

EVALUATION ON ABUNDANCE AND DIVERSITY OF SOIL MACRO-INVERTEBRATES IN IDORO COMMUNITY, AKWA IBOM STATE, NIGERIA.

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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, Akwalbom State, Nigeria was investigated between September 2015 and February, 2016. Soil samples were randomly collected at near soil surface layer (10cm x 10cm) 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, 135 invertebrates were encountered, while 114 were encountered in the wastes dump site. 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 larvaewith (27.1%), Blaniulusguttulatus(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 wereBlaniulusguttulatus(millipede)(54.1%), followed by Asiomorphacoarctata(11.1%),Oniscidea sp., Formica rufa, Crytoceruspuntulatus, Hogna sp. with (4.4%) respectively, while the least were Veronicella sp. and Oxidusgracilis (0.7%) respectively. While in the waste dump site, the percentage abundance of macro invertebrates were Arthropod larvaewith (27.1%), Blaniulusguttulatus(22.8%) followed by Pachychilidae sp. (21.1%), while the least were Hogna sp. (Wolf spider) (0.7%). 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.

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Keywords: Macro-invertebrate, Waste dump, Diversity, Abundance.

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 (Ashford *et al.*, 2013).

Unfortunately, ~~the deterioration of soil quality~~, which often lead to decrease in ~~the abundance of~~ vegetation, ~~abundance in an area has~~ ~~serious grave~~ consequences on ~~this such~~ area, ~~such as its use for the and hence opening the area up for open waste dumping waste, a fact that has recently arouse public interest and this act has recently prompted public concern~~ (Alia *et al.*, 2013). 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 (Smith *et al.*, 1996; Papageorgiev, 2006; Shayloret *al.*, 2009). 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 (Adeola *et al.* ISWA, 2011). 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 (Castro *et al.*, 2010; Kardolet *al.*, 2007).

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There are various factors influencing the composition, relative abundances, and dynamics of soil fauna. These includes biotic interactions such as competition (Ferguson and Joly, 2002) and predation (Niemela *et al.* 1992; Oliver and Beattie, 1996; Lenoir *et al.* 2003); the presence or absence of organic matter (Bengtsson *et al.* 1998; Eaton *et al.*, 2004), physical features of the soil environment such as temperature, moisture, compaction (Bouwman and Arts, 2000; Larsen *et al.*, 2004), and acidity (Filser, 2002), as well as chemical features of soil (Larsen *et al.*, 2004; Moldenke and Thies, 1996).

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.*, (2014) 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 (Chauvat, 2007). 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 (Wiwatwitaya and Takeda, 2005; Lee *et al.*, 2009). Furthermore, human interference, such as open dumping of waste can cause drastic changes to soil invertebrate population (Folgarit, 1998). 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 habitat in Idoro community of Akwa Ibom State, Nigeria.

Materials and Methods

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 $5^{\circ}2'51''$ North and longitude $8^{\circ}2'41''$ 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 2500mm 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 (*Aspilaafricana*), shrubs (*Chromolaenaodorata*) and trees (*Mangifera indica*). Soils types found around the open dumpsite and fallowed farm are of loamy soil and sandy loamy respectively.

Sampling Sites

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

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 (10cm x 10cm) 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 (1970) ~~and Kaufman, (2005)~~. The numbers of each arthropod were counted and recorded.

Physico-chemical parameters of soils of both sites

~~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 department for analysis.~~ Soil temperature was determined *in situ* with the use of mercury in glass thermometer.

~~Soil pH was taken *in situ* using buffered electronic pH meter (Kent 7020), while soil moisture content was determined according to the method given by Oduet, al. (1986). It was analyzed based on the different between the soil weight on collection and dry weight after dried (Oni et. al., 2011)~~

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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.

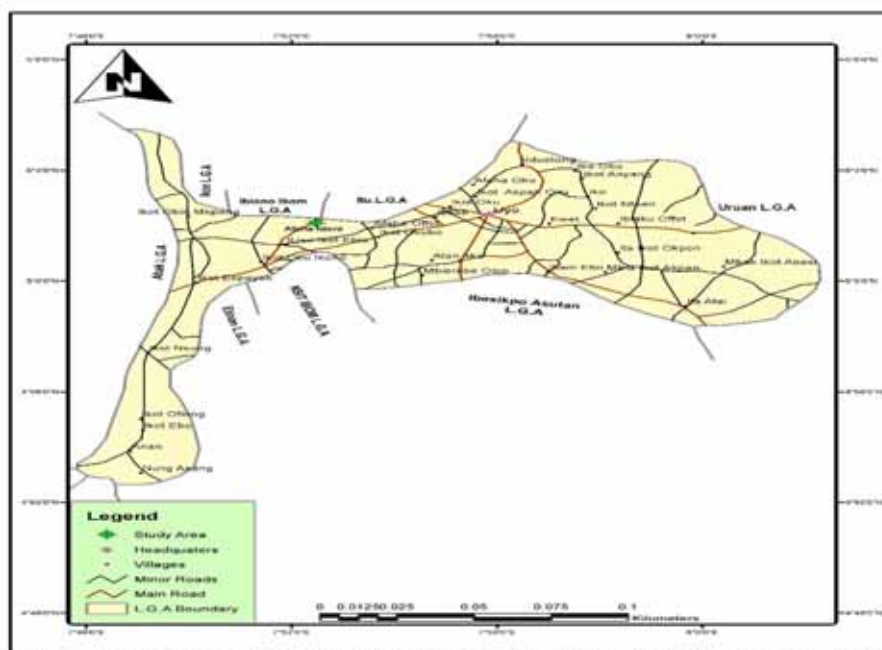


Figure 1: Map of Uyo ~~Local Government Area L.G.A.~~ of Akwa Ibom State showing selected study area (Afaha Odoro)

Results

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-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.

Table 1:Diversity of soil macro invertebrates from the two contrasting soil ~~h~~Habitat (waste dump and Farmland) ~~Cultivated L~~and)

Phylum	Class	Order	Scientific name	Common name	Waste dump Site	Cultivated land
Arthropoda	Diplopoda	Julida	<i>Blaniulusguttulatus</i>	Millipede	++ Sample	++ Sample
		Polydesmida	<i>Asiomorphacoarctata</i>	Yellow foot millipede	++ Sample	++ Sample
			<i>Oxidusgracilis</i>	Greenhouse millipede	Nil	++ Sample
	Malacostraca	Isopoda	<i>Oniscidea sp.</i>	Woodlice	++ Sample	++ Sample
	Insecta	Hymenoptera	<i>Plectroctenasp.</i>	Giant ant	Nil	++ Sample
			<i>Formica rufa</i>	Ant	Nil	++ Sample
		Blattodea	<i>Cryptocerspuntulatus</i>	Brown-hooded cockroach	Nil	++ Sample
			<i>Pycnoscelussurinamens</i>	Surinamcockroach	Nil	++ Sample
			<i>Termopsidae sp.</i>	Rotten wood termite	++ Sample	++ Sample
	Arachnida	Araneae	<i>Hogna sp.</i>	Wolf spider	++ Sample	++ Sample
Annelida	Clitellata	Haplotaxida	<i>Lumbricusterrestris</i>	Earthworm	++ Sample	++ Sample
Mollusca	Gastropoda	Sorbeoconcha	<i>Pachychilidaesp.</i>		++ Sample	++ Sample
		Systellommatophora	<i>Veronicella sp.</i>	Garden slug	++ Sample	++ Sample
Arthropoda	Insecta	<u>Insect LarvaeUnidentified</u>	<u>Insect Larvaeunidentified</u>	<u>Insect Larvae</u>	++ Sample	++ Sample

Note: ++ = encountered

-- = not encountered

Soil Macro Invertebrate Abundance

Therelative Abundance of soil macro invertebrate taxa recorded ~~from the contrasting soil habitat in Idoro community of Uyo Local Government Area~~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 ~~—(Table2)~~. In the cultivated farmland, the dominant taxa was *Blaniulusguttulatus*(millipede)(54.1%), followed by *Asiomorphacoarctata*(11.1%), *Oniscidea sp.*, *Formica rufa*, *Cryptocerspuntulatus*, *Hognasp.*with (4.4 %) respectively, while the least were *Veronicella sp.* and *Oxidusgracilis* (0.7%) respectively. Also in the waste dump site, the dominant taxa were ~~some unidentified~~ Arthropod larvaewith (27.1%), followed by *Blaniulusguttulatus*(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.

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 (%)	Domestic dump landWaste dump site No (%)
1.	Julida	<i>Blaniulusguttulatus</i>	Millipede	73 (54.1)	26 (22.8)
2.	Polydesmida	<i>Oxidusgracilis</i>	Greenhouse millipede	1 (0.7)	-
3.	"	<i>Asiomorphacoarctata.</i>	Yellow foot millipede	15 (11.1)	4 (3.5)
4.	Isopoda	<i>Oniscidea sp.</i>	Woodlice	6 (4.4)	4 (3.5)
5.	Hymenoptera	<i>Plectroctenasp</i>	Giant ant	4 (3.0)	-
6.	"	<i>Formica rufa</i>	Ant	6 (4.4)	-
7.	Blattodea	<i>Cryptocerpuntulatus</i>	Brown-hooded cockroach	6 (4.4)	-
8.	"	<i>Pycnoscelussurinamensis</i>	Surinam cockroach	3 (2.2)	-
9.	"	<i>Termopsidae sp.</i>	Rotten wood termite	3 (2.2)	2 (1.8)
10.	Araneae	<i>Hogna sp.</i>	Wolf spider	6 (4.4)	1 (0.8)
11.	Haplotaaxida	<i>Lumbricusterrestris</i>	Earthworm	4 (3.0)	15 (13.4)
12.	Sorbeochocha	<i>Pachychilida sp.</i>		2 (1.5)	24 (21.1)
13.	Systellomatophora	<i>Veronicella sp.</i>	Garden slug	1 (0.74)	5 (4.4)
14.	<u>Insect Larvacunidentified</u>	<u>Insect Larvacunidentified</u>	Insect Larvae	3 (2.2)	31 (27.19)

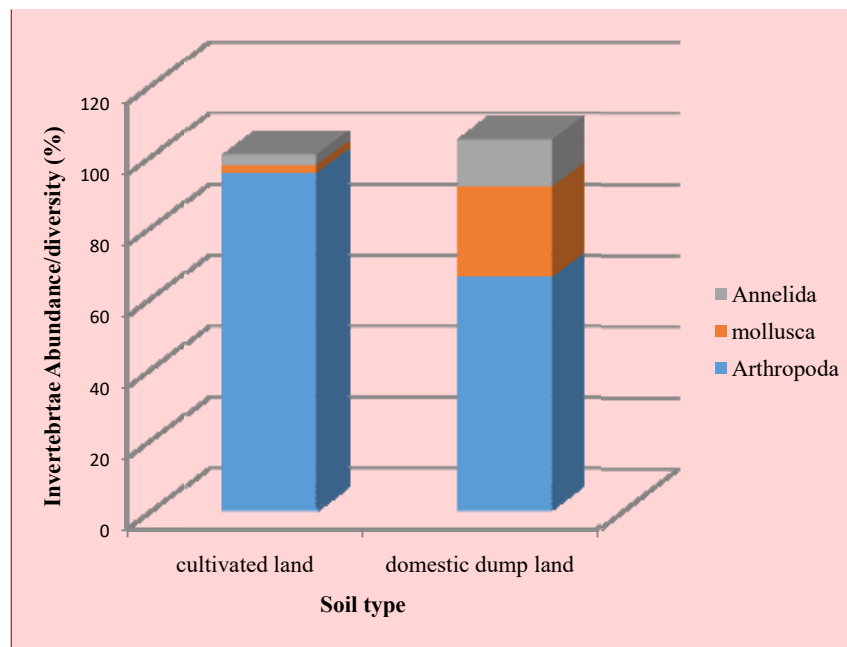


Figure 2: Invertebrate Phyla abundance and diversity at the two different sites

Physico-chemical parameters of the soil in the cultivated land and waste dump site.

The soil ph in the waste dump site ranged from 4.02-7.34, and mean value of 4.96 (Table 3).

Table 3: The physico-chemical parameters of the two sampling sites (Waste dump site and Cultivated Land)

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

Soil macro-invertebrates' diversity in the two study sites

The soil macro-invertebrates species richness, diversity and evenness are presented in Table 43. The total of

135 and 114 soil macro invertebrate individuals were encountered in the cultivated farmland and domestic waste dumpsite respectively.

Table 43: Species diversity, evenness and richness of the soil macro invertebrates encountered in the two study sites (Cultivated farmland and Waste dumpsite)

	Cultivated Farmland	Domestic waste dumpsite	Total
Total	135	114	249
Species Richness	2.658	1.695	
Species Diversity (H')	1.739	1.785	
Evenness	0.406	0.662	
Dominance - D	0.326	0.199	
Simpson 1-D	0.674	0.8	

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 (Esenowoet *al.*, 2014). 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 (Zhenget *al.*, 1997; Lorangeret *al.*, 1998). However, from the result obtained on physico-chemical parameters of the two sample areas, it could be reduced that the soil of the waste dump site is acidic, and that could explain why it has more abundance of unidentified insect larvae. Also the moisture content is high, which allows for the accumulation of soil macroinvertebrates such as the earthworm. There was no significant difference between the physico-chemical parameters of the two sampling sites. But by implication, values for the parameters indicate that the soil of the waste dump site is polluted.

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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. In the cultivated farmland, the dominant taxa were *Blaniulusguttulatus* (millipede) followed by *Asiomorphacoarctata*, followed by *Oniscidea sp.*, *Formica rufa*, *Cryptocerspuntulatus*, *Hogna sp.*, while the least were *Veronicella sp.* and *Oxidusgracilis*. Also in the waste dump site, the dominant taxa were unidentified Arthropod larvae, followed by *Blaniulusguttulatus*, *Pachychilidae sp.* and *Hogna sp.* (Wolf spider). Taxa such as *Plectroctena sp.*, *Formica rufa*, *Cryptocerspuntulatus* and *Oxidusgracilis* were totally absent in the waste dump site.

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Blaniulusguttulatus, though encountered in both sampling 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 (Bouwman and Arts, 2000; Larsen *et al.*, 2004).

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 Santorufoet *al.* (2014), highly polluted soils are composed of few species of macro invertebrate that are well adapted to extreme conditions while the moderately polluted soil have 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 (Wallace and Webster, 1996). Members of Arthropoda included Predators (*Hognasp* and *Formica rufa*), Shredder (*Termopsidae sp.*) and Decomposer (*Blaniulusguttulatus*), whereas members of Mollusca and Annelida were dominated by taxa such as *Pachychilidae sp.* and *Lumbricusterrestris* which are usually favoured by high soil organic content, moisture, (Filser, 2002) and other soil properties (Filser, 2002).

(Moldenke and Thies, 1996).

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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 which have impacted on the soil biotic community structure. *Pachychilidae sp.* and *Lumbricusterrestris* shows positive

response and preference to the domestic dump site while *Blaniulusguttulatus*(millipede) dominated the cultivated soil. This responses could be attributed to the nature of anthropogenic activities, decomposable organic, moisture and food availability (Larsen *et al.* 2004).

~~Further studies are recommended to identify the best possible combination of land use practices to allow optimal sustainability of macro invertebrate community. Nevertheless, the traditional dumpsite should be evacuated, given the danger it poses to the human population settling around the environment. Besides the high abundance of the unidentified larvae of arthropods which may be vectors to some health threatening disease causing agents, hence government and the necessary authorities should act swiftly.~~

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