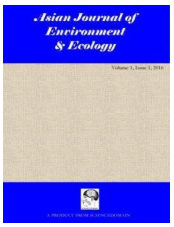

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Evaluating the Abundance of Soil Macro-Invertebrates in Idoro Community, Akwa Ibom State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author IKE wrote the first draft of the manuscript and the protocol. Author NIU managed the literature searches. Author DEA designed the study and performed the statistical analysis. Author IIU managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

A comparative study of the influence of farmland and waste dump on the abundance and diversity of soil macro invertebrates in Idoro community of Uyo, Akwa Ibom State, Nigeria was investigated between September 2015 and February, 2016. Soil samples were randomly collected at near soil surface layer (10 cm x 10 cm) by extraction using hand trowel into sterile polythene bags. The samples were analysed for macro-invertebrates using standard methods. A total of 249 soil macro invertebrate representing (13) invertebrate taxa belonging to nine (9) orders from six (6) classes and three (3) phyla (comprising of Arthropoda, Mollusca and Annelida) were encountered. In the wastes dump site, 114 invertebrates were encountered, while 135 were encountered in the cultivated farmland, The overall abundance of soil macro invertebrate phyla in both sampling sites were as follows; waste dumpsite (Arthropoda (65.5%) > Mollusca (25.5%) > Annelida (13.4%) and Cultivated farm land (Arthropoda (96.8%) > Mollusca (1.5%) > Annelida (3.0%). In the waste dump site, the percentage abundance of macro invertebrates were Arthropod larvae with (27.1%), *Blaniulus*

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guttulatus (22.8%) followed by *Pachychilidae sp.* (21.1%), while the least were *Hogna sp.* (Wolf spider) (0.7%). In the cultivated farmland, the percentage abundance of the recorded taxa were *Blaniulus guttulatus* (millipede) (54.1%), followed by *Asiomorpha coarctata* (11.1%), *Oniscidea sp., Formica rufa, Crytocerus puntulatus, Hogna sp.* with (4.4%) respectively, while the least were *Veronicella sp.* and *Oxidus gracilis* (0.7%) respectively. Conclusively, the difference in the abundance and diversity of the soil invertebrates between the contrasting habitats could be attributed to land use pattern which have greatly impacted on the soil biotic community structure.

Keywords: Macro-invertebrate; waste dump; diversity; abundance.

1. INTRODUCTION

Tropical soil macro-invertebrate communities are highly diverse and provide a number of important ecosystem services, including the maintenance of soil structure, regulation of hydrological processes, nutrient cycling and decomposition [1]. Unfortunately, the deterioration of soil quality, which often lead to decrease in the abundance of vegetation, has serious consequences on this area, such as its use for the open waste dumping, a fact that has recently arouse public interest [2]. In developing countries, open waste dumping has been a common practice due to low operational cost and ability to take all kinds of wastes.

The term open dump is used to characterize a land disposal site, where the indiscriminate deposit of solid domestic waste takes place with either no, or at best very little measures to control the operation and to protect the surrounding environment. This affects the physico-chemical properties of soil and surface water thereby posing serious threats to ground water resources and soil ecosystem productivity [3,4]. Hence an open dump is not in tune with the increasing public awareness of environmental issues and the demand for environmental improvement including the current focus on sustainability and global climate change [5]. Changes in climatic condition together with soil use can directly alter soil properties such as temperature, moisture content, chemical composition, and physical properties. These alterations consequently influence soil macro-invertebrate community assemblage, and in turn, alter important ecosystem services such as litter decomposition and nutrient cycling [6,7].

There are various factors influencing the composition, relative abundances, and dynamics of soil fauna. These includes biotic interactions such as competition [8] and predation [9-11]; the presence or absence of organic matter [12], physical features of the soil environment such as temperature, moisture, compaction [13,14], and acidity [15], as well as chemical features of soil [14].

The increasing trend in human populations and land use intensity have placed an urgent demand on a better understanding of the effects of anthropogenic activities on soil quality and soil fauna at different spatial-temporal scales. This is critically important to the conservation of global biodiversity. According to Santorufo et al. [16] highly polluted soil is composed of macro invertebrate community dominated by few species well adapted to extreme conditions, whereas the moderately polluted soils may have a community composition made of more homogenous and therefore more tolerant to fluctuating conditions.

A consistent presence of a rich organic layer of soil provides a more stable place for soil macro-invertebrates to live [17]. This creates a positive feedback mechanism, where the healthier soil promotes the presence of macro invertebrate populations, which in turn continue to convert litter into nutrient rich soil. However, population numbers of soil macro-invertebrates varies in accordance with natural changes in season, temperature, amount of rainfall, and other environmental gradients [18,19]. Furthermore, human interference, such as open dumping of waste can cause drastic changes to soil invertebrate population [20]. Hence, the dearth of information on the effects of farmland and waste dump site on the distribution, abundance and diversity of soil macro invertebrates forms the rationale for this study. The aim of this study is to investigate the abundance and diversity of soil macro-invertebrates in two contrasting habitats in Idoro community of Akwa Ibom State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Idoro community in Uyo Local Government Area of Akwa Ibom state,

Southern part of Nigeria. It lies between latitude 5°2'51" North and longitude 8°2'41" East (Fig. 1). The climatic condition of the study area is that of a typical tropical region, characterized by both rainy and dry seasons, which ranges between March to October and from November to March respectively. The annual rainfall is about 2500 mm with a mean annual temperature of 32°C and a relative humidity of 75%. The vegetation of the study sites were characterized by a great variety of grasses (*Panicum maximum*), herbs (*Aspilia africana*), shrubs (*Chromolaena odorata*) and trees (*Mangifera indica*). Soils types found around the open dumpsite and fallowed farm are of loamy soil and sandy loamy respectively.

2.2 Sampling Sites

Two sampling sites (waste dump site and cultivated farmland) were selected to compare the influence of human activities on soil macro invertebrate abundance and diversity. The waste dumpsite is a traditional one, not approved by the State Government.

2.3 Sample Collection

Sample collections were carried out once in a week for a period of six months between September, 2015 to February 2016. Four Soil samples were randomly collected from each of the study sites, at near soil surface layer (10 cm x 10 cm) by extraction using hand trowel into a well labelled polythene bag. The soils samples were immediately transported to the laboratory for processing, sorted for the soil macro-invertebrates and identified using guides provided by Borror and White [21]. The numbers of each arthropod were counted and recorded.

2.4 Physico-chemical Parameters of Soils

The soil from waste dumpsite and cultivated farmland were collected and placed in separate polythene bags and taken to Department of Animal and Environmental Biology for analysis. Soil temperature and pH were determined *in situ* with the use of mercury in glass thermometer

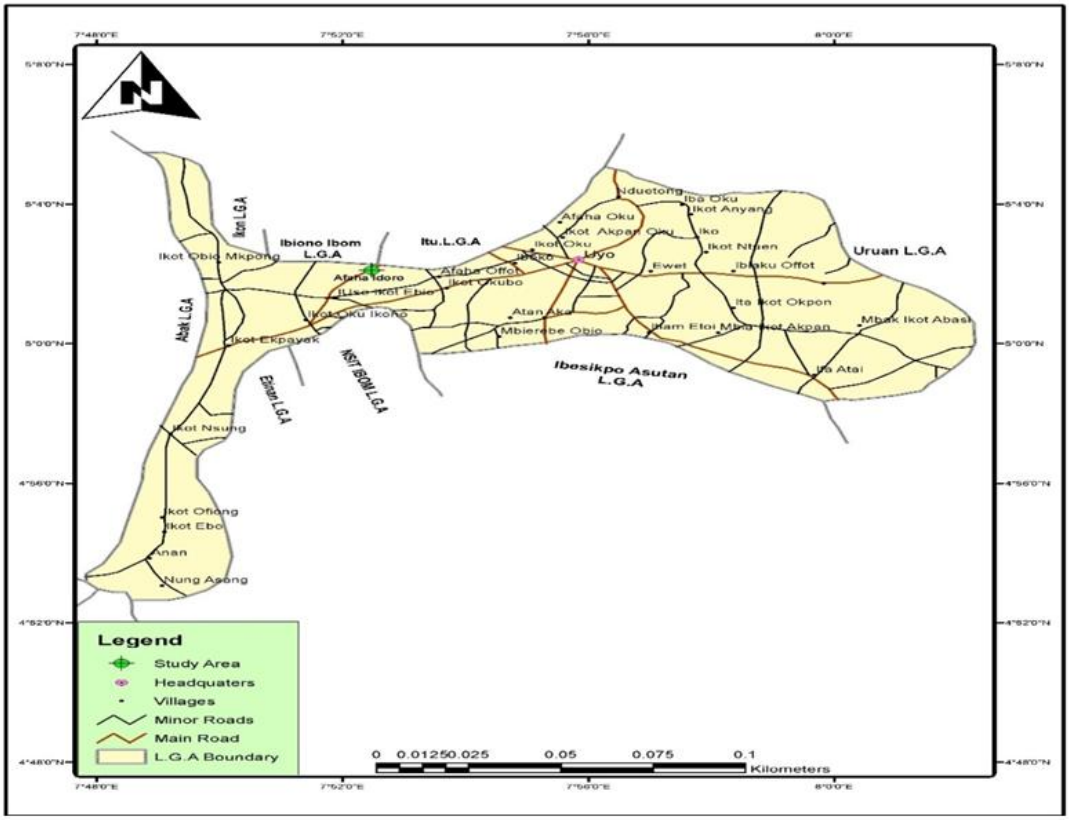

Fig. 1. Map of Uyo local government area of Akwa Ibom State showing the selected study area (Afaha Odoro)

and buffered electronic pH meter (Kent 7020) respectively, while soil moisture content was determined according to the method given by Odu et al. [22].

2.5 Data Analysis

Microsoft Excel (2007) was used for Data analysis to determine the numerical and percentage abundance, while version 3 of PAST software design was used to determine the diversity index of macro invertebrate species.

3. RESULTS

3.1 Soil Macro Invertebrate Diversity

A checklist of the soil macro invertebrate diversity in Idoro community of Uyo Local Government Area is presented in Table 1. A total of thirteen (13) species of soil macro invertebrates belonging to nine (9) orders from six (6) classes and three (3) phyla were encountered during the study.

3.2 Soil Macro Invertebrate Abundance

The relative Abundance of soil macro invertebrate taxa recorded is presented in Table 2. A total of 249 soil macro invertebrate representing 13 taxa were encountered. In the cultivated farmland, 135 individuals were encountered, while 114 were encountered in the waste dump site. In the cultivated farmland, the dominant taxa was *Blaniulus guttulatus* (millipede) (54.1%), followed by *Asiomorpha coarctata* (11.1%), *Oniscidea* sp., *Formica rufa, Crytocerus puntulatus, Hogna* sp. with (4.4 %) respectively, while the least were *Veronicella* sp. and *Oxidus gracilis* (0.7%) respectively. Also in the waste dump site, the dominant taxa were Arthropod larvae with (27.1%), followed by *Blaniulus guttulatus* (22.8%) *Pachychilidae* sp. (21.1%), while the least was *Hogna sp.* (Wolf spider) (0.7%). The invertebrate phyla abundance is presented in Fig. 2.

3.3 Physico-chemical Parameters of the Soil in the Cultivated Land and Waste Dump Site

The result of the physico-chemical parameters of the soil is shown in Table 3. pH ranges from 4.02 to 7.34 for waste dump site while for cultivated land it was 6.75 to 7.10. Soil temperature was 32.30 to 35°C for waste dump site, cultivated land recorded 30 to 32°C.

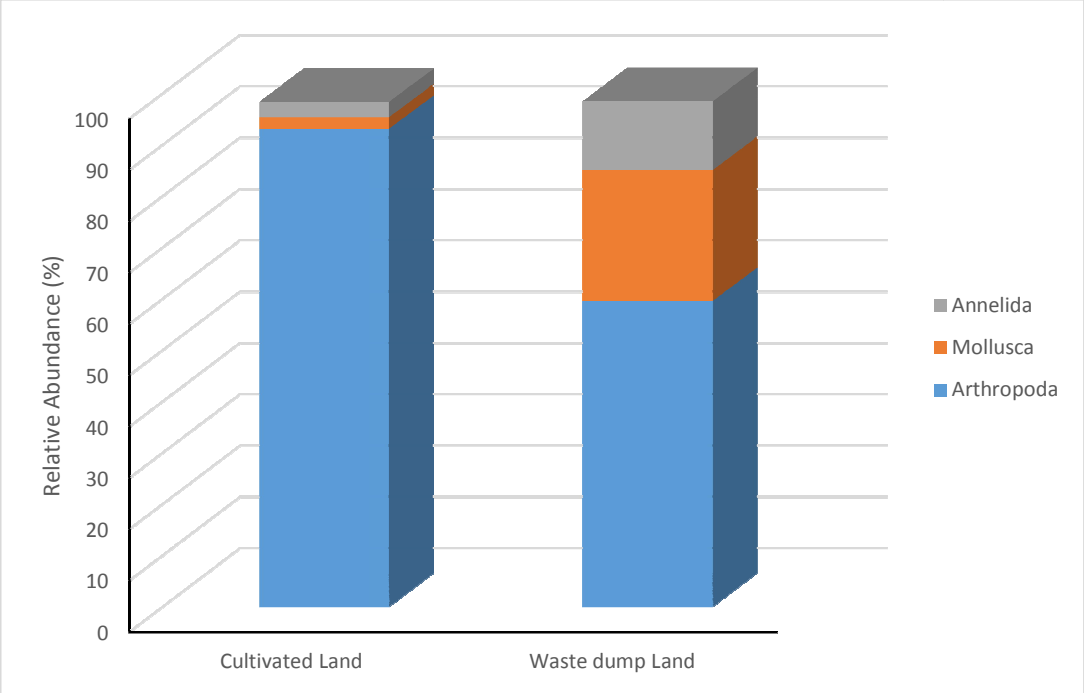

Fig. 2. Invertebrate Phyla abundance at the two different sites

Table 1. Diversity of soil macro invertebrates from the two contrasting soil habitat (waste dump and cultivated land)

Phylum	Class	Order	Scientific name	Common name	Waste dump site	Cultivated land
Arthropoda	Diplopoda	Julida	*Blaniulus guttulatus*	Millipede	++	++
		Polydesmida	*Asiomorpha coarctata*	Yellow foot Millipede	++	++
			Oxidus gracilis	Greenhouse Millipede	--	++
	Malacostraca	Isopoda	*Oniscidea* sp.	Woodlice	++	++
		Hymenoptera	*Plectroctena* sp.	Giant ant	_ _	++
	Insecta		*Formica rufa*	Ant	_ _	++
		Blattodea	*Crytocerus puntulatus*	Brown-hooded cockroach	_ _	++
			Pycnoscelus surinamensis	Surinamcockroach	_ _	++
			Termopsidae sp.	Rotten wood Termite	++	++
	Arachnida	Araneae	*Hogna* sp.	Wolf spider	++	++
Annelida	Clitellata	Haplotaxida	*Lumbricus terrestris*	Earthworm	++	++
Mollusca	Gastropoda	Sorbeoconcha	*Pachychilidae* sp.		++	++
		Systellommatophora	*Veronicella* sp.	Garden slug	++	++
Arthropoda	Insecta	Insect Larvae	Insect Larvae	Insect Larvae	++	++

Note: (++) encountered, (--) not encountered

Table 2. Relative abundance of the different soil macro invertebrate taxa from the two sampling sites

S/N	Order name	Scientific name	Common name	Abundance	
				Cultivated land no (%)	Waste dump site no (%)
1.	Julida	*Blaniulus guttulatus*	Millipede	73 (54.1)	26 (22.8)
2.	Polydesmida	*Oxidus gracilis*	Greenhouse millipede	1 (0.7)	-
3.	"	*Asiomorpha coarctata.*	Yellow foot millipede	15 (11.1)	4 (3.5)
4.	Isopoda	*Oniscidea* sp.	Woodlice	6 (4.4)	4 (3.5)
5.	Hymenoptera	*Plectroctena* sp	Giant ant	4 (3.0)	-
6.	"	*Formica rufa*	Ant	6 (4.4)	-
7.	Blattodea	*Crytocerus puntulatus*	Brown-hooded cockroach	6 (4.4)	-
8.	"	*Pycnoscelus surinamensis*	Surinam cockroach	3 (2.2)	-
9.	"	*Termopsidae* sp.	Rotten wood termite	3 (2.2)	2 (1.8)
10.	Araneae	*Hogna* sp.	Wolf spider	6 (4.4)	1 (0.8)
11.	Haplotaxida	*Lumbricus terrestris*	Earthworm	4 (3.0)	15 (13.4)
12.	Sorbeochocha	*Pachychilida* sp.		2 (1.5)	24 (21.1)
13.	Systellomatophora	*Veronicella* sp.	Garden slug	1 (0.74)	5 (4.4)
14.	Insect Larvae	Insect Larvae	Insect Larvae	3 (2.2)	31 (27.19)

3.4 Soil Macro-invertebrates' Diversity in the Two Study Sites

The soil macro-invertebrates species richness, diversity and evenness are presented in Table 4. A total of 135 and 114 soil macro invertebrate individuals were encountered in the cultivated farmland and waste dumpsite respectively.

4. DISCUSSION

Many soil invertebrate species are often sensitive to changes in their environmental conditions and they can be utilized as indicators of soil pollution or other anthropogenic disturbance such as agricultural practices (soil tilling, mulching, pesticides and herbicides application, bush burning etc.) as well as domestic sewage disposal [23]. Many other studies have shown that community structure of soil arthropods are also influenced by the availability of organic matter, substrate quality, concentration of macro and micronutrients, age and biodiversity of the habitat [24,25].

However, the result of the physico-chemical parameters shows soil pH of the waste dump site to be acidic, and that could explain the high abundance of unidentified insect larvae. This result disagreed with Oni et al. [26], who reported alkaline pH for contaminated dump site in Ibadan. Soil acidity, as reported by Madge and Sharma [27], has marked influence on the distribution of many kinds of soil organisms and only few organisms are found to survive and developed in acidic conditions such as the insect larvae. The alkaline pH of the cultivated farmland may possible be as a result of the fact that the farm operator had applied lime fertilizers in the course of the cultivation practices and this must have neutralized the activity of the soil.

There was no significant difference $p \leq 0.05$ in the mean values for the soil moisture content in the two sampling areas. The slight high mean value of the moisture content in the waste dump site may be as a result of moisture addition to the soil by leachate infiltration into the soil [26]. As reported by Jordan et al. [28], slight increase in the soil moisture content, allows for the abundance of soil macro-invertebrates such as the earthworm (*Lumbricus terrestris*). The soil temperature of the two sample sites were within range for tropical soil as similar result was reported by Desmond and Alex [29] in University of Ibadan Farmland.

In the present study, the difference in the abundance and diversity of soil invertebrates encountered in the two sampling sites could be attributed to land use pattern. Anikwe and Nwobodo [30] reported that human activities such as dumping of domestic wastes overtime in a particular area and cultivation involving the use of inorganic materials for farming will lead to changes in the soil physical properties. *Blaniulus guttulatus,* though encountered in both sampling

Table 3. The physico-chemical parameters of the two sampling sites (waste dump site and cultivated land)

Parameter	Waste dump site		Cultivated land	
	Range	Mean ± SD	Range	Mean ± SD
pH	4.02-7.34	4.96 ± 0.98^{a}	6.75-7.10	6.82 ± 0.16^{ab}
Temperature (°C)	32.30-35.00	33.7 ± 1.30^{ab}	30.00-32.00	30.92 ± 0.74^{a}
Moisture content (%)	4.50-15.60	8.07 ± 4.39^{a}	8.60-12.00	7.95 ± 4.20^{a}

$p \leq 0.05$ was not significant for each of the parameters for the two sampling sites

Table 4. Species diversity, evenness and richness of the soil macro invertebrates encountered in the two study sites (cultivated farmland and waste dumpsite)

	Cultivated farmland	Waste dumpsite	Total
Total	135	114	249
Species Richness	2.658	1.695	
Species Diversity (H^{l})	1.739	1.785	
Evenness	0.406	0.662	
Dominance - D	0.326	0.199	
Simpson 1-D	0.674	0.8	

sites were more in abundance in the cultivated land, than the waste dump site. This observation may be due to the availability of decomposable organic materials and this points to the fact that millipedes are typical floor dwellers, likes to dwell among leaf litter, dead wood, or soil, while they feed on decomposing vegetation, faeces, or organic matter [13,14].

Comparatively, the cultivated land has more abundance of Arthropods than the domestic waste dump site. Whereas, the dump site has more species diversity than the cultivated farm land. As reported by Santorufo et al. [16], highly polluted soils are composed of few species of macro invertebrate that are well adapted to extreme conditions while the moderately polluted soil has a community composition made of more homogenous and more tolerant species to fluctuating conditions.

The soil macro-invertebrates could be classified into functional groups based on their ecological niche (as grazers, shredders, gatherers, decomposer, and predators). Many of these soil dwelling macro-invertebrates would exploit the biotic and non-biotic components of their surrounding habitat to obtain food, development, reproduction and for their survival [31]. Members of Arthropoda included Predators (*Hogna* sp and *Formica rufa*), Shredder (*Termopsidae* sp.) and Decomposer (*Blaniulus guttulatus*), whereas members of Mollusca and Annelida were dominated by taxa such as *Pachychilidae* sp*, and Lumbricus terrestris* which are usually favoured by high soil organic content, moisture and other soil properties [15].

5. CONCLUSION

The difference in the abundance and diversity of soil invertebrates between the contrasting habitats could be attributed to land use pattern and soil quality and this have impacted on the soil biotic community structure. *Pachychilidae sp, and Lumbricus terrestris* shows positive response and preference to the domestic dump site while *Blaniulus guttulatus* (millipede) dominated the cultivated soil. This responses could be attributed to the nature of anthropogenic activities, decomposable organic, moisture and food availability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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