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Evaluating Soil Seed Bank Composition and Diversity in Selected Solid Waste Dumpsites in Port Harcourt, Nigeria

Obianefo, F. U.
Ph.D. Student, Department of Plant Science and Biotechnology,
University of Port Harcourt, Rivers State, Nigeria
Dr. Tanee, F. B. G.
Lecturer, Department of Plant Science and Biotechnology,
University of Port Harcourt Rivers State, Nigeria
Agbagwa, I. O.
Professor/Lecturer, Department of Plant Science and Biotechnology,
University of Port Harcourt Rivers State, Nigeria
Dr. Ochekwu, E. B.
Lecturer, Department of Plant Science and Biotechnology,
University of Port Harcourt Rivers State, Nigeria

Abstract:
The soil seed bank, floristic composition and diversity in selected solid waste dump sites located in Port Harcourt metropolis Rivers State, Nigeria were evaluated. The systematic sampling technique was employed and soil samples were collected at three stratified depths of 0-5 cm, 5-10 cm and 10-15 cm. The seedling emergence method was used for the soil seed bank analysis. The Shannon/Weiner diversity index was used for species diversity. Results revealed a total number of 36 species belonging to 21 families in the wet season while the dry season recorded 34 species belonging to 17 families. The Poaceae family dominated the soil seed bank in the dump sites and control for both seasons. There was no significant difference between the different dump sites studied. High seedling density recorded in the soil seed bank from the dumpsites indicated the rich nutrient level of the soil. There was significant difference in the seedling density down the soil profile; in the level of 0-5 cm > 5-10 cm > 10-15 cm depths. Hence, anthropogenic input as a result of solid wastes has altered the species composition and diversity in the dump sites.

Keywords: *Soil seed bank, Plant species density, Diversity, Composition, Solid wastes, Evenness.*

1. Introduction

Vegetation pattern can be indicators of biotic and abiotic factors which can invariably influence plant species assemblages express in different ways (community and species). Therefore, differentiating vegetation on the basis of level of degradation is important in conserving biodiversity (Godinez *et al*., 2009; Kent, 2012). Furthermore, variation in vegetation pattern is one of the most important characteristics that may be determined in the study of any vegetation (Khan *et al*., 1989; Habib, 2011).

When the recycling and fertility service is impaired as a result of poor solid waste management, all life on earth is threatened as life is either directly or indirectly reliant on plants and their products (Olatunji *et al*., 2013; Saatkamp *et al*., 2014). Plant communities when severely disturbed and are degraded, recovery to its native biological diversity becomes unlikely (Akinola *et al*., 1998; Akande and Ajayi, 2014; Dedeke and Akomolafe, 2014).

Nevertheless, Seed banks are important in the dynamics of many plant communities. They are reserve of viable seeds on the surface or buried in the soil, which are ready to germinate if germination requirements are met (Christoffoleti and Caetano, 1998; Baskin and Baskin, 2006). There are numerous seeds buried in the soil although some are not persistent so they die within a year or two, but others may stay for decades and give memory of past environmental conditions favouring growth and seed production of different population (Maranon, 1998). Seed banks are important as they provide propagules that may influence plant community changes after disturbance (Scott *et al*., 2010; Gomaa, 2012).

Furthermore, abandoned solid waste dump sites are now being converted to viable land for agricultural purposes and studies indicate that soil seed banks are the main source of weed population in agricultural land (Gulshan *et al*., 2013). Most plants start their life from a single seed and a single weed may grow and produce many seeds which may pose management challenge if the proper control measures are not taken (Abella and Springer, 2008).

Moreover, knowledge of the soil seed bank species composition of dump sites may help in the proper management in protecting against noxious species and also to restore these sites. Hence, this study focuses on determining the soil seed bank composition in solid waste dump sites.

2. Materials and Methods

This study was carried out in two wet and dry seasons of 2015 and 2016 at five solid waste dump sites located in Port Harcourt metropolis in Rivers State, Nigeria. Port Harcourt lies between latitude 4^{0}5"N and5^0 00" and longitude 6^0 55"E and 7^{0}00"E (Figure 1). The climate is basically that of tropical equatorial latitude with rainfall occurring almost all year round except for December, January and February (Gobo *et al*. 2008). In the first year of sampling (2015) the minimum temperature was 20.1^{0}C and the maximum was 31.4^{0}C and the average rainfall was 160.6 mm. In the second year of sampling (2016) the minimum temperature was 20.0^{0}C and the maximum was 32.2^{0}C and the average rainfall was 196.8 mm (Source: Nigerian Meteorological Agency, Abuja). In this study, five dump sites with their corresponding control were investigated.

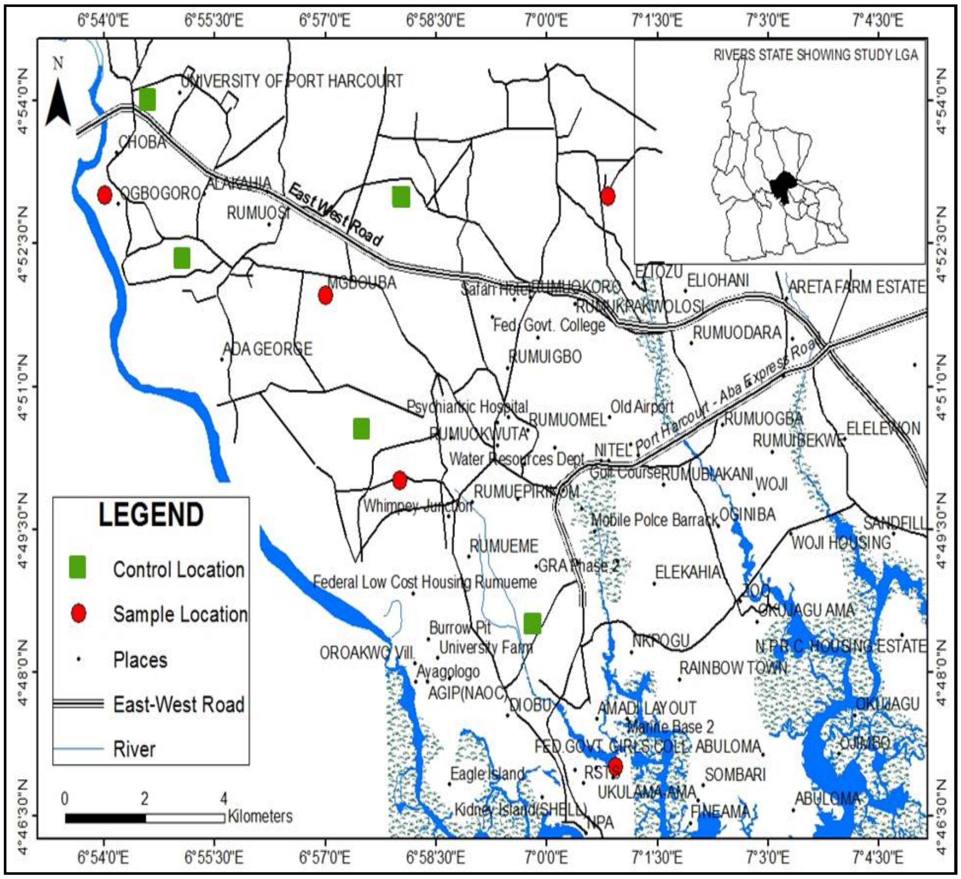

Figure 1: showing the distribution of the sampling locations

2.1. Sample Collection

The systematic sampling technique was used and a 20 x 20m area was mapped out. A total of 180 soil samples were collected from the five dumpsites including the controls, with 18 samples from each site for one season making it 720 soil samples for the entire sampling period. The soil samples were collected using a soil auger from each dump sites were classified according to their depths of collection (0-5cm, 5-10cm and10-15cm).The soil samples were air-dried, sieved with a 2-mm mesh and 100g of soil sample weighed out in three replicates and placed in perforated plastic bowels with whatmann filter paper No.45 at the base of the bowls. The filter paper was used to prevent water clogging and also to allow free and moisture exchange. The bowls were placed outdoors to allow natural daily temperature fluctuations to promote germination. It was then draped with polythene hood to reduce evaporation. Samples were watered daily and seedling emergence identification was done weekly for 12 weeks (Butler and Chazdon, 1998; Price *et al*., 2010).

The seedlings were identified, counted and discarded using the Flora of West Africa by Hutchinson and Dalziel (1954-1972), Encyclopedia of Tropical plants (Ahmed, 2011) and A Handbook of West African Weeds (Akobundu *et al*., 2016). Unidentified seedlings were transplanted in pots until identification was possible. Identified and counted emerging seedlings were used as measure of seed density. The seedling emergence distributions at the three stratified depths were also determined.

2.2. Data Analysis

The emerging plant seedlings in these dump sites were usedfor the determination ofdensity diversity and evenness. Species diversity and evenness were calculated using Shannon/Weiner (1963) diversity index ascited in Anyanwu *et al. (2014)*. The data were statistically analyzed using analysis of variance and significant means were separated using Least Significant Difference (SPSS version 21).

3. Results

3.1. Species Composition and Diversity

The results of the number of plant family, species, diversity and evenness at the study locations for wet and dry seasons are presented in Tables 1. The soil seed bank recorded a total of 32 species distributed in 17 families in the dump sites and 34 species distributed in 18 families in the control sites for wet season. While the dry season had 28 species distributed in 16 families in the dump sites and 31 species distributed in 21 families in the control sites.

The soil seed bank recorded species diversity of between 1.21 to 1.86 and 1.62 to 2.35 in the dump sites for wet and dry season respectively. While the control sites had values ranging from 0.7 to 1.95 and 1.52 to 1.93for wet and dry season respectively. The highest diversity in the wet season was at the Eliozu dump site, while the Rumuokwuta dump site had the highest diversity in the dry season. The control sites had relatively low diversity as compare to the dump sites (Table 1). It was observed that there was not much variation in the evenness between the dump sites and their respective controls. In the dump sites the soil seed bank had values between 0.41 to 0.62 and 0.61 to 0.80 for wet and dry season respectively, while the control species evenness was between 0.26 to 0.76 for the wet season and 0.56 to 0.65 for the dry season.

Location	Number of species Number of family				Diversity				Evenness			
	Wet		Dry		Wet		Dry		Wet		Dry	
	DS	CS	DS	CS	DS	CS	DS	CS	DS	CS	DS	CS
Iwofe	19	15	23	11	1.59	0.7	2.11	1.52	0.54	0.26	0.67	0.63
	11	12	14	10								
Eliozu	20	16	22	15	1.86	1.53	1.81	1.66	0.62	0.55	0.59	0.61
	14	12	14	13								
Choba	19	13	16	20	1.21	0.7	1.62	1.93	0.41	0.76	0.59	0.65
	12	9	10	14								
Rumuokwuta	17	19	19	22	1.69	1.66	2.35	1.72	0.61	0.70	0.80	0.56
	13	13	13	16								
Ozuoba	23	21	18	21	1.75	1.95	1.81	1.82	0.55	0.64	0.61	0.60
	15	14	12	15								
Total	32	34	28	31								
	17	18	16	21								

Table 1: The soil seed bank number of species, family, diversity and evenness at study location.
DS=Dump site; CS= Control site

3.2. Plant Species Density/m²

The soil seed bank seedling density in the dump sites was between 360.2 to 2960.02seedling/m² and 427.76 to 5065.51seedling/m² for wet and dry seasons (Table 2 and 3). The control sites had values ranging from 293.79 to 2357.29seedling/m² and 411.53 to 1350.91seedling/m² for wet and dry seasons (Table 2). The Dump site located at Iwofe had the maximum seedling density in the wet season while the Ozuoba dump site had the highest density in the dry season. *Cyperus* sp. had the maximum density closely followed by *Oldenlandia* sp. in the dump site while the control recorded *Oldenlandia* sp. with the highest density in the wet season (Table 2). For the dry season *Oldenlandia* sp. recorded the highest density while in the control *Cyperus* sp. recorded the highest density (Table3). The Poaceae family had the maximum number of species of 10 and 8 in the dump sites for wet and dry season respectively, while in the control sites the Poaceae family had the maximum number of 7 plant species for both seasons.

Location		Iwofe		Eliozu		Choba		Rumuokwuta		Ozuoba	
Plant name	Family	DS	CS	DS	CS	DS	CS	DS	CS	DS	CS
Cyperus sp.	Cyperaceae	1158	295.4	169.5	429.2	1203.3	58.8	140.6	179.3	410.6	188.3
Oldenlandia sp.	Spermacoceae	1022	1928.3	230.3	172.1	527.2	108.8	106.8	304.7	1034	58.7
Phyllanthus sp.	Phyllanthaceae	34.3	7.33	42.14	27.9	47.1	11.7	3.88	73.5	34.2	5.8
Cynodon dactylon	Poaceae	199.6	0	22.57	0	4.9	32.3	1.94	5.9	33.14	0
Spermacoce sp.	Spermacoceae	0	5.88	5.82	158.1	17.6	13.2	0	2.9	0	19.09
Lindernia sp.	Linderaceae	226.3	51.42	162.6	42.6	79.4	10.3	47.1	36.7	193.8	7.34
Digitaria sp.	Poaceae	7.7	10.3	0.9	1.46	0	27.91	0	0	1.94	1.46
Ageratum sp.	Asteraceae	0.98	4.41	6.88	0	0	5.88	4.93	23.49	3.88	11.74
Dissotis sp.	Melastomataceae	0	2.9	0	5.8	1.9	2.9	0	0	20.6	27.9
Solenostemon sp.	Labiatae	2.9	2.9	14.7	8.81	0	0	0	42.6	5.8	0
Ludwigia sp.	Onagraceae	85.4	20.6	241.1	11.7	50.8	10.3	20.5	14.7	78.3	19.1
Aspilia sp.	Asteraceae	5.8	0	0	0	5.9	0	0	4.4	0	1.5
Eleusine sp.	Poaceae	50.9	0	9.7	0	12.6	2.9	12.8	19.1	117.5	0
Talinum sp.	Portulacaceae	23.6	0	1.9	0	0.9	0	0.9	0	61.7	0
Solanum sp.	Solanaceae	0	0	1.9	0	0	0	0.9	0	0.9	1.5
Panicum sp.	Poaceae	0	0	0	0	11.8	0	1.9	0	0	0
Eleutheranthera sp.	Asteraceae	0	0	0	0	11.8	0	0	16.2	10.7	0
Triumfetta sp.	Malvaceae	2.9	2.9	0	0	0	0	2.9	8.8	3.9	2.9
Axonopus sp.	Poaceae	1.9	2.9	0	5.8	0	7.3	0	0	10.75	0
Mimosa sp.	Mimosaceae	0	0	4.9	0	1.9	0	7.9	0	0	0
Paspalum sp.	Poaceae	5.9	0	0.9	1.5	4.9	0	0	0	40.2	0
Peperomia sp.	Piperaceae	0	0	3.9	0	1.9	1.5	1.9	0	1.9	0
Setaria sp.	Poaceae	8.8	0	0	0	2.9	0	0	16.2	13	0
Cleome sp.	Cleomaceae	116.7	0	1.9	0	1.9	0	2.9	0	9.8	0
Amaranthus sp.	Amarantheceae	0	0	0	0	0	0	0	0	0.9	2.9
Altheranthera sp.	Amaranthaceae	0	0	1.9	0	0	0	0	5.8	0	0
Celosia sp.	Amaranthaceae	0	0	0.9	4.4	0	0	0	0	0.9	16.2
Chromoleana sp.	Asteraceae	0	1.5	0.9	4.4	0	0	0.9	0	0	13.2
Dactyloctenium sp.	Poaceae	4.9	0	0	0	0	0	0	0	0	0
Echinochloa sp.	Poaceae	0.9	0	0	0	0	0	0	14.7	27.5	0
Brachiaria sp.	Poaceae	0	0	0	0	8.8	0	0	0	0	0
Selaginella sp.	Selaginellaceae	0	19.1	0	47	0	0	0	63.2	0.9	0
Starchytarpheta sp.	Verbenaceae	0	0	0	0	0	0	0	1.5	0	0
Indigofera sp.	Fabaceae	0	0	0	4.4	0	0	0	0	0	0
Plalostoma sp.	Lamiaceae	0	0	0	0	0	0	0	0	0	5.9
Commelina sp.	Commelinaceae	0	1.5	0	0	0	0	0	0	0	1.5
Physalis sp.	Solanaceae	0	0	0	5.9	0	0	0	8.8	0	2.9
Sida sp.	Malvaceae	0	0	0	0	0	0	0	0	0	1.5

Table 2: The seedling density/m² of the soil seed bank in the study locations for wet season
DS= Dump site; CS= Control site

Location		Iwofe		Eliozu		Choba		Rumuokwuta		Ozuoba	
Plant name	Family	DS	CS	DS	CS	DS	CS	DS	CS	DS	CS
Cyperus sp.	Cyperaceae	526.1	169.1	343	211.5	79.2	423.2	164.7	230.7	812.3	386.58
Oldenlandia sp.	Spermacoceae	307.7	135.2	951	95.4	201.9	321.8	109.6	407	1961.5	420.26
Phyllanthu sp.	Phyllanthaceae	52.9	10.22	124.3	1.5	1.9	5.8	47.9	11.8	11.8	24.85
Cynodon dactylon	Poaceae	76.3	4.4	99.8	0	8.8	33.8	14.6	7.4	382.2	23.61
Spermacoce sp.	Spermacoceae	15.6	0	1.9	5.8	6.7	0	1.9	4.45	13.7	25.03
Lindernia sp.	Linderaceae	72.5	48.48	342.8	95.5	65.57	89.6	49.9	138.1	569	102.8
Digitaria sp.	Poaceae	11.6	13.21	1.9	0	0	0	0	8.81	0	0
Ageratum sp.	Asteraceae	12.8	5.82	28.9	2.9	5.98	8.86	4.93	4.4	3.9	19.03
Dissotis sp.	Melastomataceae	10.7	2.99	0	7.4	0	0	0	0	74.4	1.46
Solenostemon sp.	Labiatae	0	0	0	7.4	0	0	4.86	2.92	6.8	5.82

Location		Iwofe		Eliozu		Choba		Rumuokwuta		Ozuoba	
Ludwigia sp.	Onagraceae	80.4	2.99	96.8	13.2	37.2	61.9	107.8	30.85	794.7	129.26
Aspilia sp.	Asteraceae	0	0	3.8	0	0.9	0	3.88	0	0	1.46
Eleusine sp.	Poaceae	135.5	0	82.5	0	5.8	29.3	96.11	58.7	195.1	47.13
Talinum sp.	Portulacaceae	50.4	0	28.3	0	0.9	92.5	112.86	2.9	176.2	1.46
Panicum sp.	Poaceae	0.98	0	0	0	6.8	2.99	6.8	2.99	5.82	0
Eleutheranthera sp.	Asteraceae	11.64	0	12.87	0	1.96	0	0	0	0	0
Triumfetta sp.	Malvaceae	4.93	0	2.99	0	0	11.81	36.74	2.99	0	1.46
Axonopus sp.	Poaceae	6.87	0	8.81	0	0	1.46	0	0	10.85	1.46
Mimosa sp.	Mimosaceae	0	0	4.86	1.46	0	2.99	0	11.8	0	2.99
Paspalum sp.	Poaceae	23.45	0	0	0	0	4.4	0	1.46	4.93	0
Peperomia sp.	Piperaceae	5.82	0	3.97	0	0.98	1.46	7.85	1.46	0	1.46
Setaria sp.	Poaceae	26.44	0	5.98	0	0.98	8.81	1.94	1.46	9.86	1.46
Cleome sp.	Cleomaceae	16.74	0	7.85	0	1.94	1.46	89.23	4.4	31.31	1.46
Portuluca sp.	Portulacaceae	0	0	0	0	0	0	0.98	0	0	0
Altheranthera sp.	Amaranthaceae	0.98	0	9.87	0	0	0	9.87	2.99	0	0
Celosia sp.	Amaranthaceae	0	0	0	1.46	0	238.14	0	0	0	24.68
Echinochloa sp.	Poaceae	1.94	0	1.94	0	0	0	0	0	0	0
Selaginella sp.	Selaginellaceae	1.94	17.63	0	41.27	0	0	0	0	0.98	0
Starchytarpheta sp.	Verbenaceae	0	0	0	0	0	0	0	1.46	0	0
Indigofera sp.	Fabaceae	0	0	0	2.99	0	0	0	0	0	0
Plalostoma sp.	Lamiaceae	0	0	0	0	0	2.99	0	10.22	0	0
Commelina sp.	Commelinaceae	0	1.46	0	0	0	0	0	0	0	0
Schwenkia sp.	Solanaceae	0	0	0	1.46	0	0	0	0	0	0
Physalis sp.	Solanaceae	0	0	1.94	5.82	0	0	0	0	0	2.99

Table 3: The seedling density/m² of the soil seed bank in the study location for dry season
DS= Dump site; CS-= Control site

3.3. Seedling Emergence in the Three Stratified Depths

In the three stratified depths studied, the 0 – 5 cm depth recorded the highest seedling density and the 10 – 15 cm depth had the lowest density in the wet season. The values ranged from 173 to 2188 seedling/m² for 0-5 cm, 105-773 seedling/m² for the 5-10 cm depth while the 10-15cm depth had values ranging from 58.77 – 659 seedling/m² and the Iwofe dump site recorded the highest density (Figure 2). Generally, all the control sites had lower density than their respective dump sites for all the study locations. While in the dry season the seedling emergence density ranged from 189 to 3200 seedling/m² for the depth of 0-5 cm and 99.4 to 1206 seedling/m² for the depth of 5-10 cm while the values for the depth of 10-15cm ranges from 140-659.41 seedling/m² (Figure 3). The 0 – 5 cm depth also had the highest density and the Ozuoba dump site recorded the highest density in the dry season. At p=0.05 there was significant difference between the 0-5cm depth and the 10-15cm depth for all the study locations.

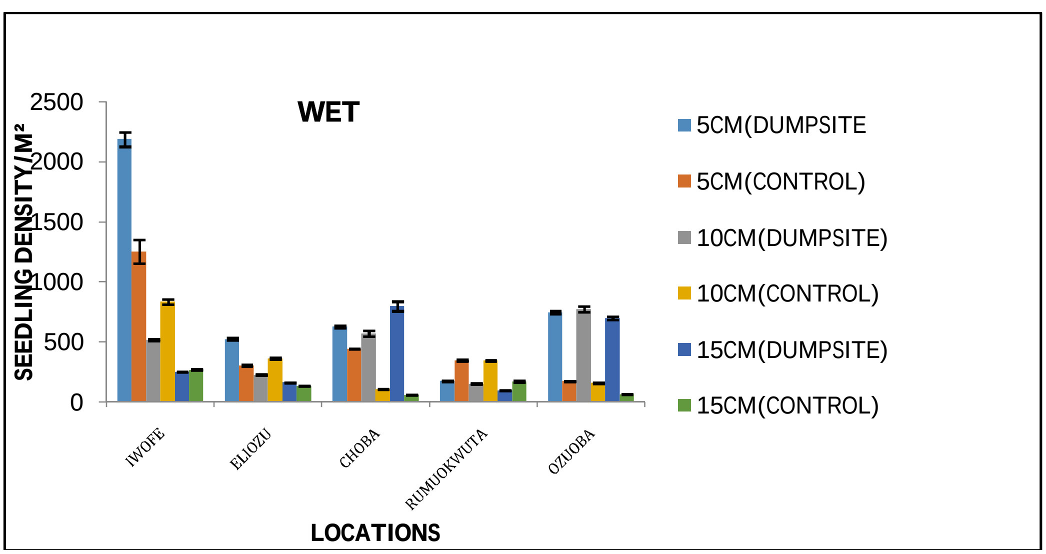

Figure 2: Seedling emergence density for the three stratified depths from the study locations in the wet season

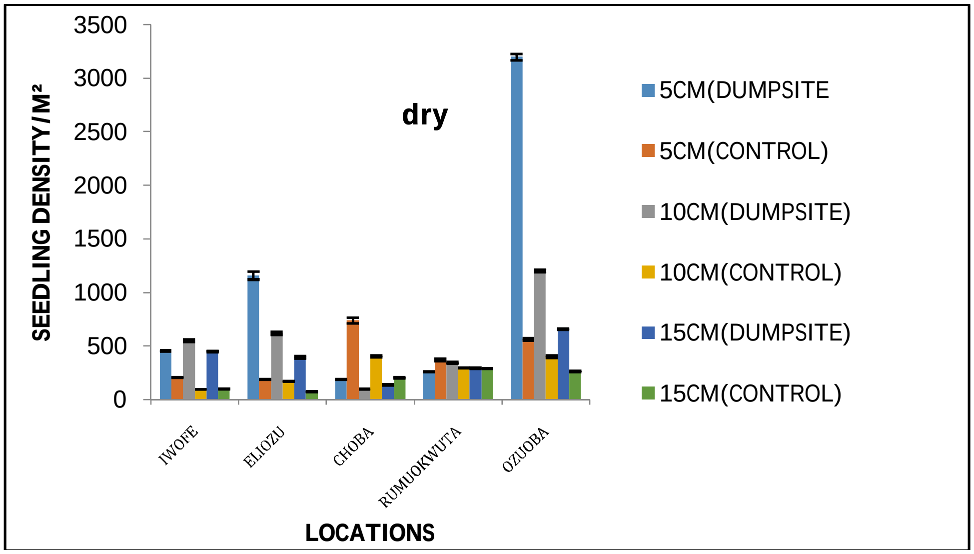

Figure 3: Seedling emergence density for the three stratified depths from the study locations in the dry season

4. Discussion

Environmental degradation as a result of poor wastes management adversely altered the floristic composition of the environment globally and this has resulted in the introduction of new species, species extinction and even reduction of indigenous ones (Getachew *et al*., 2004).The results showed that there was great difference between the floristic compositions of soil seed bank of the dump sites and the control sites. The composition of the seed bank reflects the species richness although studies have shown that disturbance may influence species richness and diversity (Akinola *et al*., 1998; Oke *et al*., 2006; Scott *et al*., 2010). The grasses and herbaceous species dominated the soil seed bank, which agrees with other findings that grass seeds are normally many and tiny and easy to germinate when conditions are favourable. The difference in the density and diversity at the various locations confirmed the fact that they have different tolerance capacity and also the effect of anthropogenic activities on plant composition (Habib *et al*., 2011; Chima *et al*., 2013; Akinyemi *et al*., 2013).

Furthermore, the high species composition of the soil seed bank in the dump sites may have been due to the introduction of alien seeds from solid wastes and also the effect of the rich nutrients of the soil as a result of the decomposition of organic wastes which favours high seedling emergence (Eshalomi-Mario and Tanee, 2015). The low species diversity in the soil seed bank at the dumpsites may be from the contribution of lower organisms such as earthworm or microorganisms from decomposing wastes which may have feasted on the dormant seeds on the soil thereby making room for resilient species to survive (Ayade, 2003). This also is in conformity with other studies that when the soil organic matter recycling service is impaired, life on earth is threatened as life is directly or indirectly reliant on plants and their products (Godinez *et al*., 2009).

5. Conclusion

This study reveal that changes in soil seed bank composition and diversity as a result of anthropogenic activities through poor solid wastes management has led to changes in biodiversity. This has contributed to the alteration of species composition and diversity of the soil seed bank. As such this has promoted the germination of certain seeds and plant species in the environment around the dump sites which are alien due to changes in the soil physiochemistry resulting from the effect of solid wastes. This alien species can pose threat to the use of such sites for agricultural purposes.

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