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ASSESSMENT OF PLANT SPECIES DISTRIBUTION WITHIN SCRAP METAL DUMP SITES IN BENIN CITY, NIGERIA

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ABSTRACT

The collection of scrap metals is a major source of heavy metal pollution of the environment. Metal tolerant plants that grow in heavy metal polluted sites are known as metallophytes. Thus, this study identified plants around scrap metal dump sites that could be used for phytoremediation. Strategic random quadrat sampling method was used for plant identification. Plants identified from the study include: Talinum triangulare, Hewittia sublobata, Eleusine indica, Andropogon gayanus, Andropogon tectorum, Eragrostis tenella, Eragostis astrovirens, Axonopus compressus, Chloris Pilosa, Cleome rutidosperma, Triantherma portulacastrum, Oldenlandia herbacea, Spermacoce ocymoides, Newbouldia laevis, Ipomoea vagans, Aneilema aequinoctiale, Amaranthus spinosus, Hyptis lanceolata, Combretum hispidum, Amaranthus spinosus, Alchornea cordifolia, Croton hirtus, Laportea aestuans and Peperomia pellucida. Therefore, the plants could be applied for phytoremediation of heavy metals. It was observed that plants in the Poaceae family had the highest frequency of occurrence. Eleusine indica was most cited in the frequency of citation.

1. INTRODUCTION

Scrap metal dump sites are found in many vacant plots and open spaces within Benin City and indeed Nigeria. Small and medium sized recycling companies have, as a result, sprung up around these scrap metal dump sites and by so doing have constituted major sources of heavy metal pollution in the environment (Raskin *et al,* 1994; Alloway and Ayres, 1997; Shen *et al.,* 2002). The increased activity of scrap metal gathering has greatly depleted the quality of the atmosphere, lithosphere, hydrosphere, pedosphere and biosphere. It is known that over time these scrap metals begin to release some heavy metals into the soil, which could be washed off into water and also absorbed by plants and then back to animals and man. These toxic heavy metals released from scrap metal dump sites are non-degradable and could pose a very big treat to the health of man as they can be biomagnified in the tissues and organs of man (Garbisu *and* Alkorta, 2001). Similarly, the introduction of heavy metals into the environment would on the long run lead to physiological changes in the growth and development of plants.

The impact of heavy metals have resulted in the reduction in plant growth, changes in the biochemical and physiological processes in plants growing on heavy metal polluted soils (Chatterjee and Chatterjee, 2000). A continuous decline in the growth of plants would result in reduced yield which eventually leads to food scarcity. Therefore, the remediation of heavy metal polluted soils cannot be overemphasized.

The toxic effect of heavy metals in plants shows itself through visual symptoms such as wilting, necrosis, and chlorosis through biomass accumulation and reduced growth (Sanitá di Troppi and Gabbrielli, 1999). Physiological effects have also been noted in plants exposed to contamination at various levels of the photosynthetic process, including the chlorophyll biosynthesis (Chugh and Sawhney, 1999), the dynamics of photochemical reactions and the activity of Calvin cycle enzymes (Cagno *et al.,* 1999). These symptoms could partially justify the lower phytomass production in that a smaller volume of soil being explored can influence the nutrition and water balance in plants. The effect of heavy metals on plants has resulted in reduced growth and phytomass accumulation (Barceló *et al.,* 1990; Marques *et al.*, 2000). The visible symptoms of the aerial part includes, chlorotic spots, leaf curling, reduced flexibility of the leaf blade, reduced growth and reduced emergence of leaves were observed. Visible symptoms developed by plants in response to heavy metals have been widely reported (Alloway and Ayres, 1997).

Metallophytes have been identified around scrap metal dumpsites. These plants could have the capacity to clean up heavy metals from polluted soil. Anoliefo *et al. (*2006) identified plants that could be used for phytoremediation. The aim of this study is to identify of plant species that could be effective in the remediation of the heavy metals that have been deposited into the environment by scrap metals.

2. METHODOLOGY

2.1. Description of Study Area

The study was conducted in Benin City, the capital of Edo State, Nigeria (Fig. 1). It has an estimated population of 1,147,188 (2006, Population Census). It is approximately 40 km (25 mi) north of the Benin River, and 320 km (200 mi) by road east of Lagos. Field investigation was carried out at nine different scrap metal sites within Benin City. The different scrap metal sites were accessed with the assistance of scrap metal dealers.

2.2. Study Location

Scrap metal sites investigated include the ones at the following locations:

1. Osasoghie Street by Total Petrol Station, off Benin-Sapele Road (Latitude 6º 15′ 22.4″N and Longitude 5º 38′ 09.2″E Elevation 47m.)

2. Omoragbon Agho Street, off Benin-Sapele Road, Etete, Benin City (Latitude 6º 17′ 40.3″N and Longitude 5º 37′ 70.4″E Elevation 61m.)
3. Evbuotubu Junction by Ekehuan Road Benin City (Latitude 6º 19′ 17.7″N and Longitude 5º 34′59.9″E Elevation 30m)
4. Asoro Hill by Upper Ekehuan Road Benin City (Latitude 6º 19′ 39.9″N and Longitude 5º 34′ 46.9″E Elevation 76m)
5. Christopher Osewengie Street, Ekae Quarters, off Sapele Road, Benin City (Latitude 6º 15′ 52.9″N and Longitude 5º 38′ 04.8″E Elevation 55m)
6. Akugbe Street, off Saint Saviour Road, Benin City (Latitude 6º 19′ 21.8″N and Longitude 5º 38′ 46.8″E Elevation 88m)
7. Upper Iwehen, off Lagos Street, Oba Market, Benin City (Latitude 6º 20′ 35.2″N and Longitude 5º 37′ 25.1″E Elevation 91m)
8. Evbienwen Street, off Wire Road, Benin City (Latitude 6º 20′ 34.5″N and Longitude 5º 37′ 15.4″E Elevation 92m)
9. Iduowina Quarters, off Benin-Auchi Road, Benin City (Latitude 6º 25′ 19.7″N and Longitude 5º 36′ 08.5″E Elevation 125m)
10. Control Site; Reserved Area, University of Benin, Benin City (Latitude 6º 24′ 19.6″N and Longitude 5º 38′ 33.1″E Elevation 58m)

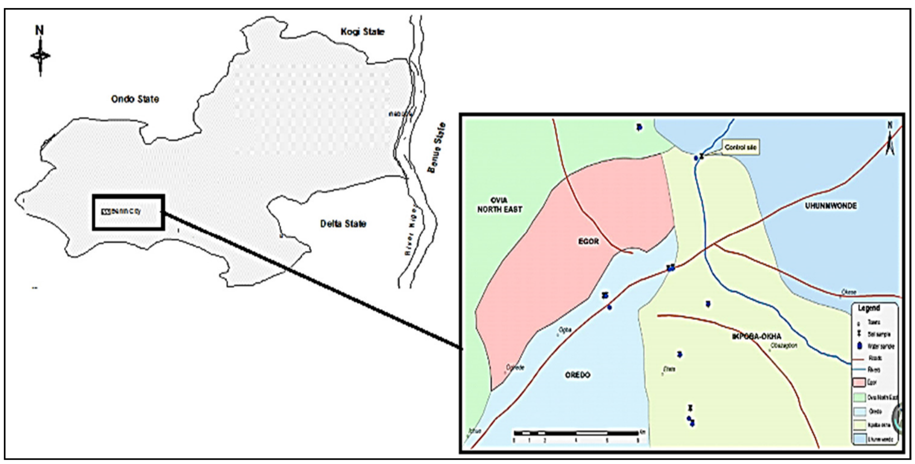

Figure 1: Map of the study area

2.3. Activity Assessment at the Scrap Metal Sites
At each scrap metal dump site, information about the business activities at the sites, volume of scrap metals collected per site, age of scrap metal dump site as well as information on expenses incurred during the course of business were sourced by one-on-one interaction with workers and owners of the scrap metal dump sites. This became necessary in order to access relevant economic contributions of each site as well as possible implications to the environment.

2.4. Determination of Plant Distribution using Quadrats
Plants were sampled within a 3 m radius of the core of each scrap metal dump site, using a 1m by 1m quadrat. Strategic quadrat random sampling method was applied (Barbour *et al.*, 1987).

2.5. Plant Samples Surveyed

Biodiversity of plant samples surveyed was computed in order to determine species richness indices, diversity indices, evenness indices and Simpson's dominance indices. Only weeds that were >3 cm in plant height were counted (Ikhajiagbe and Anoliefo 2012). The plant species distribution at the nine scrap metal dump sites were compared with a control site with no history of scrap metal dumpsites (Uniben reserved area).

Given that:
S= total number of species
N= total number of individuals
n*i*= number of individuals in the i^{th} species

2.5.1. Species richness index

Margalef'f index:

$$d = \frac{S-1}{\ln(N)} \quad (1)$$

2.5.2. Diversity index

Where:

$$pi = \frac{ni}{N} \quad (2)$$

Shannon-Weiner's index:

$$H = \frac{N \log N - \sum_{i=1}^{S} . fi \log fi}{N} \quad (3)$$

This index gives the level for which a plant population consists of several species in cohabitation.

2.5.3. Evenness index

Evenness:

$$E = \frac{H}{\ln(S)} \quad (4)$$

The index varies between 0 and 1, where E=1 gives the situation when all species are equally abundant.

2.5.4. Simpson's and dominance indices

Simpson's index:

$$C = \sum_{i=1}^{S} pi^2 \quad (5)$$

Dominance index:

$$D = \sum_{i=1}^{S} \left(. \frac{ni(ni-1)}{N(N-1)} \right) \quad (6)$$

The index varies between 0 and 1, and gives the probability that two individuals drawn at random from a population belong to the same species.

2.6. Citation Index

The citation index (CI) was calculated as an index of 1. It was used in this study as a measure to the regularity of locating a particular plant species in any or all of the sites visited. This was calculated thus:

$$Ci = \frac{L}{N} \quad (7)$$

L = number the locations where each plant species was sited, N = total number of sites visited in the study.

2.7. Frequencies of Distribution of Plant Families

In an attempt to categorize plant family on the bases o frequency pf occurrence in the sites visited, a frequency of distribution of plant families identified was assigned to the latter as thus;

$$\text{Freq.}(\%) = \frac{n}{\Sigma N} \quad (8)$$

Where n - Number of sites where plant family was observed (occurrence); N – totalities of all occurrences.

3. RESULTS AND DISCUSSION

3.1. Components of Scrap Metal Dumpsites

The various components of scrap metals identified in the scrap metal dump sites investigated include used construction beams, plates, pipes, tubes, wiring, old automobiles and other automotive scraps including lead obtained from battery plates. These scrap metals identified can be grouped into iron, copper, lead and zinc.

3.2. Background Information on Scrap Metal Dump Sites by Interview

The reconnaissance survey of scrap metal business indicated that there is a geometric increase in the scrap-metal business in the study areas. The business is profit-driven, implying continued pollution of environment. It was observed that the workers at the scrap metal sites visited were mainly male youths that fell between the ages of 15 and 35 years. Some of the boys scavenge for scrap metals sell to scrap metal site owners, who in turn, supply to recycling companies at a higher rate. Thus, scrap metal business has provided jobs for thousands of teeming unemployed youths in Nigeria. The major components of the scrap metals identified were iron, copper, aluminum and condemned batteries. At present, 1kg of iron is sold for twenty (20) naira, 1kg of brass is sold for three hundred (300) naira, 1kg of aluminum is sold for one hundred and fifty (150) naira and a condemned battery is sold for a thousand and five hundred (1500) naira only. A major tool in the scrap metal sites was the weighing scale. It is usually built with a strong metallic scale hanging from a chain supported by sticks at the sides. It is used to weigh the scrap metals brought to the scrap metal dump site.

3.3. Economic Basis for Describing the Scrap Metal Dump Sites

The continuous production of scrap metals as a result of the activities of the population, and the attractive financial reward from the business has made it impossible to be overestimated. The study has shown that there will be a continuous boom in the scrap metal business that will in turn, pose a threat to man and his environment. Scrap metal sites were investigated in Benin City Edo State between October 15 2015 and June 31 2016 (Table 1). It was observed that the older scrap metal sites had larger volumes of scrap metals. This indicated geometric increase in the dumping of scrap metals, irrespective of the site elevation and size. For example, site located at upper Iwehen, at longitude 6º 20′ 35.2″N and latitude 5º 37′ 25.1″E, started in the year 1995, had the largest quantity of scrap metals (20,000kg), which at thirty-three naira (₦33) per kilogram, an income of six hundred and sixty thousand naira (₦660, 000) would be realized.

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Table 1: Results from reconnaissance study from nine scrap metal dump sites

Sites within Benin City	GPS placement for each location	Elevation of site (m)	Size of site (m^2)	Start year	Total weight (kg) of scrap metals	Amount @ ₦33/kg
Osasoghie street	6º 15′ 22.4″N 5º 38′ 09.2″E	47	6.71 by 4.27	2003	2,000	66,000
Omoragbon-agho street	6º 17′ 40.3″N 5º 37′ 70.4″E	61	15.24 by 12.19	1998	13,000	429,000
Evbuotubu junction ekehuan	6º 19′ 39.9″N 5º 34′ 46.9″E	76	7.32 by 4.88	2003	6,000	198,000
Asoro hill upper ekehuan	6º 19′ 40.9″N 5º 34′51.7″E	63	3.66 by 3.35	2001	9,000	297,000
Christopher Osenwenghie str.	6º 15′ 52.9″N 5º 38′ 04.8″E	55	7.62 by2.74	2003	10,000	330,000
Akugbe street,	6º 19′ 21.8″N 5º 38′ 46.8″E	88	5.49 by 4. 88	2000	16,000	528,000
Upper Iwehen, Lagos street	6º 20′ 35.2″N 5º 37′ 25.1″E	91	30.48 by 4.88	1995	20,000	660,000
Evbienwen street,	6º 20′ 34.5″N 5º 37′ 15.4″E	92	7.01 by 4.57	2000	4,000	132,000
Iduowina street	6º 25′ 19.7″N 5º 36′ 08.5″E	125	8.23 by 53.95	2002	2,000	66,000

The enticing reward from the business have attracted the unemployed youths of the Nigerian population. However, the business may pose a threat to the population as research has shown that mining and dredging activities, metal scraps and industrial waste products are major sources of heavy metal deposition in the environment (Anoliefo, 2016; Ikhajiagbe *et al.,* 2008; Husain et al., 2009).

Heavy metals can be emitted into the environment by natural and anthropogenic causes. For example mining operations releases heavy metals into the environment (Hutton and Symon, 1986; Battarbee et al., 1988; Nriagu, 1989). Scrap metals coated with heavy metals such as Cr, Zn, Cd, Cu, Fe and Pb, over time begin to break off as a result of heaping of the scrap metals, or washed off by erosion therefore causing anthropogenic increase in the environment. The deposition of heavy metals in the environment has a long term effect as it is not easily degraded.

3.4. Plant Species Distribution

The results of the study showed *E. indica* as the most prevalent plant species, occurring in all the sites visited (Table 2). With a citation index of 80.7, *A. tectorum* and *A. compressus* were next in line in plants with high occurrence of the metal scrap sites. *C. rutidosperma*, *T. triangulare*, *T. portulacastrum*, *A. aequinoctiale* and *A. cordifolia* were least prevalent (0.2). A total of twelve (12) plant families were identified in the study area (Table 3). Poaceae family had the highest percentage frequency of 58.24% followed by Amaranthaceae with 12.77% and Rubiaceae 9.57% in that order.

Results showed increased plant species diversity at Osasogie street (1.72) compared to (0.47) as species richness at Omoragbon Agho street (Table 4). Similarly, the highest diversity index was

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recorded at Osasogie (2.312) and the least at Evbienwen (0.563). Evenness index was observed to be highest (0.991) at Omoragbon Agho street, followed by Evbuotubu (0.960). However, the least evenness index (0.629) was observed at Asoro. Evbienwen had the highest dominance index (0.626) followed by Omoragbon Agho street (0.506), and upper Iwehen (0.470) in that order.

Heavy metal toxicity to plants causes reduction in photosynthesis, water uptake, and nutrient uptake. Plants grown in soil containing high levels of Cd showed visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips, and finally death (Wojcik and Tukiendorf, 2004). Excess of Cu in soil plays a cytotoxic role, induces stress and causes injury to plants. This leads to plant growth retardation and leaf chlorosis (Lewis *et al.,* 2001). Exposure of plants to excess Cu generates oxidative stress and ROS (Stadtman and Oliver, 1991). Oxidative stress causes disturbance of metabolic pathways and damage to macromolecules (Hegedus *et al.,* 2001).

The research showed that the older sites had least plant species diversity this could be as a result of continued deposition of heavy metals in the soil. Therefore only metalliferous plants were cited in the different scrap metal dump sites. For example, only *Peperomia pellucida* was observed at Upper Iwehen and Evbienwen. This plant had been listed for phytoremediation (Anoliefo *et al.,* 2006). The continuous deposition of heavy metals in the environment could result in extinction of plant species that do not have the capacity to grow in metalliferous soils.

It was seen that *Talinum trigulare,* (family Portulacaceae), *Cleome rutidosperma* (family Cleomaceae), *Triantherma portulacastrum,* (family Aizoaceae) and *Alchornea cordifolia* (Euphorbia family), appeared only at scrap metal site located at Osasogie. *Aneilema aequinoctiale* (family Commelinaceae) was only seen at Christopher Osenwenghie scrap metal site. Thus, the difference in plant species distribution, dominance and diversities in the different scrap metal dump sites investigated could be dependent on the type of heavy metals that have been deposited into the soil by scrap metals.

However, some plants have been used to cleanup heavy metals from the environment (Anoliefo *et al*., 2006). The plants growing around scrap metal sites are tolerant to heavy metals. They have the ability to either exclude heavy metals or accumulate them in their roots or shoots (Anoliefo, 2016). Biodiversity prospecting has led to the discovery of wild plants that could clean polluted environments of the world. It could be used to conserve nature. This gives glimpses of hope as the use of plants to clean up the environment is applicable, affordable and achievable within a short period of time. Thus, this study has identified various plants that could be used for phytoremediation.

Becker *et al. (*2008) and Lucassen *et al. (*2010) showed that plants found in heavy metal polluted soil could be identified as metallophytes and could be applied in phytoremediation. The study also revealed that plants growing in heavy metal polluted soils have reduced plant growth and vitality as this corresponds to the findings of Massa *et al. (*2010). The eco-taxonomic distribution of plants identified around the nine scrap metal sites in this present studies includes; *Talinum triangulare, Hewittia sublobata, Eleusine indica, Andropogon gayanus, Andropogon tectorum, Eragrostis tenella, Eragostis astrovirens, Axonopus compressus, Chloris Pilosa,* C*leome rutidosperma, Triantherma portulacastrum,* O*ldenlandia herbacea, Spermacoce ocymoides,* N*ewbouldia laevis, Ipomoea vagans, Aneilema aequinoctiale*, *Amaranthus spinosus, Hyptis lanceolata, Combretum hispidum, Amaranthus spinosus Linn., Alchornea cordifolia Schum. & Thonn, Croton hirtus, Laportea aestuans Linn.* and *Peperomia pellucida.* These plants identified could be applied in phytoremediation of heavy metals.

Table 2: Plant species distribution within 3m radius of scrap metal dump sites in Benin City Nigeria

Name of plant species	Families	Types	A	B	C	D	E	F	G	H	I	J	Sum	CI
Talinum triangulare	Portulacaceae	Herb	4	0	0	0	0	0	0	0	0	0	4	0.2
Andropogon gayanus	Poaceae	Grass	4	0	0	0	0	0	0	0	4	0	8	0.3
Andropogon tectorum	Poaceae	Grass	0	0	8	8	15	10	0	0	10	0	61	0.7
Eragostis tenella	Poaceae	Grass	3	0	0	0	0	4	0	0	2	0	9	0.4
Chloris Pilosa	Poaceae	Grass	3	0	0	0	0	4	0	0	2	0	9	0.4
Eragostis atrovirens	Poaceae	Grass	0	0	0	0	0	4	0	0	0	8	12	0.3
Axonopus compressus	Poaceae	Grass	8	0	6	0	5	6	0	0	10	6	41	0.7
Eleusine indica	Poaceae	Grass	20	8	10	6	5	8	4	2	10	6	79	1.0
Cleome rutidosperma	Cleomaceae	Herb	2	0	0	0	0	0	0	0	0	0	2	0.2
Triantherma portulacastrum	Aizoaceae	Herb	2	0	0	0	0	0	0	0	0	0	2	0.2
Oldenlandia herbaceae	Rubiaceae	Herb	0	0	0	0	0	0	0	0	4	6	10	0.3
Spermacoce ocymoides	Rubiaceae	Herb	6	0	4	4	0	0	0	0	6	6	26	0.6
Ipomoea vagans Bak.	Convolvulacea	Herb	3	0	0	0	0	0	0	0	0	2	5	0.3
Hewitta sublobata	Convolvulacea	Herb	2	0	0	0	0	0	0	0	0	2	4	0.3
Aneilema aequinoctiale	Commelinacea	Herb	0	0	0	0	2	0	0	0	0	0	2	0.2
Amaranthus spinosus	Amaranthaceae	Herb	0	10	0	12	0	12	0	0	14	0	48	0.4
Hyptis laceolata	Lamiaceae	Herb	0	0	4	0	0	0	0	0	3	6	13	0.4
Phyllanthus amarus	Euphorbiaceae	Herb	3	0	0	0	0	0	0	0	1	0	4	0.3
Alchornea cordifolia	Euphorbiaceae	Shrub	1	0	0	0	0	0	0	0	0	0	1	0.2
Croton hirtus	Euphorbiaceae	Herb	0	0	0	0	0	2	0	0	0	2	4	0.3
Laportea aestuans	Urticaceae	Herb	5	0	0	4	0	0	2	0	0	5	16	0.5
Pepperomia pellucida	Piperaceae	Herb	0	0	0	0	0	0	10	6	0	0	16	0.3
Total													376	

A.) Osasogie Street by Total Filling Station, Off Benin Sapele Road, Benin City; B.) Omoragbon Agho, Off Benin Sapele Road, Etete, Benin City; C.) Evbuotubu Junction by Ekehuan Road Benin City; D.) Asoro Hill by Upper Ekehuan Road Benin City; E.) Christopher Osewengie Street, Ekae Qtrs, off Sapele Road, Benin; F.) Akugbe Street, off Saint Saviour Road, Benin City; G.) Upper Iwehen, off Lagos Street, Oba Market, Benin City; H.) Evbienwen Street, off Wire Road, Benin City; I.) Iduowina Road, Iduowina Quarters, off Benin Auchi Road, Benin City; J.) Control Site; Uniben Reserved Area, University Of Benin, Benin City

Table 3: Distribution of families within and around scrap metal sites in Benin City

Plant family	Number of occurrence	Total individual plants	Frequency of occurrence (%)
Portulacaceae	1	4	1.06
Poaceae	7	219	58.24
Cleomaceae	1	2	0.53
Aizoaceae	1	2	0.53
Rubiaceae	2	36	9.57
Convolvulaceae	2	9	2.39
Commelinaceae	1	2	0.53
Amaranthaceae	1	48	12.77
Lamiaceae	1	13	3.46
Euphorbiaceae	3	9	2.39
Urticaceae	1	16	4.26
Pipperaceae	1	16	4.26
Total	-	376	100

Research on Eco-taxonomic distribution of plant species around motor mechanic workshops in Asaba and Benin City, Nigeria: Identification of oil tolerant plant species by Anoliefo *et al. (*2006), surveyed plant species and their families present in auto mechanic workshops in Benin City and Asaba. The result reported thirty-five (35) plant species that are likely candidates in phytoremediation. The identified species greatly corresponds to the species that were identified around scrap metal dump sites. Thus, these plants could be said to be metal tolerant and could have the capacity for phytoremediation of heavy metals.

Table 4: Diversity and dominance indices for weeds present in sampled sites.

Sites	Species richness	Shannon index	Evenness index	Dominance index	Simpson's index
A	1.72	2.312	0.876	0.140	0.124
B	0.47	0.687	0.991	0.506	0.477
C	0.88	1.545	0.960	0.228	0.201
D	0.86	1.013	0.629	0.239	0.217
E	0.77	1.143	0.825	0.383	0.358
F	1.13	1.395	0.671	0.158	0.142
G	0.75	0.900	0.819	0.470	0.433
H	0.71	0.563	0.812	0.626	0.572
I	1.35	2.036	0.839	0.133	0.119
J	1.43	2.291	0.955	0.107	0.096

Poaceae family, in the study, was observed to be most prevalent. *Eleusine indica* which belongs to the family Poaceae, has been used to remediate the soil (Mang *et al*., 2010). Incidentally, *Eleusine indica* was observed in all the sites studied. The presence of these species in the different scrap sites investigated could imply tolerance to specific heavy metals deposited in the soil. In this study, the most prevalent species representatives of the nine scrap metal dump sites visited include: *E. indica, A. spinosus, A. tectorum* and *P. pellucida*. The selected plant species were among those identified for phytoremediation by Anoliefo *et al. (*2006).

4. CONCLUSION

It has been established that scrap metal business has come to stay, as metallic waste is on the increase due to new technology, increased industrial activities and increased population. Man must therefore think of a way to avert this environmental disaster while *extracting* the economic juice. However, with the preponderance of the identified plant species in this study, the option of combining the derivable economic benefits from scrap sites and the possible introduction of plausible bioremediation strategies using these resident plant species therefore suffices. Although the study did not centre on phytoremediative capabilities of the identified species, but the continued existence of these plants in the metal-contaminated soils may necessarily imply possible heavy metal resistance, a characteristic that is a priority during selection of plants for environmental reclamation strategies.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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