Available online at http://ajol.info/index.php/ijbcs

Int. J. Biol. Chem. Sci. 9(2): 614-632, April 2015

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper

http://indexmedicus.afro.who.int

Relationship between the standing vegetation, soil properties and soil seed bank of an industrially degraded vegetation of Iron Smelting Factory

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ABSTRACT

This study assessed the floristic composition, soil properties and the soil seedbank of the vegetation around the Iron smelting factory. This was with a view to determining the functional role played by soil chemical composition and the seed bank in the modifications of vegetation patterns. Five 100 m × 5 m plots were selected from the study site; vegetation, soil seed bank and some soil chemical parameters were assessed. One-way Analysis of Variance and Duncan multiple range tests were employed for data analysis. The results showed that the soil samples collected were slightly basic (or neutral) with the total Nitrogen in all the five plots ranged from 0.22 to 0.33%. There was a little contribution by woody species to the floristic composition of both the standing vegetation and soil seed bank. There was very low similarity (10.6% - 28.57%) between the standing vegetation and the soil seed bank species composition in the study site. The results of seedling emergence showed that herbaceous species dominated the soil seed bank compared to other life forms. Our result revealed a shift between seed-bank and vegetation composition which could be a consequence of the soil chemical properties and also as a result of different level of disturbance occurring due to the citing of industry in the area.
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Keywords: Emergence, nutrient cycling, regeneration, soil properties, soil seed bank, standing vegetation.

INTRODUCTION

Vegetation influences soil properties directly through the supply of organic matter and in a number of indirect ways. Pellissier et al. (2008) observed that vegetation exerts a substantial influence upon the type of soil found in a particular location and concluded that vegetation has numerous impacts on soils, such as the prevention of erosion caused by excessive rain and the resulting surface runoff. He also observed that plants covering soils ameliorate the temperature and slow down evaporation of soil moisture. According to Pellissier et al. (2008), the type and amount of above ground vegetation present in an area depends on several factors such as the presence of ungerminated seeds potentially capable of replacing adult plant, the rate of disturbance, climate, land form, soil properties as well as its nutrients composition, and biological factors. Soil factors such as density, depth, chemistry, pH, temperature and moisture greatly affect the type of plants that can grow in a given location. Soil and vegetation exhibit an integral relationship, in that soil abhor seeds and gives support

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DOI : http://dx.doi.org/10.4314/ijbcs.v9i2.4

(moisture, nutrient and anchorage) to vegetation to grow efficiently on one hand and on the other hand vegetation provides protective cover for the soil to reduce erosion, and helps to maintain soil nutrients through litter accumulation and subsequent decay i.e. nutrient recycling.

Hence, vegetation and soil are interrelated and provide reciprocal effects on each other. According to Brant et al. (2006) vegetation strongly affects soil characteristics including productivity, structure and floristic composition. Van der maarel (2004) reported soil as being fundamental to ecosystem and agricultural sustainability and productivity because it supplies many of its essential requirements for plant growth like water, nutrient, anchorage, oxygen for root and moderate temperature. However, the disturbances and degradation of soil through various industrial activities impact the soil structure and reduce its ability to provide these functions.

Metal smelters cause extensive damage to local vegetation and important changes in soil characteristics (Dudka and Adriano, 1997; Ginocchio, 2000) with the most affected areas immediately surrounding the smelters called the barrens by McCall et al. (1995). These areas are generally characterized by bare and sparsely vegetated land, dominated by pollution resistant plant species, and by severely eroded, acidic and highly metal contaminated soils (Ginocchio, 2000; McCall et al., 1995). However, heavy metals generated as a result of metal smelter can cause severe damage to vegetation and even lead to complete death of sensitive individuals (Kapustka et al., 1995). Therefore, high heavy metal concentrations in soils have been usually cited as one of the primary factors limiting vegetation establishment and growth in the barrens (Galbraith et al., 1995; Gunn, 1995; McCall et al., 1995). It is remarkable that almost all the studies carried out in smelter polluted areas have mainly characterized vegetation changes as the net change in numeric composition of adult fraction of the populations, both in time and place. However, these changes cannot only be explained by the death of adult individuals but also by alterations produced at several stages of the plant life cycle. There are some evidence that atmospheric pollution has negative effects on plant reproduction and regeneration such as decrease in seed production (Steubing and Fangmeier, 1991), seed germination and seedling establishment (Ginocchio, 1997). Therefore, when environmental conditions change because of metal smelter pollution and when adult individuals are eliminated, regeneration processes may be altered.

However, to understand the relationship between soil chemical properties, standing vegetation and the soil seed bank, it is essential to investigate the effect of industrial disturbance as a result of its location and production activities through its various discharges both on the soil and above ground standing vegetation. This study therefore investigated the chemical composition of the soil, variations in species composition of the vegetation and soil seed bank and the functional role played by the seed bank in the modifications of vegetation patterns.

MATERIALS AND METHODS

Study area

The study was carried out around the Iron Smelting Factory Fashina Ile-Ife in Osun state, Southwestern Nigeria. Five plots (A, B, C, D, E) each measuring 100 m×5 m were selected in the vegetation around the Iron Smelting Factory for complete enumeration of the plant species (Figure 1).

Floristic inventory

Total enumeration of the floristic composition was done in order to establish the species composition of the above ground vegetation in all the five plots. All the plant species, i.e. trees, shrubs, climbers, and herbs within each quadrat were identified to the species level. The species whose identities were in doubt were collected and taken to Ife Herbarium for proper identification.

Plant species diversity (H) were calculated using the Shannon – wiener index (Shannon and Weaver, 1949)

$$H=-\sum \frac{n1}{N} \ln\ n/N$$

Where; n - Importance value for each species

N - Total importance value.

Species evenness were calculated using Shannon's equitability

$E_H= H^i/H_{max}$

Where:H^i is the Shannon – weaver index of diversity

H_{max} = ln S, and S is the total number of species in the community.

Determination of seedling emergence

To assess the soil seed bank composition, soil samples were collected from all the selected plots. A total of twenty five soil samples were collected randomly in the entire reference plot at 0 -15 cm depth representing the top soil using soil auger for the seedling emergence test. Soil samples were air dried in the laboratory and then spread out in a thin layer of 20 mm in each designated plastic pot. Prior to the spreading, each sample was thoroughly mixed after removal of all roots and debris. The seedling emergence method is the most frequently used and the more reliable method in soil seed bank studies (Baskin and Baskin, 1998). The method was used in this study to determine the species composition of the soil seed bank, assuming that the number of seedling detected by this method is the number of the buried viable seed which would indicate the number of the readily germinable seed in the soil.

All plastic pots were placed on a bench in the screen house and subjected to daily wetting cycle known to promote germination of seed (Mayer and Poljakoff-mayber, 1989). Soil samples were maintained and checked for seedling emergence. All seedlings from germinated seeds were identified counted and removed as soon as possible (in order to avoid the suppression of germination of other seeds in the soil by these seedlings) (Touzard et al., 2002) every week up to 6 months period after which further germination is expected to decrease remarkably (Baskin and Baskin, 1998).

During this period, soil samples were stirred as often as possible to bring any non-germinated seed to the surface in order to increase the possibility of seeds to be exposed to light. Total number of emerged seedling was used to measure the viable seed and the ability of the soil seed bank to contribute to the above ground vegetation regeneration.

Soil analysis

Soil samples were collected randomly in each of the five plots at 0-15 cm depth representing the topsoil. The soil samples were spread on benches for air drying. The samples were sieved through a < 2 mm mesh sieve. The samples were then analyzed for particle size, nitrogen, phosphorus, organic matter content and pH. Soil organic matter contents were determined through the determination of carbon. The organic matter contents were then calculated from carbon content on the assumption that soil organic matter contains 58% carbon. The soil pH was measured in 1:2 0.01M $CaCl_2$, using the glass electrode pH meter. Total Nitrogen was determined by Kjedahl method (Tel and Rao, 1982). Total Phosphorus was determined by using Bray – 1 solution (Bray and Kurtz, 1945). Exchangeable cations were also determined by leaching soil samples with 1M ammonium acetate solution and exchangeable Na and K determined on the leacheate by flame photometer and Ca by Atomic Absorption spectrophotometer (Tel and Rao, 1982). Soil particle size distributions were determined by the hydrometer method using hexametaphosphate as the dispersing agent (Bouyoucos, 1951). The presence of heavy metal such as Zn, Cd, Pb, Cu and Cr, associated with iron and steel production were also analyzed using Atomic Absorption

spectrometer (AAS). The analysed soil samples were used to compare the soil properties of the five plots within the study area in relation to the structure of the vegetation.

Sorenson Index of Similarity was used to explain various relationships existing between the soil seed bank and floristic composition of the standing vegetation. One way analysis of variance and Duncan multiple range tests were employed to test significant difference in the soil properties of the five plots.

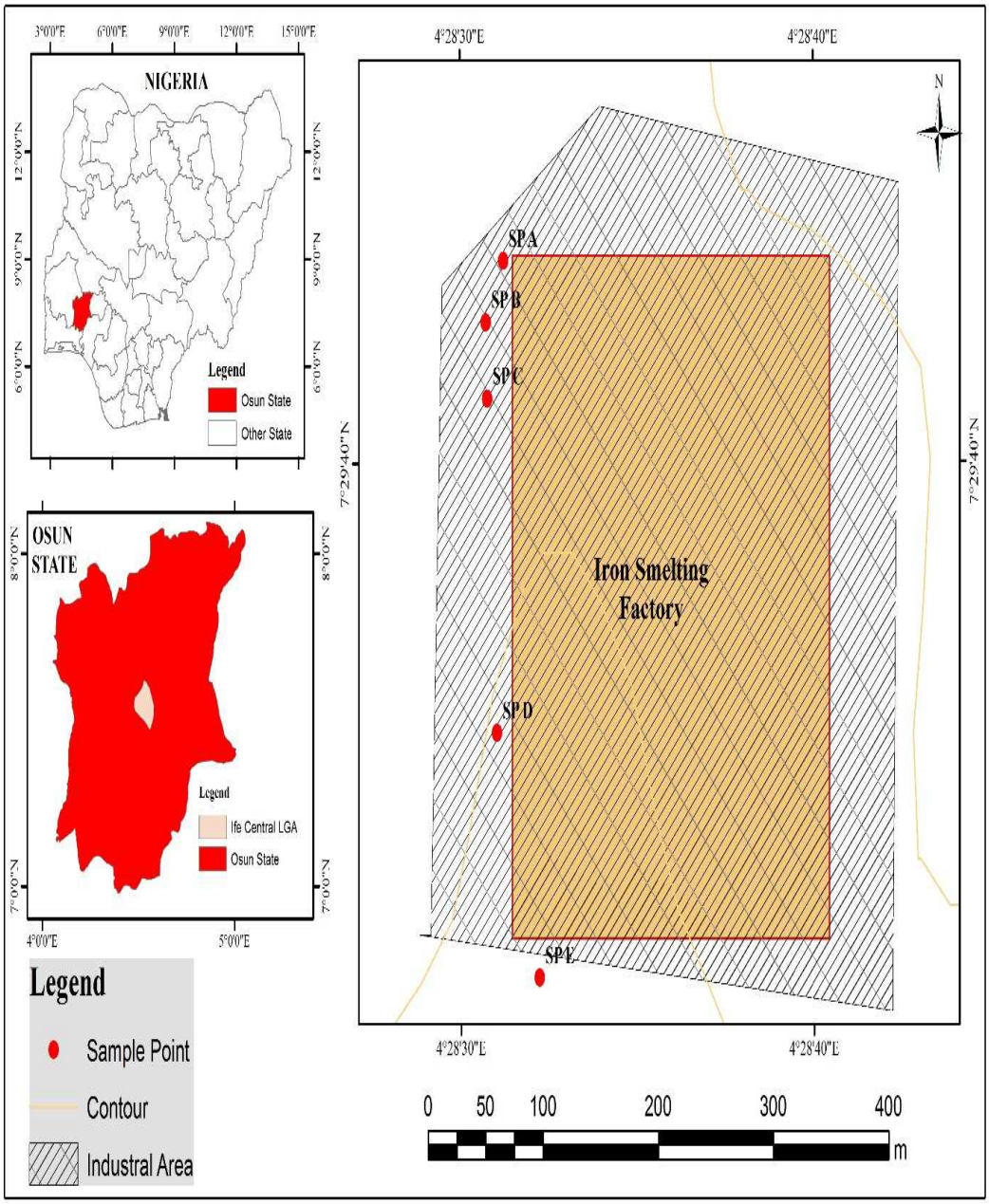

Figure 1: Map of the study area showing the sampling point.

RESULTS

A total number of 101 plant species belonging to 46 families were encountered in the vegetation of the five study plots (Table 1). Asteraceae and Papilonaceae had the highest number of species (8 species each), followed by Araceae and Poaceae with six species. The only grass species common to the five plots is *Panicum maximum* (Table 1), while others such as *Bambusa vulgaris, Digitaria gayana, Imperatacylindrica, Oplismenus burmanni* and *Papsalumorbiculare* were found in at least one of the plots. Some of the climber common in the study plots were *Calopogonuim mucunoides, Combretumracemosa, Ipomea involucrata, Vigna gracillis* and *Paulina pinnata* which is the only species common to the five plots. Plot E had the highest number of herbaceous species (17 species) followed by plot A and B (16 species) while plots C and D had eight and nine species respectively. The proportion of herbaceous were higher almost in all the plots than any other habit forms except in C and D where tree had the highest proportion (Figure 1). Four herbaceous species were common to the five plots; *Asystasia gagentica, Aspilia africana, Chromolaena odorata, Melanthera scadens,* while other herbaceous species were found in at most three plots.

Habit contribution of the standing vegetation in all the five plots shows that Plot D had the highest percentage of tree species (31.25%), followed by plot C (30.55), while plot A and plot B had the intermediate value of 24.28% and 20.58% respectively; plot E had the lowest number of tree species (Figure 1). Plot C and E had the highest number of shrub species followed by A and D while B had the least. However, the percentage contribution of herbaceous species to the standing vegetation of the study area was found to be higher in Plot B and E (47.05 and 47.22 respectively) (Figure 1). Plot A had the highest percentage of climber (26.53%) and least percentage value of grass, followed by plot C with percentage herbaceous value of 19.44% and percentage grass contribution of 5.55%. Plot D had the highest percentage value of grass species as well as tree species; however, most of the tree species in Plot D are saplings (Figure 1). Shannon-Weiner Index for the five plots showed that plot A had the highest community diversity (3.693), closely followed by plot C (3.557) and Plot D had the least value (3.1440) while other plots had intermediate values (Table 2). The result of species evenness for all the five plots under consideration showed a similar trend, with the evenness value ranging from 0.9928 (plot C) to 0.9071 (plot D) while others were intermediate (Table 2).

Soil seed bank

The seed density in different plots ranged from 1602 seeds/m^2 (in plot C) to 4464 seeds/m^2 (in plot B) (Table 3).

A total of 114 seedlings (2052 seeds/m^2) belonging to 14 species and 8 families emerged in plot A (Table 3). Of the 14 species, herbaceous species had highest contribution of 91.84% followed by grass (8.16%) while other life form were not represented (Figure 2). In plot B, fourteen species belonging to 9 families with a total density of 248 seedlings (4464 seeds/m^2) emerged. Only herbaceous and grass species emerged in this plot while other plant habits were absent (Table 3). Herbaceous had the highest contribution of 89.48% while grass had 10.52% (Figure 2). In plot C, a total density of 1602 seed/m^2 consisting 17 species which belong to eight (8) families emerged. Of the 17 species, herbaceous species had the highest contribution in term of percentage seed bank (59.11%) with 12 species and grass species with a contribution of 39.77%. *Solanum verbasifolium* with a contribution of 2.27% was the only woody species that emerged (Figure 2). Plot D had a total density of 120 seedlings (2160 seeds/m^2) consisting of fifteen (15) species belonging to nine (9) families (Table 3). Of the 15 species, the herbaceous species has highest seedbank contribution of 77.57% followed by grass

(22.5%) while no emergence was observed for other life habit (Figure 2). In plot E, a total density of 1656 seeds/m^2 emerged from the soil sample collected in this plot. Seven (7) herbaceous species, three (3) grass species and one species of Climber emerged from this plot (Table 3). The grass species had the highest seedbank contribution (70.64 %), followed by herbaceous species (24.99) and climber which had the least (2.17 %) (Figure 2).

Relationship between standing vegetation and soil seed bank

Approximately 60% of the plant species found in the standing vegetation did not occur in the soil seed bank of the study area; on the other hand, 25% of the species in the soil seed bank were not found in the above ground vegetation while only 15% were common to both seed bank and standing vegetation. The index of similarity of the seed bank and standing vegetation in all the five plots using Sorenson Index of similarity show a low similarity index between seed bank and corresponding standing vegetation in each of the plot. Plot D had the highest value (28.57) and closely followed by Plot E (28.12) while Plot C had lowest (10.16) (Table 4).The comparison of the species that emerged from the soil collection with the species encountered in the standing vegetation revealed that none of the woody species encountered in the standing vegetation had their representation in the soil seed bank. Of the grass species that emerged in the soil seed bank only *Panicum maximum* and *Oplismenus burmannii* had their representative in the standing vegetation. Of all the herbaceous that emerged in soil seed bank, only fourteen (13) species (*Ageratum conyzoides, Asystasia gangentica, Chromolaena odorata, Guyonia ciliate, Melanthera scadens, Synedrella nudiflora, Sida acuta, Sida cordifolia, Sida corymbosa, Spigellia anthelmia, Stachytarpheta cayanensis, Tithonia diversifolia and Talinum triangulare*) were found in the above ground vegetation.

Soil mineral nutrient composition

The results of the soil samples analysis (Table 5) showed that in all the five plots, the soil samples collected were slightly basic (or neutral). Plot A had the least pH value which was significantly different from the other plots while the other Plots had intermediate values which are not significantly different ($P<0.05$) from each other (Table 5). The total Nitrogen in all the five plots ranged from 0.22 to 0.33 %. Plot E had significantly higher total nitrogen than the other four plots which were not significantly different from each other. There was no significant difference ($P<0.05$) in the total phosphorus content recorded for Plot A, B and E. Plot C had the highest value while Plot E had the lowest with other plots having intermediate values (Table 5). The organic matter contents ranged from 2.26 to 2.66% in different plots. Plot B had the highest organic matter content while Plot A had the least, other plots had intermediate values. There was no significant difference in the organic matter content value obtained among the five plots (Table 5). There was no significant ($P<0.05$) difference in K^+ and Ca^+ content of the soil sample collected in different plots (Table 5). There was no significantly ($P<0.05$) difference in Na^+ content among the five plots. Plot E had the least Na^+ content while Plot D had the highest sodium content. There was no significant ($P>0.05$) difference in the value of Zinc among the five plots. There were significant differences ($P < 0.05$) among the five plots for their Cadmium, Lead and Chromium contents. The Cadmium content in the soil sample collected from Plot B was significantly ($P<0.05$) higher than that of the other four plots. Plot B had higher Lead content which was significantly ($P<0.05$) higher than the Lead content of the soil sample collected from Plots C, D and E. The Chromium content in the soil sample collected from Plot E was significantly ($P<0.05$) higher than that of Plot B and C. However, there was no significant difference in the Copper content among the plots except plot E (Table 3).

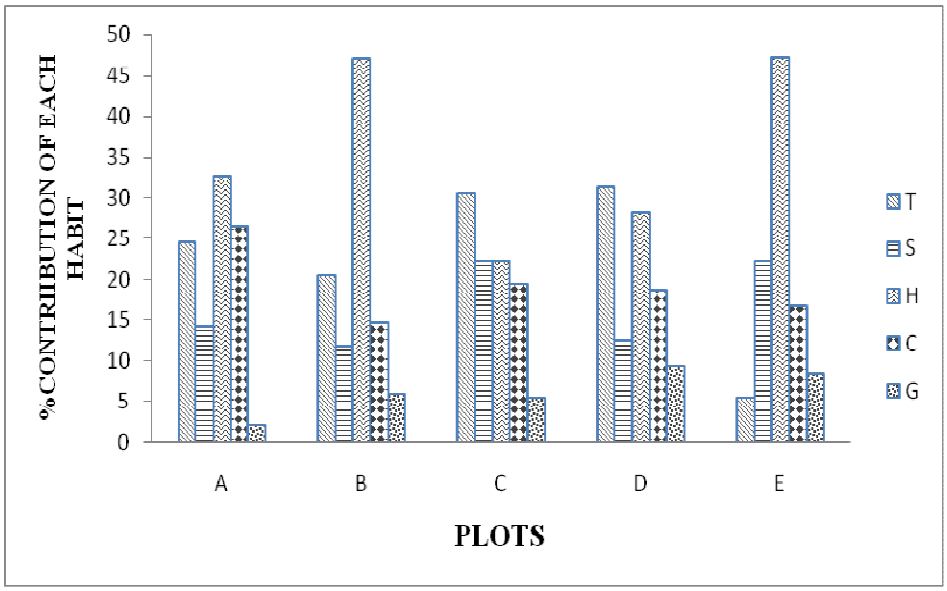

Figure 1: Habit contribution (percentage) of the above ground vegetation in each of the study plot.
T-Tree, S- Shrub, H- Herb, C- Climber, G- Grass.

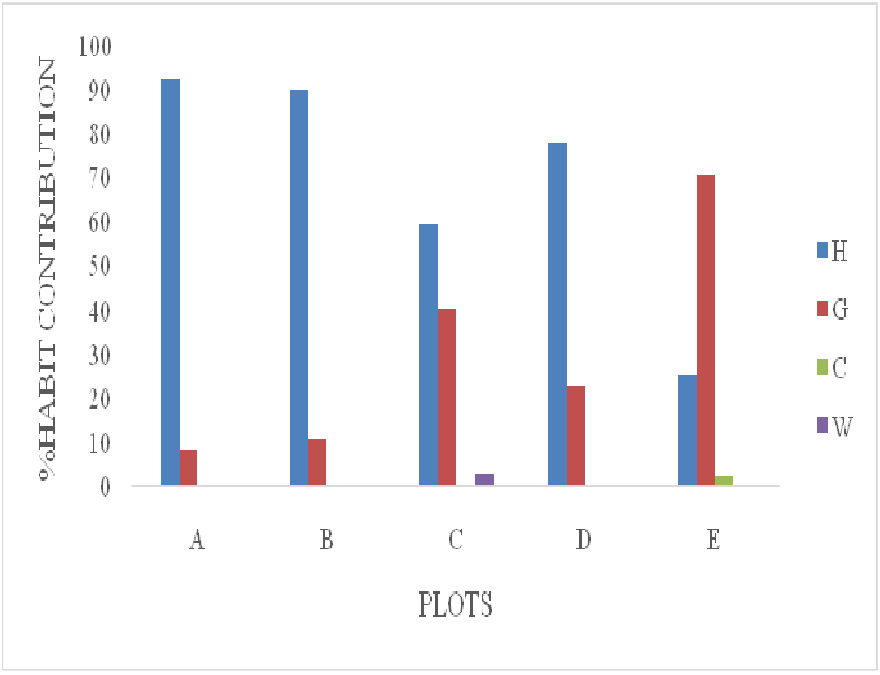

Figure 2: Habit contribution (percentage) of the soil seed bank species in the study plots.

Table 1: Species encountered in all the sample plots of the study area.

	Species encountered	Family	Habit	Plots				
				Plot A	Plot B	Plot C	Plot D	Plot E
1	*Abrusprecatorius*	Papilonaceae	C	-	+	-	-	-
2	*Ageratum conyzoides*	Asteraceae	H	-	-	-	-	+
3	*Albizia andianthifolia*	Mimosaceae	T	+	+	-	-	-
4	*Albizia zygia*	Mimosaceae	T	+	+	+	+	-
5	*Alchornea cordifolia*	Euphorbiaceae	S	-	+	-	+	+
6	*Alchornea laxiflora*	Euphorbiaceae	S	-	+	-	+	-
7	*Ananascomosus*	Bromeliaceae	H	+	-	-	+	-
8	*Anchomanes difformis*	Araceae	S	-	+	-	-	-
9	*Aneilema beniniense*	Commelinaceae	H	+	-	-	-	-
10	*Antiaris africana*	Asteraceae	T	+	-	-	+	-
11	*Aspilia africana*	Asteraceae	H	+	+	+	+	+
12	*Asystasia gagentica*	Acanthaceae	H	+	+	+	+	+
13	*Bambusa vulgaris*	Poaceae	G	-	-	-	-	+
14	*Baphia nitida*	Papilonaceae	S	-	-	+	-	-
15	*Blighia sapida*	Sapindaceae	T	+	-	-	-	-
16	*Calopogonium mucunoides*	Papilonaceae	C	-	-	-	+	+
17	*Canadium bicolor*	Araceae	H	+	-	-	-	+
18	*Cassia mimisoides*	Caesalpinaceae	S	-	-	+	-	+
19	*Cassia scadens*	Caesalpinaceae	T	-	-	-	+	-
20	*Celosia argentea*	Amaranthaceae	H	+	-	-	-	-
21	*Chassalia kolly*	Rubiaceae	S	+	+	+	-	-
22	*Chromolaena odorata*	Asteraceae	H	+	+	+	+	+
23	*Citrus spp*	Rutaceae	T	+	-	+	+	+
24	*Cnestis ferruginea*	Connaraceae	S	+	+	-	+	+
25	*Cola milenii*	Sterculiaceae	T	-	-	-	+	-
26	*Combretumracemosa*	Combretaceae	C	+	+	-	-	+
27	*Combretumsmeathmanni*	Combretaceae	C	+	-	+	+	-

28	*Commelina erecta*	Commelinaceae	H	+	-	-	-	+
29	*Cyperus insipid*	Cyperaceae	Se	-	-	-	-	+
30	*Cyperus spp*	Cyperaceae	Se	-	-	+	-	+
31	*Dalbergiasaxatilis*	Papilonaceae	H	-	-	+	-	-
32	*Desmodium canescens*	Papilonaceae	C	+	-	-	+	-
33	*Desmodium salicifolium*	Papilonaceae	S	+	+	-	-	-
34	*Desmodium scorpiurus*	Papilonaceae	C	+	-	-	-	-
35	*Digitaria gayana*	Poaceae	G	-	-	-	+	+
36	*Diodascadens*	Rubiaceae	H	-	-	-	-	+
37	*Dioscorea bulbifera*	Dioscoraceae	C	-	-	-	-	+
38	*Dioscorea dumentorium*	Dioscoraceae	C	+	-	-	-	-
39	*Dioscorea spp*	Dioscoraceae	C	-	-	+	+	-
40	*Elaeis guineensis*	Aracaceae	T	-	-	+	-	-
41	*Emilia coccinea*	Asteraceae	H	-	+	-	-	+
42	*Euphorbia heterophylla*	Euphorbiaceae	H	-	+	-	+	+
43	*Ficus exasperata*	Moraceae	T	+	-	-	+	-
44	*Ficus spp*	Moraceae	T	+	-	-	-	-
45	*Fluggea virosa*	Euphorbiaceae	S	+	-	-	-	-
46	*Gomphrenacelosoides*	Amaranthaceae	H	-	-	-	-	+
47	*Guyonia ciliate*	Melastomataceae	H	-	-	-	-	+
48	*Harungunamadagascariensis*	Hypericaceae	T	-	-	+	-	-
49	*Hedranthera bateri*	Apocynaceae	S	+	-	-	-	-
50	*Hipocrata spp*	Celastraceae	C	+	-	-	-	-
51	*Holarrhena floribunda*	Apocynaceae	T	-	+	+	-	-
52	*Huslundiaopposita*	Lamiaceae	S	+	-	-	+	-
53	*Icacineatrichanta*	Icacinaceae	S	-	-	-	+	-
54	*Imperatacylindrica*	Poaceae	G	-	-	+	-	-
55	*Ipomea involucrata*	Convolvucaceae	C	-	+	+	+	+
56	*Jateorhizamacrantha*	Menispermaceae	C	+	-	-	-	-
57	*Lecanodiscus cupanoides*	Sapindaceae	T	+	-	+	+	+
58	*Ludwigiaabysinica*	Onagraceae	H	-	-	-	-	+

59	*Manihot esculenta*	Euphorbiaceae	H	+	+	-	-	-
60	*Melanthera scadens*	Asteraceae	H	+	-	+	+	+
61	*Mondiawhitei*	Periplocaceae	C	+	-	-	-	-
62	*Monodora tenuifolia*	Annonaceae	T	+	+	-	-	-
63	*Mormodica charantia*	Curcubitaceae	H	+	+	-	+	-
64	*Mucuna pruriens*	Fabaceae	C	-	-	+	-	-
65	*Musa paradisiaca*	Musaceae	H	+	-	-	-	-
66	*Musa spp*	Musaceae	H	-	+	-	-	-
67	*Napoleona imperialis*	Lecythidaceae	S	-	-	+	-	-
68	*Newbouldia laevis*	Bignonaceae	T	+	+	+	+	-
69	*Olax subscorpioida*	Olacaceae	T	-	-	-	-	+
70	*Oplismenus burmanni*	Poaceae	G	-	+	-	-	-
71	*Panicum maximum*	Poaceae	G	+	+	+	+	+
72	*Papsalumorbiculare*	Poaceae	G	-	-	-	+	+
73	*Passiflorafoetida*	Passifloraceae	C	+	-	-	-	-
74	*Paulina pinnata*	Sapindaceae	C	+	+	+	+	+
75	*Philopsis bateri*	Acanthaceae	H	-	+	-	-	-
76	*Rauvolfia vomitoria*	Apocynaceae	T	+	-	-	+	-
77	*Rytgynia nigerica*	Rubiaceae	S	+	-	-	-	-
78	*Senna siamen*	Caesalpinaceae	T	-	-	+	-	-
79	*Senna siberiana*	Caesalpinaceae	T	-	-	+	-	-
80	*Senna occidentalis*	Caesalpinaceae	T	+	-	-	-	-
81	*Sida acuta*	Malvaceae	H	-	+	-	+	+
82	*Sida corymbosa*	Malvaceae	H	+	+	+	+	+
83	*Smilax kraussina*	Smilcaceae	C	-	-	+	-	-
84	*Solanum torvum*	Solanaceae	S	-	-	+	-	-
85	*Spigelia spp*	Loganiaceae	H	-	-	-	-	+
86	*Spondia mombin*	Anacardiaceae	T	-	-	+	+	-
87	*Stachytarpheta cayenensis*	Verbanaceae	H	-	-	+	-	+
88	*Sterculia tragacantha*	Sterculiaceae	T	-	-	+	-	-
89	*Synedrella nodiflora*	Asteraceae	H	-	+	-	+	+

90	*Talinum triangulare*	Portulacaceae	H	+	+	-	-	-
91	*Thaumatococcusdanielli*	Maranthaceae	H	-	+	-	-	-
92	*Theobroma cacao*	Sterculiaceae	T	+	+	-	-	-
93	*Tithonia diversifolia*	Asteraceae	H	-	-	-	+	-
94	*Triumfetta cordifolia*	Tiliaceae	S	-	-	-	+	-
95	*Triumfetta corymbosa*	Tiliaceae	S	-	-	+	-	-
96	*Urena lobata*	Malvaceae	H	-	-	-	-	+
97	*Vigna gracilis*	Papilonaceae	C	-	-	-	-	+
98	*Vigna spp*	Papilonaceae	C	-	-	+	+	+
99	*Xanthosomaesculenta*	Araceae	H	-	-	+	-	+
100	*Xanthosomamafaffa*	Araceae	H	+	+	-	-	-
101	*Xanthosoma spp*	Araceae	H	+	+	-	+	-

C- Climber; H- Herb; T- Tree; S- Shrub; G- Grass; Se- Sedge; Absent - ; Present +

Table 2: Shannon wiener index of the species diversity of the standing vegetation in each sample plots.

Plots	**H^1**	**E**
A	3.693	0.9489
B	3.431	0.9730
C	3.557	0.9928
D	3.144	0.9071
E	3.440	0.9600

H^1 –Shannon Wiener E- Evenness

Table 3: Floristic composition and soil seed bank density (seeds/m^2) of different plots.

Species	Family	Habits	Plots				
			A	B	C	D	E
Ageratum conyzoides	Asteraceae	H	234	198	54	18	-
Andropogon gayanus	Poaceae	G	-	-	90	-	-
Andropogon spp	Poaceae	G	-	-	-	-	18
Asystasia gangentica	Acanthaceae	H	-	-	-	-	90
Calopogonium mucunoides	Papilonaceae	C	-	-	-	-	36
Chromolaena odorata	Asteraceae	H	54	-	343	72	36
Crotolaria retusa	Papilionaceae	H	-	-	-	18	-
Croton hirtus	Euphorbiaceae	H	-	-	108	-	-
Eleusine indica	Poaceae	G	72	450	360	432	990
Euphorbia hirta	Euphorbiaceae	H	-	18	-	-	-
Guyonia ciliate	Melastomataceae	H	-	-	-	90	-
Heterotis rotundifolia	Melastomataceae	H	-	18	-	-	-
Laportea aestuans	Urticaeae	H	144	18	-	396	-
Melanthera scadens	Asteraceae	H	18	-	-	-	-
Mirabilis jalapa	Nyctaginaceae	H	270	882	-	180	-
Mitracarpus villosus	Rubiaceae	H	-	-	18	-	-
Oldelandia corymbosa	Rubiaceae	H	-	-	36	18	18
Oplismenus burmanni	Poaceae	G	-	18	36	-	-
Panicum maximum	Poaceae	G	-	-	144	-	-
Panicum spp	Poaceae	G	18	-	-	54	160
Peperomia pellucida	Piperaceae	H	-	18	-	-	-

Phylianthus ninuri	Euphorbiaceae	H	36	-	-	-	-
Portulaca quadrifida	Portulacaceae	H	-	18	-	-	-
Pouzolsia guineensis	Urticaeae	H	558	378	108	108	216
Sida acuta	Malvaceae	H	-	-	72	-	-
Sida cordifolia	Malvaceae	H	-	-	18	18	-
Sida corymbosa	Malvaceae	H	-	-	54	-	-
Solanum verbasifolium	Solanaceae	S	18	-	36	-	-
Spermacoce ocymoides	Rubiaceae	H	-	450	90	162	18
Spermacoce verticillata	Rubiaceae	H	18	-	-	-	-
Spigellia anthemia	Loganiaceae	H	-	-	18	18	-
Spilanthes filicaulis	Asteraceae	H	18	846	18	342	-
Stachytarpheta cayenensis	Verbanaceae	H	-	18	-	-	-
Synedrella nodiflora	Asteraceae	H	504	288	-	234	18
Talinum triangulare	Portulacaceae	H	72	846	-	-	36
Total			2052	4464	1602	2160	1656

T-Tree, S- Shrub, H- Herb, C- Climber, G- Grass.

Table 4: Sorenson index of similarity of the soil seed bank and above ground standing vegetation of the plots.

Plots	**A**	**B**	**C**	**D**	**E**
A	11.42				
B		18.46			
C			10.16		
D				28.57	
E					28.12

C- Climber, G- Grass, H- Herb, W- Woody.

Table 5: Chemical properties of the soil sample collected around the Iron smelting factory.

Parameters	Plots				
	A	B	C	D	E
Soil pH (1:1)	7.32±0.15[b]	7.62±0.21[a]	7.90±0.13[a]	7.84±0.24[a]	7.88±0.11[a]
Total nitrogen%	0.22±0.01[c]	0.24±0.02[c]	0.23±0.02[c]	0.26±0.01[c]	0.33±0.04[b]
Total Phosphorus(PPM)	65.13±2.57[b]	64.52±1.88[b]	70.06±1.41[a]	69.84±0.54[a]	64.14±2.97[b]
Potassium (Cmol/kg)	0.22±0.02[a]	0.26±0.02[a]	0.26±0.06[a]	0.22±0.02[a]	0.28±0.01[a]
Calcium (Cmol/kg)	0.75±0.02[d]	0.75±0.03[d]	0.77±0.01[d]	0.73±0.04[d]	0.82±0.05[d]
Sodium (Cmol/kg)	0.10±0.01[a]	0.12±0.01[a]	0.10±0.01[a]	0.13±0.01[a]	0.09±0.01[a]
% Organic Matter	2.26±0.15[c]	2.66±0.08[c]	2.33±0.20[c]	2.64±0.17[c]	2.62±0.18[c]
Zinc (mg/kg)	19.24±1.86[a]	20.17±2.80[a]	20.78±0.97[a]	19.14±0.74[a]	19.14±0.53[a]
Cadmium (mg/kg)	0.32±0.02[b]	0.51±0.06[a]	0.32±0.02[b]	0.37±0.07[b]	0.41±0.05[b]
Lead (mg/kg)	1.10±0.07[ab]	1.27±0.13[a]	0.72±0.04[c]	1.06±0.01[b]	0.89±0.03[c]
Chromium (mg/kg)	0.08±0.00[a]	0.07±0.00[b]	0.07±0.00[b]	0.08±0.00[a]	0.08±0.00[a]
Copper(mg/kg)	7.81 ± 0.83[a]	8.41± 0.39[a]	10.30 ± 0.65[a]	6.61± 0.35[b]	7.51± 0.83[a]

[a,b,c] mean within the same row with different superscript are significantly (P<0.05) different.

DISCUSSION

The density of the woody species, herbaceous species, grass species and the climbers varied considerably among the plots under consideration. This corroborate, Tilman (1998) who stated that species range usually have a clear limit at both extremes of spatial and temporal disturbance gradients. The presence of few early succession woody species in each of five plots, most of which are secondary regrowth forest species, is an indication that the area have been subjected to recent anthropogenic disturbances which is in agreement with Hall and Okali (1979) and Oke et al. (2009) who noted that the presence or dominance of early succession species is an indication of disturbance. Some of these woody species such as *Albizia zygia, Cnestis ferruginea* and *Newbouldia laevis* were found peculiar to four out of the five plots while other few woody species were found at most in three plots. Chandrashekera and Ramarkishan (1993) have reported that level of disturbance and successional age of forest do have effects in species composition, therefore, the difference in species composition observed across the plots could be attributed to the disturbance occurring in the vicinity of the factory wall as well as soil properties and other factors which affect species composition. The different plant species richness observed in all the plots shows that there is variation in the plant species composition. The result of the study revealed that plot A is the richest, having highest value of species richness when compared with other plots, meaning that plot A is less disturbed or impacted when compared with other plots. This is in agreement with Offiong et al. (2011) who observed that vegetation in the less impacted site was richer, more diverse and heterogeneous than vegetation in impacted site. However, the general reduction in species richness observed in most of the plots is an indication that the area was recently disturbed and thus typical of secondary rain forest after disturbance. This is in agreement with Nest (1991) and Parthasarathy (1999) who reported that a number of human factors such as bush burning, urbanization etc. may lead to reduction in species abundance and subsequently resulted into a waste land. Species diversity indices recorded for all the plots using Shannon –Wiener index show a high value and this is in agreement with Decocq et al. (2004) who reported that species

diversity is higher in disturbed ecosystem than in undisturbed forest.

The seed density obtained in this study can be ascribed to the large number of herbaceous species in the seed bank of the study site, the longer time allowed for seedling emergence which was six months and also to the fact that the citing of the factory in the study area is recent. This is in agreement with the study of Marone et al. (2004) who observed differences in seed composition in different microhabitat and also reported heavy recruitment of herbaceous species in each of this microhabitat. The heterogeneous seed bank density observed in each the plots corroborate the work of Marone et al. (2004) who observed highly heterogeneous seed density in different microhabitats of open woodland and shrub land of the central Monte Desert. The differences in soil seed bank densities observed in this study may also be attributed to the change in soil condition due to surface disturbance experience at each location in the different plots and this is in agreement with Kinloch and Friedel (2005) who demonstrated that the soil seed densities are influenced by changes in soil condition due to surface disturbance which may result into direct looses of seed-bearing plants. Correlation between extant vegetation and the soil seed bank composition have usually been found to be weak (Falinska, 1999) and this is often attributed to disturbance, with closer relationships found in more stable communities. Approximately 60% of the plant species found in the standing vegetation did not occur in the soil seed bank of the study area; on the other hand, 25% of the species in the soil seed bank were not found in the above ground vegetation while only 15% were common to both seed bank and standing vegetation. This confirms the assertion of Chaideftou et al. (2009) who observe low similarity between above-ground vegetation and persistent soil seed bank in forest ecosystem and then conclude that the above ground vegetation does not necessarily reflect the soil seed bank composition. The shift between seed-bank and vegetation composition could be a consequence of the soil nitrogen concentration: as stated by Bischoff (2002) and van der Valk (1986), as high levels of nutrients (including nitrogen) may act as environmental sieves regarding the germination abilities of several vascular species (Roze et al., 2008).

The availability of essential elements is known to affect plant species richness, the yield and quality of crops (Heitholt et al., 2002; Parsons et al., 2007). Soils are major sources for plant nutrients; however, their nutrient availability varies during the growing season depending on some characteristics of the soil such as soil organic matter content, pH, and exchange-cation capacity (Cancela et al., 2002; Strahm and Harrison, 2007). Moffat (1988) reported that trees will increase the organic matter coupled with the organic carbon content of the soil. Therefore, the high organic matter content recorded in Plot B may be due to the presence of large amount of fallen leaves from the dominant *Theobroma cacao* stands that were found in the plot as it has been noted that litter fall tends to increase the organic matter content of the soil.

Soil nitrogen increase is very important in degraded land rehabilitation projects, since, according to Francis and Read (1994), it enhances the capacity of the system to support a more complex community. The presence of large number of herbaceous species in the plot E may be attributed to the high nitrogen content recorded for this plot as it has been reported by Davidson et al. (2004) that higher N concentrations reduced individual plant mortality. According to Li et al. (2003), moister soils tend to have higher mineral soil C and N as well as higher N mineralization rates than drier soils, therefore the higher N observed in this study may also be attributed to high soil moisture content of the plot. Available phosphorus was high in all the plots especially in Plot C. This can be attributed to the presence of phosphorus fixing species such as *Alchornea cordifolia* on the site. This conforms to the report of Kang et al. (1984) that species of *Alchornea cordifolia* and

Gliricidia sepium have high potential of fixing phosphorus content when present in the soil. Soil pH influences nutrient uptake, nutrient availability and species diversity. Soil pH values at the extremes (< 4.0 and > 8.5) can make some nutrient toxic and others unavailable to plants. At lower pH values (< 4.5), Aluminum, Iron and Manganese are readily available for plant uptake. At higher pH levels (> 5.5) Calcium and Potassium are over abundant (Andrew and Roberts, 2002). Most plants grow best where the soil is slightly acidic in the range of pH 5.8 to 7.0 and since the pH values (5.58 – 7.8) obtained in this study falls within this range, the plants growing in these vegetation types are provided with good growing conditions as reflected in the physiognomy of all the plots under consideration. However, the average potassium (0.22 Cmol/kg - 0.28Cmol/kg) and calcium (0.73Cmol/kg - 0.82 Cmol/kg) contents obtained in this study is low when compared to those reported by Wild (1988) (1%-2% for potassium) and Jakovljević et al. (2003) (1.37% for calcium) for soils in the world. The low calcium and potassium contents observed in this result may be attributed to the disturbance.

Seed is a stage in the plant life cycle that is well protected against various stresses. However, soon after imbibition and subsequent vegetative developmental processes, they become stress-sensitive in general. Therefore, seeds are carefully monitored against some external parameters such as light, temperature and nutrient in order to maintain the protective state until external conditions become favorable for developmental processes (Karssen 1982; Pritchard et al., 1993; Bungard et al., 1997). The relationship between soil conditions and the soil seed bank dynamics is rarely reported in the literature. The result of this study showed variation in species composition of the soil seed bank across the plots. This may be attributed to the varying disturbance regime across the plots. Some authors have stated that continuous disturbance (e.g. annual hay-cutting, trampling, annual ploughing, etc.) lead to a decrease in seed density and the seed bank diversity (Zabinski et al., 2000; Smith et al., 2002). Also, the functional composition of the seed bank may also be related to the soil fertility level. According to Bouwmeester et al. (1994) and De Keersmaeker et al. (2004), the optimum soil nitrogen concentration is suitable for seedling emergence. Due to the high and continuous deposition of pollutants on soil, several environmental gradients have been created (Lukina and Nikonov, 1995). From this result, the concentration of heavy metal observed can be regarded as not been toxic as all the value observed was lower than the value reported to be toxic. It is well-known that heavy metals can cause severe damage to vegetation and even lead to complete death of sensitive individuals (Fernandez and Henrõques, 1991; Kapustka et al., 1995). Therefore, high heavy metal concentrations in soils have been usually cited as one of the primary factors limiting vegetation establishment and growth in the barrens (Ginocchio, 2000; McCall et al., 1995). There are some evidence that atmospheric pollution has negative effects on plant reproduction and regeneration such as decrease in seed production (Steubing and Fangmeier, 1991), seed germination and seedling establishment (Ginocchio, 1997). However, the variation in above ground vegetation and soil seed bank observed in this study cannot be attributed to high heavy metal content as the value observed were not high but rather to other factors while the species richness observed may be as a result of low value of those heavy metal contents. According to Fernandes and Henriques, (1991), some heavy metals at low doses are essential micronutrients for plants, thereby enhancing species richness as well as diversity but in higher doses they may cause metabolic disorders and growth inhibition for most of the plants species.

Conclusion

Investigations into floristic composition and their environment provide a better understanding of the dramatic changes in

nutrient status and species composition due to the influence of human activities as depicted in the result obtained. Our result revealed a shift between seed bank and vegetation composition which could be a consequence of the soil chemical properties and also as a result different level of disturbance occurring due to the citing of industry in the area.

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