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Composition of Resident Macro-Invertebrates in Refuse Dumps at University of Port Harcourt, Nigeria

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Abstract
Improper dumping of solid wastes has detrimental impact on both aquatic and terrestrial environments. The macro-invertebrate fauna, resident in open dumps have recently drawn the attention of researchers on environmental health and safety. In Nigeria, solid wastes are regularly dumped in low-lying lands close to slums. Lack of sorting the wastes into different categories results in medical and hazardous wastes being mixed with household biodegradable solid wastes that serve as breeding sites for insects, vermin and scavengers. The dumps are capable of causing air, water and arthropod-borne diseases. Macro-invertebrates (centipedes, earthworms, insects, millipedes, pill bugs, snails and spiders,) of University of Port Harcourt dumps were collected with pitfall traps. Arthropods dominated in number in the dumps and are more diversified. The higher abundance of the arthropods and relatively representation of annelids and molluscs in all the dumps were attributed to ecological partitioning of the invertebrates and the dumps providing them suitable ground for habitation, feeding, reproduction and development. The health implications of the insect and other invertebrates were discussed. The international best practice of recovery, recycle, reuse and reduction in addition to use of incinerator and landfill systems in management solid wastes were recommended as blue print for the larger community of Port Harcourt, Nigeria.

Keywords: *Macro-invertebrates; residence; refuse dumps; environment, health*

1. Introduction

Dumps are isolated locations where solid wastes are discarded which are usually left bare for direct sunlight and rainfall. There are many of these dumps in urban and semi-urban cities in Nigeria that mostly contain wastes from households, markets, schools, health and commercial institutions. These wastes are dumped in a manner that negates environmental health and sustainability. In Nigeria, many of the sites are chosen without observing international best practice for waste disposal and management (Nwosu and Pepple, 2016).The sites are usually located in swampy or low lands or even in fertile uncultivated lands. However, the open dumping of solid wastes in designated places in the urban and semi-urban centers of Nigeria cities was earlier acceptable as the only way to manage solid wastes, but presently such practice is associated with environmental and health problems due to lack of evacuation logistics.

Dumps in Nigeria and their environmental challenges range from the redistribution of refuse on the streets from wind-blown litter (Abdus-Salam, 2009) to presence of non-biodegradable waste materials that contain heavy metals and hazardous substances as well as biodegradable solids. The decomposition of the biodegradables attracts pathogens and invertebrate fauna. Some of the invertebrates are capable of vectoring pathogens of economic and health importance. The environmental health concern of the dumps includes leachates emanating from the dumps and the prevalence of arthropod vectors resident in them. Leachates percolate beneath the dump after rain had fallen on the dump that moves through the soil horizons and contaminate groundwater. Dissolution of heavy metals in leachate poses severe pollution threat to the soil and water biodiversity (Abdus-Salam, 2009; Oni *et al.,* 2011; Magaji, 2012; Nartey *et al*., 2012; Popoola and Amusat, 2015; Tanee and Eshalom-Mario, 2015; Esenowo *et al*., 2017). Nevertheless, the ecological roles of some invertebrates of dumps are copious in (Morales and Wolff, 2010; Gbarakoro *et al*., 2015; Oka and Bassey, 2017) and their health implications in (Onyido *et al*., 2009 and 2011 and Ahmed, 2011).

The Nigerian government is no longer providing regular evacuation of wastes in open dumps to government approved dumpsites due to lack of man-power and shortage of machinery occasioned by economic recession. Hence, these dumps are becoming worrisome to the general public as they impair the aesthetics of the cities and harbor disease vectors. Thus, these dumps and their resident invertebrates are now potential threats to the environment and human health. Therefore, this study is geared towards surveying open dumps of University of Port Harcourt, Nigeria in relation to collection and identification of their resident macro-invertebrates in relation to their ecological and health threats.

2. Materials and Methods

2.1. Study Area

The experimental study was conducted at the Abuja campus of the University of Port-Harcourt Choba, Rivers State, Nigeria from June-August, 2018. The University is located at the north-south dimension of the New Calabar River along East-West road Port Harcourt. It is characterized by coastal and deltaic swamp which lies on a relatively flat land and is bordered in the northern part of Ikwerre Local Government Area (Aluu Town). On the west is the New Calabar River (which separates Obio Akpor from Emohua local Government Area). In the Eastern side it is bordered with Alakahia town in Obio/Akpor Local Government Area, and in the southern part by Choba community.

University of Port Harcourt, is a residential university for both staff (3,257) and students (35,000) with three campuses; Abuja, Choba and Delta parks (www.uniport.edu.ng). Each of these campuses have academic and residential buildings, mini shops and eateries to serve the economic needs of the staff and students.

Insect collection was carried out at four selected dumps at Abuja campus which were:

Ofrima 1 (4˚54′04.8″ N; 6˚55′24.7″ E). The dump is behind the Faculty of Science building known as (Ofrima building). The dump was damp throughout the study period due to a large water tank hung over it which was constantly dripping water on the dump. Soiled diapers were continuously seen in the dump. Others include decomposing research animals (white rats), research wastes (syringes, needles, soiled cotton wool, EDTA bottles, glass slides, etc.), leftover foods in disposable plates, papers, glass bottles, and plastic bottles.

Ofrima 2 (4˚54′11.4″ N; 6˚55′18.9″ E). The dump is in front of the Ofrima building and is characterized by papers, plastic cans, polythene bags and grass clippings.

Mandela 1 hostel (4˚54′2.8″ N; 6˚55′22.4″ E) and Mandela 2 hostel (4˚54′0.8″ N; 6˚55′25.2″ E). These are the male and female hostels respectively very close to the Abuja motor park. The dumps constitute mainly domestic wastes. The female section of the hostels contained cosmetic containers and tubes, sanitary pads, and waste water. Figure 1 presents the map of the study area.

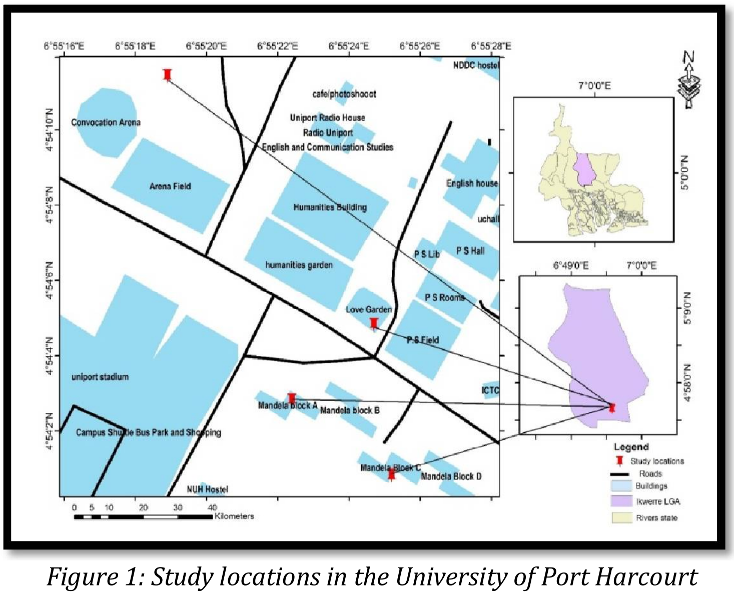

Figure 1: Study locations in the University of Port Harcourt

2.2. Method of Collection of Macro-Invertebrates in the Dumps

Macro-invertebrates resident in the dumps were collected with pitfall traps. Holes for the traps where dug with bucket Auger. Two plates of the same size and shape (17 cm diameter and 11 cm depth) were sunk into a hole; this is to prevent the hole from closing when the top plate is removed for collection of any invertebrate trapped in the plate thus, allowing the remaining plate to stay untouched. The rims of the plates aligned with the ground to avoid digging-in-effect hence, invertebrates that crawled across the plate fell into it and were trapped. The plates were filled to 1/3 with water and 20 ml of 5 % formalin added to it to break the water surface tension and as well preserve the specimens before their collection. The traps were allowed to stand for 24 hours and 3 collections were made in a week between 07.00 and 10.00 hours. The specimens trapped were collected with Camel hair brush and blunt forceps after sucking out the water in the plates with a 20 ml syringe. The collected specimens were preserved with 70% ethanol in plastic bottles. After the last collection of every week, the specimens were sorted with dissecting microscope to their taxonomic level in the Animal and Environmental Biology Laboratory, University of Port Harcourt. At the end of the study, insect samples were labeled and sent to a taxonomist at Insect Museum, Ahmadu Bello University (ABU) Zaria for identification while the other invertebrates were identified using descriptive guide by (Segun, 1998) and online aid on vermin images. Numerical data were statistically analyzed to determine the invertebrates' abundance and their species diversity.

3. Results

At the end of the invertebrates' collection from the dumps at the University of port Harcourt, 2085 specimens were counted. They were composed of three invertebrate phyla; Annelida, Arthropoda and Mollusca. The phylum Annelida has 1 class Oligochaeta, 1 order Opisthophora and 1 family Eudrilidae and 1 species *Lumbricus* spp. The phylum Arthropoda has 5 classes; Arachnida, Chilopoda, Crustacea, Diplopoda and Insecta. It has 14 orders; Aranea, Opiliones, Geophilomorpha, Scolopendromorpha, Isopoda, Polydesmida, Spirobolida, Coleoptera, Dermaptera, Dictyoptera, Diptera, Hemiptera, Hymenoptera, Orthoptera, with 31 families and 49 species. The phylum Mollusca has 1 class Gastropoda, 1 order Pulmonata, 4 families; Achatinidae, Philomycidae, Planorbidae, Terebridae and 4 species; *Physid* sp., *Limax* sp., *Biomphalria* sp. and *Terebra* sp. (Table 1). The invertebrates were highly dominated by the insectan order while the isopodan order has the highest abundance; the least abundant was the opisthophoran order (Table 2). Among the invertebrates collected at the dumps, the larval stages of arthropods were found in the collections. They include the larval stages of beetles, caterpillars, cockroaches, crickets, and flies (Table 3).

Phylum	Class	Order	Family	Species	Common Names
Anellida	Oligochaeta	Opisthophora	Eudrilidae	*Lumbricus* spp.	Earth worm
Arthropoda	Arachnida	Aranea	Araneidae	SNR	Spider
		Opiliones	FNR	SNR	Daddy longlegs
	Chilopoda	Geophilomorpha	Geophilidae	*Geophilus* spp.	Centipede
		Scolopendromorpha	Cryptopidae	*Cryptops* sp.	
			Scolopendridae	*Scolopendra* sp.	
	Crustacea	Isopoda	Armadillidiidae	*Armadillidium* spp.	Pill bug
	Diplopoda	Polydesmida	Chelodesmidae	*Prepodesmus* spp.	Millipede
			Paradoxomatidae	*Asimorpha* sp.	
				Asiomorpha coarctata (De Saus.)	
				Oxidus sp.	
		Spirobolida	Pachybolidae	*Pachybolus* spp.	
			Spirostrespidae	*Orthoporus* sp.	
	Insecta	Coleoptera	Carabidae	*Aulacoryssus aciculatus.* (Dej.)	Ground beetle
				Drimostoma punctulatum (Tsch.)	
				Drypta spp.	
				Eccoptomenus eximus (Dej.)	
				Egadroma sp.	
				Hyparpalus juvencus. (Dej.)	
				Lanchesternus politus (Gory)	
				Scarites gagatinus (Dej.)	
			Chrysomelidae	*Crioceris nigropunctata* (Lac.)	Leaf beetle
				Crytocephalus risbeci (Dry.)	
				Lema cephalotes (Lac.)	
			Coccinellidae	*Adonia variegate* (Gze.)	Ladybird beetle
			Histeridae	*Hister* spp.	Hister beetle
				Hypocacculus buqueti (Mars.)	
			Lampyridae	*Luciola bimyxata* (Murr.)	Firefly
			Nitidulidae	*Aethina* sp.	Sap beetles
			Staphilinidae	*Creophilus* spp.	Rove beetle
			Tenibrionidae	*Zophosis* sp.	Darkling beetle
		Dermaptera	Forficulidae	*Labidura riparia* (Pars.)	Earwig
		Dictyoptera	Blathollidae	*Blathella germanica* (Linn.)	Cockroach
			Blattidae	*Blatta orientalis* Linn.	
		Diptera	Calliphoridae	*Chrysomya albiceps* (Rob-desv.)	Blow fly
			Culicidae	*Aedes* spp.	Mosquito
				Culex spp.	
			Muscidae	*Musca domestica* (Linn.)	House fly
				Musca sp.	
		Hemiptera	Coreidae	*Choerommatus angusticollis* (Linn.)	Leaf footed bug
			Nepidae	*Nepa* sp.	Water scorpion
			Reduviidae	*Oncocephalus* sp.	True bug
			Tingidae	*Mezira* sp.	Lace bug
		Hymenoptera	Formicidae	*Pheidole* spp.	Big headed ant
				Camponotus macalatus (Fab.)	Carpenter ant
				Camponotus perrisi (For.)	
				Dorylus affinis (Fab.)	Army ant
				Dorylus sp.	
		Orthoptera	Acridiidae	*Spharagemon* sp.	Grasshopper
			Gryllidae	*Acheta domesticus* (Linn.)	Cricket
Mollusca	Gastropoda	Pulmonata	Achatinidae	*Physid* sp.	Giant snail
			Philomycidae	*Limax* sp.	Mantle slug
			Planorbidae	*Biomphalaria* sp.	Ramshorn snail
			Terebridae	*Terebra* sp.	Auger snail

Table 1: Composition of Macro-Invertebrates Resident at the University of Port Harcourt Dumps, June-August, 2018

Phylum	Class	Species	Common Names	Number Trapped
Anellida	Oligochaeta	*Lumbricus* spp.	Earth worm	26
Arthropoda	Arachnida	SNR	Spider	101
		SNR	Daddy longlegs	24
	Chilopoda	*Geophilus* spp.	Centipede	6
		Cryptops sp.		9
		Scolopendra sp.		12
	Crustacea	*Armadillidium* spp.	Pill bug	401
	Diplopoda	*Prepodesmus* spp.	Millipede	48
		Asimorpha sp.		36
		Asiomorpha coarctata (De Saus.)		3
		Oxidus sp.		12
		Pachybolus spp.		186
		Orthoporus sp.		15
	Insecta	*Acheta domesticus* (Linn.)	Cricket	24
		Adonia variegate (Gze.)	Ladybird beetle	3
		Aedes spp.	Mosquito	27
		Aethina sp.	Sap beetles	3
		Aulacoryssus aciculatus. (Dej.)	Ground beetle	15
		Blathella germanica (Linn.)	Cockroach	41
		Blatta orientalis Linn.		47
		Camponotus macalatus (Fab.)	Carpenter ant	89
		Camponotus perrisi (For.)	Carpenter ant	74
		Choerommatus angusticollis (Linn.)	Leaf footed bug	3
		Chrysomya albiceps (Rob-desv.)	Blow fly	6
		Creophilus spp.	Rove beetle	41
		Crioceris nigropunctata (Lac.)	Leaf beetle	33
		Crytocephalus risbeci (Dry.)	Leaf beetle	16
		Culex spp.	Mosquito	9
		Dorylus affinis (Fab.)	Army ant	204
		Dorylus sp.	Army ant	44
		Drimostoma punctulatum (Tsch.)	Ground beetle	11
		Drypta spp.	Ground beetle	33
		Eccoptomenus eximus (Dej.)	Ground beetle	27
		Egadroma sp.	Ground beetle	15
		Hister spp.	Hister beetle	11
		Hyparpalus juvencus. (Dej.)	Ground beetle	17
		Hypocacculus buqueti (Mars.)	Hister beetle	13
		Labidura riparia (Pars.)	Earwig	19
		Lanchesternus politus (Gory)	Ground beetle	26
		Lema cephalotes (Lac.)	Leaf beetle	3
		Luciola bimyxata (Murr.)	Firefly	3
		Mezira sp.	Lace bug	3
		Musca domestica (Linn.)	House fly	34
		Musca sp.	House fly	6
		Nepa sp.	Water scorpion	1
		Oncocephalus sp.	True bug	9
		Pheidole spp.	Big headed ant	157
		Scarites gagatinus (Dej.)	Ground beetle	3
		Spharagemon sp.	Grasshopper	15
		Zophosis sp.	Darkling beetle	3
Mollusca	Gastropoda	*Biomphalaria* sp.	Ramshorn snail	41
		Limax sp.	Mantle slug	8
		Physid sp.	Giant snail	6
		Terebra sp.	Auger snail	63
TOTAL				**2085**

Table 2: Abundance of Macro-Invertebrates Resident at the University of Port Harcourt Dumps, June-August, 2018
Note: SNR= Species Name Not Recognized

ORDER	FAMILY	COMMON NAME
Coleoptera	Drillidae	False firefly
Coleoptera	Dermestidae	Carrion beetle
Dictyoptera	Blattidae	Cockroach
Diptera	Calliphoridae	Blow fly
Diptera	Muscidae	House fly
Diptera	Stratiomyidae	Black solder fly
Lepidoptera	FNR	Caterpillar
Orthoptera	Gryllidae	Cricket

Table 3: Composition of Insect Larvae Resident at the University of Port Harcourt Dumps, June-August, 2018
Note: FNR= Family Name Not Recognized

Most of the arthropods collected especially the insects used the dumps to produce and develop their young ones. The number of the insects collected range from 63 for cockroaches, housefly 58, black soldier fly 25, blowfly and carrion beetle 18 respectively, cricket 17 to false firefly 4 (Fig. 2). The proportion of the individual species of the invertebrates showed that *Armadillidium* spp. (pill bugs) has the highest relative abundance of 19.25% and was followed in that trend by *Dorylus affinis* (army ant) 9.78%, *Pachybolus* spp., (millipedes) 8.92% and *Pheidole* sp. (big headed ant) 7.53%. Others with relative abundance of more than 1 but less than 5 % include; *Acheta domesticus, Aedes* spp., *Biomphalaria* sp., *Blatta* spp., *Camponotus* spp., *Dorylus* sp., *Drypta* sp., *Eccoptomenus eximus, Lanchesternus politus, Lumbricus* spp., and *Musca domestica*. Others with less than 1% include; *Adornia variegate, Aethina* sp., *Asiomorpha coarctata, Aulacoryssus aciculatus, Choerommatus angusticollis, Chrysomya albiceps, Cryptops* sp., *Crytocephalus risbeci, Culex* spp., *Dristoma puntulatum, Egadroma* sp., *Geophilus* spp., *Hister* spp., *Hyparpalus juvencus, Hypocacculus buqueti, Labidura riparia, Lema cephatotes, Lima* sp., *Luciola bimyxata, Mezira* sp., *Musca* sp., *Onchocephalus* sp., *Orthoporus* sp., *Oxidus* sp., *Physid* sp., *Scarites gigantinus, Scolopendra* sp., *Spharagemon* sp. and *Zophosis* sp. (Fig. 3).

The proportion of the 3 invertebrate phyla showed that phylum Arthropoda has the highest relative abundance of 93% while phylum Mollusca and Annelida have relative abundance of 6 and 1% respectively (Fig. 4). Further analysis of the proportion of the 93% of the arthropods showed that its 5 classes was represented and dominated by the class Insecta with 55% followed by Crustacea with 21%. The Diplopoda has 15%, Arachnida and Chilopoda have 6 and 3% respectively (Fig. 5). The preponderance of the 55% of the insects were dominated by the orders; Hymenoptera 27.79%, Coleoptera 11.50%, Dictyoptera 4.31, Diptera 4,01%, Orthoptera 1.91%, Dermaptera 0.93% and Hemiptera 0.78% (Fig. 6). The invertebrate species were diversified but were not evenly distributed in the dumps (Fig. 7).

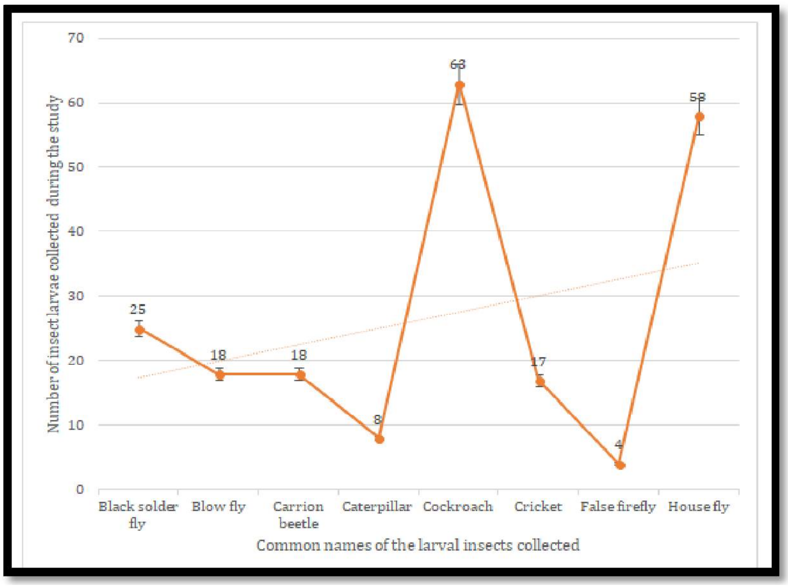

Figure 2: Number of Insect Larvae Resident at the University of Port Harcourt dumps, June-August, 2018

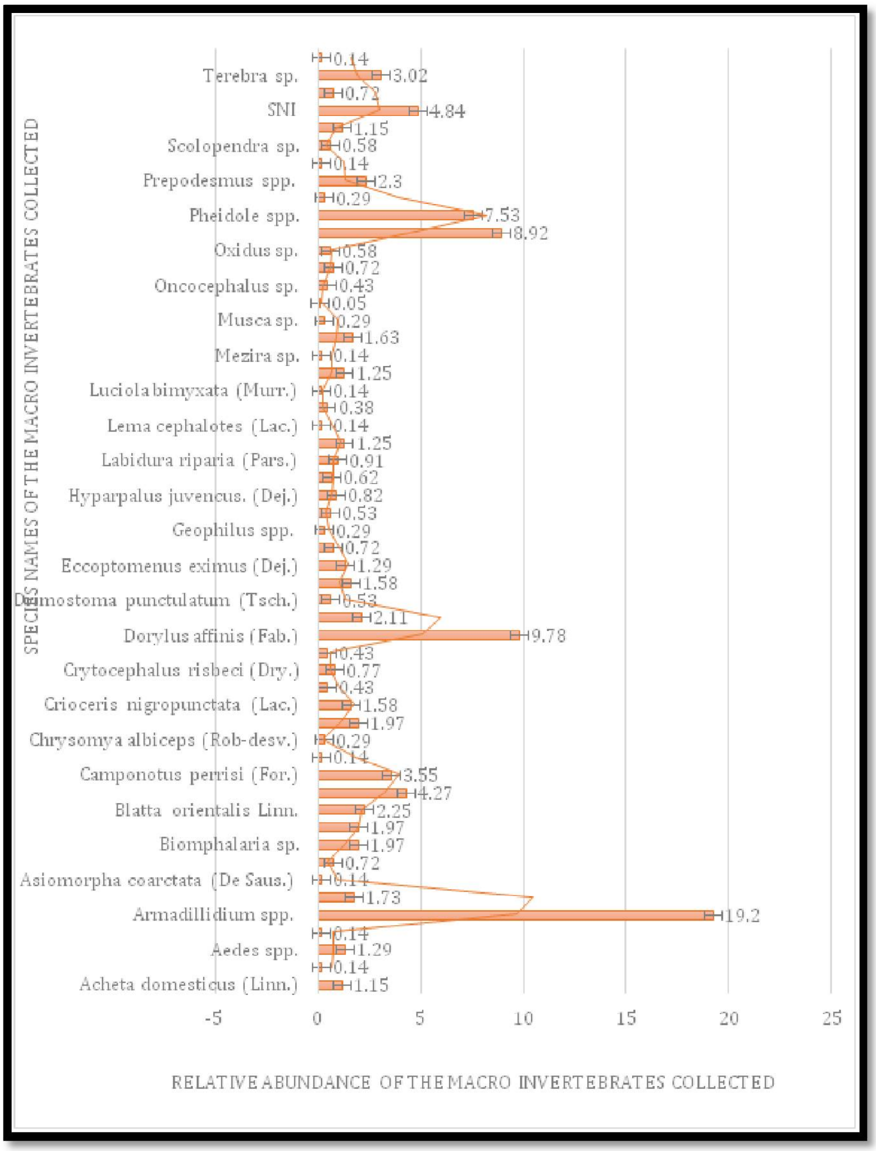

Figure 3: Relative Abundance of the Marco-Invertebrates Resident at the University of Port Harcourt Dumps, June-August, 2018

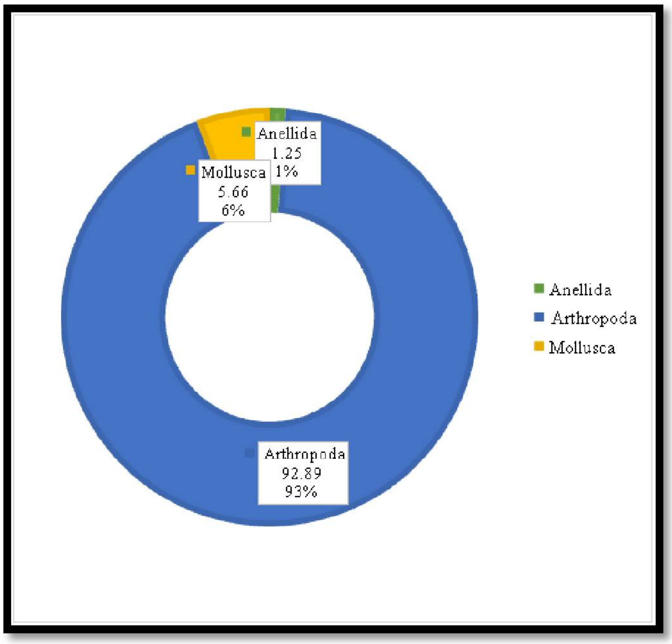

Figure 4: Relative Abundance of the Three Marco-Invertebrate Phyla Resident At The University Of Port Harcourt Dumps, June-August, 2018

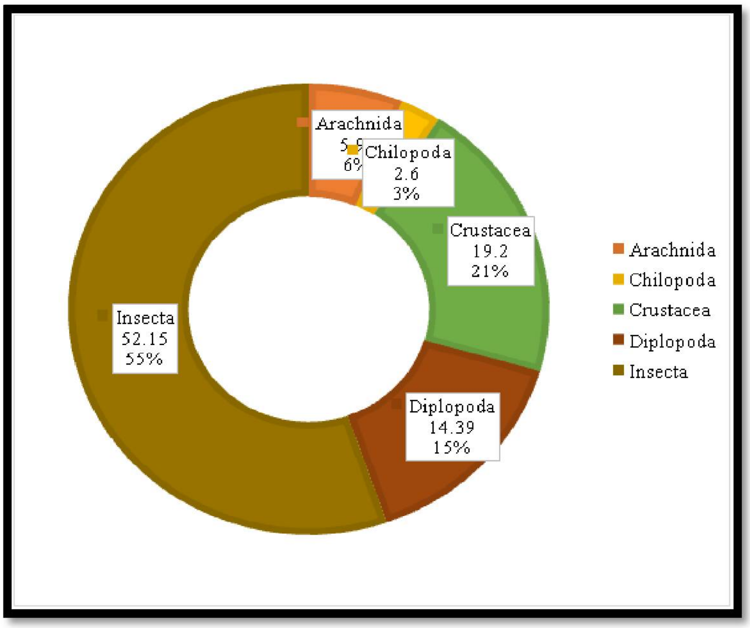

*Figure **5:** Relative Abundance of the five Marco-Invertebrate Arthropods Resident at the University of Port Harcourt Dumps, June-August, 2018*

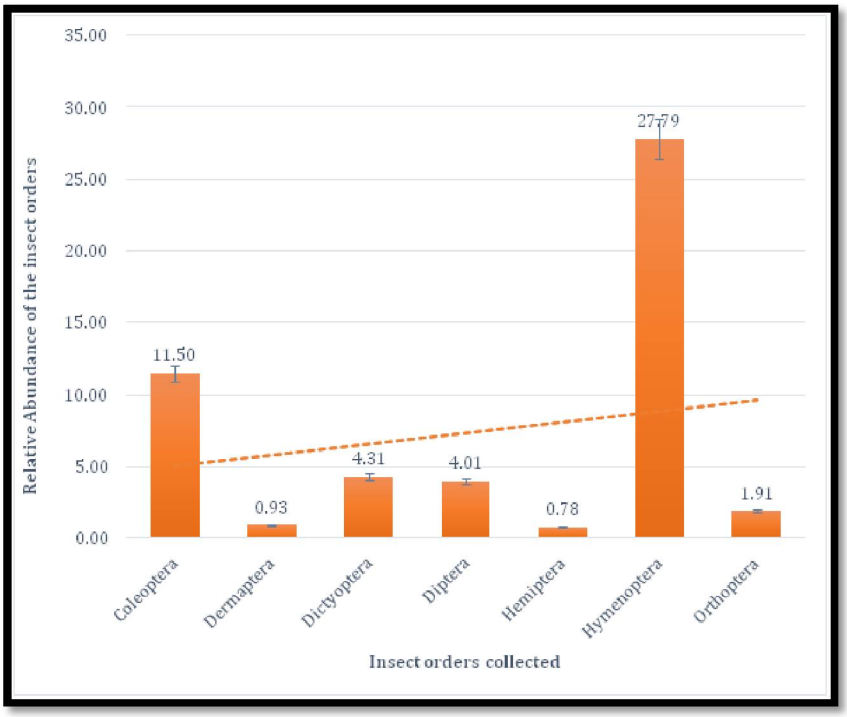

Figure 6: Relative Abundance of the Seven Marco-Invertebrate Insects Resident at the University of Port Harcourt Dumps, June-August, 2018

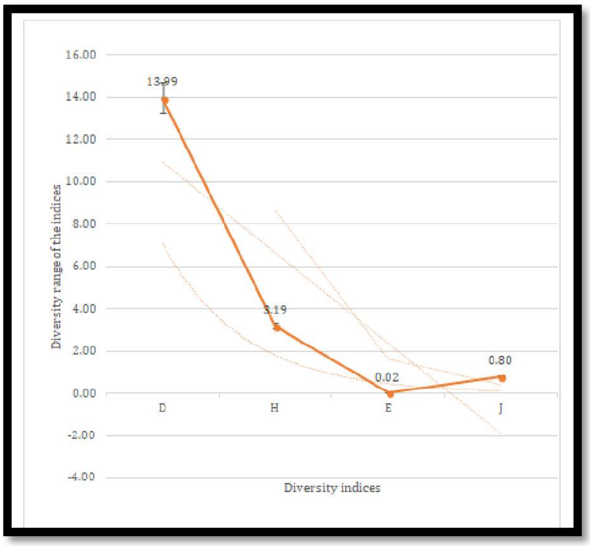

Figure 7: Species Diversity of the Macro-Invertebrate Phyla Resident at the University of Port Harcourt Dumps, June-August, 2018
Note: D = Simpson diversity index; H = Shannon diversity index; E = Simpson evenness; J = Shannon evenness

4. Discussion

The macro-invertebrates of this study, play vital roles in ecological food chain hence, they may bio-accumulate any toxic substance due to heavy metal leachates from the dumps which are threat to animals' health and capable of affecting their biodiversity (Abdus-Salam, 2009). The characteristic roles of these macro-invertebrates in nutrient cycling cannot be underestimated thus, the decomposers for instance are vital in the reduction of the dumps volume and in turn are dependent on the contributions from the higher trophic levels of that allogenic community. Succession of the macro-invertebrates in the dumps and interactions within themselves were evidence on such allogenic communities on soil surfaces as they are the primary recyclers of organic matter. This study provided the insight to understand the habitational requirements of these macro-invertebrates as well as their dispersal capacities. The dynamics of the insects like the ants, fly larvae, snails, millipedes, beetles and the detritivorous caterpillars that initiated the breakdown of the materials into fragments were also fascinating.

The earthworms (annelids) found in the dumps were evidence that the dumps were moisturized for them to thrive. Earthworms tend to tolerate highly contaminated terrestrial environment provided the surroundings are moderately moisturized. They are known to burrow into soils which aids in soil aeration thereby reducing soil compaction and acidity. The arachnids, chilopods, crustaceans, diplopods and insects (arthropods) on the other hands are also very important group of invertebrates that provide a lot of ecosystem services by exploiting the biotic and the abiotic components of the dumps. They act as either decomposers (ants, beetles, cockroaches, fly larvae, millipedes, pill bugs), predators (beetles, centipedes, spiders,) or vectors (cockroaches, flies and mosquitoes). The snails (molluscs) are herbaceous grazers and their defecations in or on the dumps are decomposition catalyst. Their presence in the dumps are biological indication that the dumps are susceptible to contamination. The reports that snails and other macro-invertebrates, many of them implicated in this study, have the potential to bio-accumulate heavy metals like lead (Ologhobo and Ebenso, 2008) and reservoirs of helminth parasites (Segun, 1998) are therefore, aligned in this study as a serious public health threats.

Public health concern of these macro-invertebrates' resident in University of Port Harcourt dumps range from mechanical and biological transmission of pathogens (protozoans, viruses, fungi and helminthes) from dumps to man and animals. Emission of foul odour from the decomposing organic matters is also a serious public health concern. The decomposition of the food garbage from the hostels and restaurants in the dumps provided enough food for the cockroaches and the flies for them to breed. Even, rodents are also attracted to the dumps due to crumbs and discarded foods in the dumps hence, may harbor ectoparasites like fleas and ticks. These parasitic arthropods are notorious vectors of diseases like lassa and plague. Apart from the rodents that are resident in the dumps due to food garbage, the preponderance of fly maggots, ants and beetles may attract lizards and snakes which will unavoidably make the dumps unsafe for waste collectors and people scavenging the dumps for recyclable wastes (Onyido *et al*., 2009; Oka and Bassey, 2017).

The insects in particular remained resident in the dumps because the plastic components of the dumps collected and retained water for a long time due to rain and mosquitoes continued to breed in them. The cockroaches and flies were also feeding on the decomposing organic matters in the dumps and breed in them as well. Cockroaches, flies and mosquitoes cause substantial economic loss to man and the nation at large. Not only that these insects are nuisance, the female mosquitoes for instance depend on vertebrate blood especially that of man for fecundity and survival and when sucking the blood, they transmit disease causing pathogens to man and animals. Diseases like malaria, yellow fever, dengue fever and filariasis are all caused by mosquitoes of different species. The cockroaches and the flies in the same vein are mechanical transmitters of diseases from filthy dumps to man and animals. Such diseases like dysentery, cholera,

diarrhea, typhoid, skin disease and different forms of helminthiasis are diseases linked to be mechanically transmitted by cockroaches and flies (Ozumba and Nwosu, 2003; Onyido *et al*., 2009; Ahmed, 2011; Onyido *et al*.,2011; Ojiegbe, 2015).
The macro-invertebrates are highly diversified in the dumps probably because the dumps lack industrial and electronic wastes. Dumps with constituents of industrial and electronic wastes are bound to drip leachates capable of affecting the macro-fauna diversity of a refuse dump (Oni *et al*., 2011; Ewuim *et al*., 2014). The higher abundance of arthropods in the study is probably an indication that the suspected heavy metals expected to drive them out of the dumps were negligible. Therefore, it is assumed that the dumps and its surroundings were contaminated but not polluted due to lack of wastes of metallic origin. However, the dumps continued to serve as breeding ground for insects of public health importance. Evacuation of dumps in the university is not given adequate attention by the university waste management committee. Because the waste collectors lack the modern and technical facilities in managing solid wastes, they occasionally attend to wastes within the vicinities of the office buildings and hostels and dump them behind the university swimming pool which now serve as illegal dumpsite of the Abuja campus of the university. The distance of this dump is less than 50 m from the university swimming pool, university motor park, medical and graduate hostels hence, a potential public health threat to staff and students of the university.

5. Recommendations

Nearness of dumps to human settlements activates environmental health threats and when dumped very close to water bodies or water ways are capable of facilitating air, water and arthropod-borne diseases. It is therefore, advisable that the university dumpsite should be sited at a distance not less than 960 m from any water body and the slope of the site shouldn't be less than 5°. The distance of the dumpsite from the road and residential areas should be at least between 100 m and 8000 m respectively. Soil and geology types suitable for dumpsite should be Nitisols and Charnock/Granite respectively (Nwosu and Pepple, 2016). However, when such soil and geology types are not found within the university, alternative impermeable surfaces should be created.

The university should practice diversion and disposal of solid wastes which are the cheapest option in managing waste. In diversion, the management should recover, recycle, reuse, and reduce wastes generation while in disposal; they should dump wastes in a controlled and approved site. In doing this, the university should procure or improvise incinerator to reduce the wastes to barest minimum or alternatively adopt landfill system. Any of these options, should be well selected and access to it should be well controlled and provided with waste compacting machines. If an incinerator is preferred, a complimentary sanitary landfill is required because ash, non-combustible materials and other by-passed wastes should be landfilled. The university as the mirror of the society should be the vanguard of this practice, so that the larger society could follow suit.

6. References

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