites revealed that all the metals determined were detected. The samples from all the sites largely concentrate Fe with mean value 112.5 μgg^{-1}. The least concentrated metal is Cu with mean value 1.34 μgg^{-1}. Bark samples from site A generally had high levels of heavy metals except Zn. This may be attributable to the closest proximity of site A to the source of contamination coupled with heavy traffic often witnessed at the site. Samples from site D showed low levels of heavy metal burdens with the exception of Mn and Cu. In fact the samples from site D concentrated the highest level of Cu 2.75 μgg^{-1}. The low level of metals observed in this site is expected as it is the farthest site from the source of contamination. The site is also close to the road that leads to Jibia L.G.A. which relatively less busy with traffic. The high concentration of Mn and Cu may be traced to root up take by the plants site D corroborating the investigation of De Miguel [18].

The concentration of metals from sites A, B and C is higher compared to those from site D. This is due to the close proximity of the former sites to the source of contamination (the Dana Steel Rolling Company) and heavy trafficking of vehicles and other machinery witnessed at the sites. Samples from all the four sites concentrated high levels of Fe, Mn, Zn over Cr, Co, Pb, Ni and Cu. The least concentrated metals across the sites are Pb (2.67 μgg^{-1}), Ni (2.63 μgg^{-1}) and Cu (1.34 μgg^{-1}). The group Ni – Mn – Co may reveal the influence of emission from domestic heating systems or fossil fuel combustion [18]. Cr levels reported from sites B, C and D is in the range 4.00-0.00 μgg^{-1} and 0.00-0.00 μgg^{-1} respectively. These are in accordance with the research conducted by Hassan and Umar [19] that shows the uptake of Cr in amended soil is relatively less compared to other metals. Also Sani [20] reported level of Cr in lettuce and spinach in the range 5.25-5.00 μgg^{-1}. The value reported in site A (18.75 μgg^{-1}) in this study is less than that reported by Uwah [21] which is given in the range 93.50-90.50 μgg^{-1}.

The Zn concentration range over the four sites as shown in Table 2 is 12.50-1.50 μgg^{-1}. This value is low compared to 26.17 μgg^{-1} reported by Lone [22]. The value in this present study is far lower than 50.00 μgg^{-1} reported by Miller-ihli and Baker [23] in spinach leave. Sani [20] findings reported a similar range of 24.21-20.40 μgg^{-1} for Zn in the analysis of spinach and lettuce. Generally, the values were within the range of 150.00-20.00 μgg^{-1} reported as the normal Zn concentration in plants [24].

The value of Pb concentration in the present study (5.00-0.00 μgg^{-1}) is higher than that reported by Sani [20], which is 2.07-1.59 μgg^{-1}. However, it is lower than 10.13 μgg^{-1} earlier reported by Anthony [25] and 13.99 μgg^{-1}, 17.03 μgg^{-1} respectively in the leaves of cocoyam and pawpaw leaves as observed by Amusan [26]. The values in this present study compared well with 2.00 μgg^{-1} value set as critical level for edible portions of vegetables by WHO.

The Fe concentration level across the four sites ranges from 210.00-20.00 μgg^{-1} in the present study. This level is less than 357.78 μgg^{-1} for lettuce and 211.00 μgg^{-1} for spinach as reported by Sani [20]. The analysis reported by Yahaya [27] showed Fe level at 1075.79 μgg^{-1}. The concentration reported by Amusan [26] in cocoyam leaves (211.64 μgg^{-1}) is almost the same as that of this study. The values are within 500.00-100.00 μgg^{-1} range recommended as normal Fe concentration in plants by ICAR [28].

The four sampled sites range concentration of Mn is 37.00-12.00 μgg^{-1}. This amount is higher than 7.00 μgg^{-1} (spinach) and 7.50 μgg^{-1} (lettuce) reported by Sani [20]. It is significantly less than 165.00 μgg^{-1} (spinach leaves) reported by Miller-ihli and Baker [23]. However, the value of the present study compared well on the lower limit with 10.00 μgg^{-1} observed in spinach and Indian standard by Kashif [29]. Generally, the values are within the range of 500.00-25.00 μgg^{-1} dry mass reported as the normal Mn concentration in plants [28]. The concentration of Ni across the four sites ranges from 6.00-0.00 μgg^{-1}. Omogbehin and Osesua [30] reported 0.24 μgg^{-1} (onion), 0.69 μgg^{-1} (spinach), 0.86 μgg^{-1} (bitter leaf) and 0.78 μgg^{-1} (Drum tree) for Ni levels in their analysis. These values are within the result of this present study, where Neem bark is employed. Okorie [31] reported the level of Co in samples of river as 3.09-10.10 μgg^{-1}. This value correlates significantly with mean result of this study as shown in Table 2.

Conclusion

The results of eight (8) heavy metals Fe, Mn, Zn, Co, Cu, Cr, Pb and Ni analyzed from samples of Neem tree (*Azadirachta indica*) bark, collected from all the sites revealed that all the metals studied were detected. The levels of Fe and Co correlate with distance from the source of pollution, while the levels of other metals (Mn, Zn, Cu, Cr, Pb and Ni) do not. The study further revealed that metal concentrations in bark samples from site A are the highest with the exception of Zn and Cu. Site D concentrated the least levels of the eight metals studied. Fe has the highest concentration while Cu has the least concentration of the analyzed metals. Sites A, B and C concentrated more metals than site D. This may be due to the closeness of the sites to industrial activities or effluents, emissions from domestic heating system, heavy traffic vehicles or emission from various roasting activities at these sites.

The low levels of metals recorded in site D may be attributed to its farthest distance from the source of pollution coupled with less trafficking activities along Jibia Road where it is located. These levels of heavy metal in the bark of Neem tree do not pose any hazardous threat on the inhabitant and other lives in Katsina Township.

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