Effects of soil properties on arthropod biodiversity in dumpsites in Ibadan, Oyo state, Nigeria

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Abstract: The impact of soil properties, temperature and relative humidity on arthropod species composition, abundance and diversity was investigated in Apete and Aba-eku dumpsites and in a control site in Ibadan, Oyo state, Nigeria. Ten 250g size pitfalls one third filled with 5% formalin were placed in each point in order to trap and preserve the arthropods. The arthropods trapped in each pitfall were preserved in separate specimen bottle containing 70% ethanol before identification. A total of 20 soil samples were collected from the sites using Auger and analyzed for particle size distribution, bulk density, moisture content, water holding capacity, porosity, organic matter, pH, total nitrogen, available phosphorus, potassium, calcium in (mol/kg^{-1}) and available iron and zinc in mg/kg^{-1}. Analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) were conducted to compare the mean values of the soil properties and arthropods abundance. A total of 4,763 arthropods were recorded belonging to 17 orders. Twenty six families of arthropods containing 31 species were recorded in Aba-Eku, while 24 families with 24 species were encountered in Apete and 19 families with 21 species were recorded for the control site. Soil parameters examined showed significant difference ($p>0.05$) across the three sites. The high percentage abundance of Dipterans (*Musca domestica*) and heavy metal recorded, Zinc and Iron indicates that the environments were polluted. Pearson correlation coefficient (r) showed negative correlation for the relative humidity and temperature to the arthropods abundance. The distinct taxa found in Apete and Aba-eku suggest that the organic input from residential areas around the dump sites favoured their abundance.
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Introduction

Soil contamination or soil pollution is caused by xenobiotic (human-made) chemicals or other alterations in the natural soil environment. This type of contamination typically arises from application of pesticides, leaching of wastes from landfills or direct discharge of industrial wastes such as petroleum, hydrocarbons, solvents, lead and other heavy metals to the soil. Health consequences, from exposure to soil contamination vary greatly depending on pollutants type and pathway of attack. Chronic exposure to chromium, lead, and other metals can be carcinogenic, and can cause congenital disorders to both human and other living organisms of which arthropod is one (Snyder, 2005).

Asides this, soil contaminants may have significant deleterious consequences on ecosystem. There are radical changes in soil chemistry due to the presence of many hazardous chemicals even at low concentration of the contaminant species (Snyder, 2005). These changes can manifest in the alteration of metabolism of endemic micro-organisms and arthropods resident in a given soil environment (Snyder, 2005). The result can be virtual eradication of some members of the primary food chain, which in turn could have major consequences for predator or consumer species (Snyder, 2005). A well-known effect is the concentration of persistent DDT (Dichloro Diphenyl Trichloroethane) materials for consumers, which leads to weakening of egg shells, increased chick mortality in poultry and potential extinction of some species (Snyder, 2005).

Landfills or open dumps are designated land areas provided by the authority for disposal solid waste generated and collected from various refuse collection points (Muraina, 2001). The offgassing of methane generated by decaying organic waste can be a danger to the fauna of an area such as arthropods. Bioaccumulation of toxins and heavy metals which may occur on the dumpsites can also reduce the number of arthropods present there (Ogbonna *et al.,* 2002). Anthropogenic effect on the abiotic environment in which soil is one are likely to influence the distribution of arthropods, through changes in temperature (Convey *et al.,* 2002).

Arthropods are joint legged animals with segmented bodies and exoskeleton. This diverse group comprises of the insects, arachnids (spiders, mites and scorpions), millipedes and centipedes. They are biologically successful and occupies both terrestrial and aquatic ecosystem. There are far more species of arthropods than all other higher animal put together (Cleveland *et-al*., 1979). Traditionally, forest entomologists have viewed arthropods in term of their negative impact on timber production nevertheless, less attention have been given to the crucial roles they play in functioning of the ecosystem (Samuel, 2000; Thompson, 1994).

The endless and usual usefulness of arthropods to man and its environment are well enumerated by work form John (1975) and Samuel (2000), Charles (1960), Kendall (2009), Popoola, 1991; Thompson, 1994).

Materials And Methods

The study sites were Aforuta village, Amuloko area and Apete; all in Ibadan, Oyo state, Nigeria, located on latitude 7^o 19' to 32^o 27' North and longitude 3^o 59' to 0$^{o.}$ 47' East and at an altitude 197 metres (Aluko *et al.*, 2003). On latitude 7^o 27' and 45^o 20' North and longitude 3^o 50' and 55^o 32' East respectively. The control site was in the Zoology Department, University of Ibadan, Ibadan which is on latitude 7^o 26' and 36^o 59' North and Longitude 3^o 53' and 44^o 31' East with an altitude of about 240 metres. The site was free of dump with a natural forest environment for organisms to dwell.

Pitfalls, made of tin of 250g size were used for the collection of arthropods at different points. The collected arthropods were preserved in 5% formalin in a specimen bottles until they were analysed. Auger was used for collection of soil samples and stored in sterilized labeled nylon.

Sampling Procedure

Pitfalls numbering 10 filled with about one third volume of 5% formalin were placed in each points at different location in order to trap and preserve the arthropod collected from the sites which give an adequate representation of the arthropods. Each pitfall was covered with rectangular (12cm x 6 cm metal plate) lid which was lifted above the pit to allow easy entrance of crawling arthropods.

Collection and analysis of soil samples

Soil samples were collected using the auger, at 6cm depth. A total of 20 soil samples were collected for a period of 6 month that spread through the rainy and dry season. The soil samples were taken to the Department of Agronomy University of Ibadan, Ibadan for analysis. Soil properties analysed were; particles size distribution, bulky density, moisture content, water holding capacity, porosity organic matter, pH, Total Nitrogen, available phosphorus, potassium and calcium in (mol/kg-1) and available iron.

Statistical analysis

Data collected were analysed using Analysis of Variance (ANOVA) to test for statistical difference between the means of the arthropod order collected from the three sampled sites. The Duncan's Multiple Range Test (DMRT) was used for multiple comparisons of the means of the soil properties and the arthropod order so as to determine similarities of the sampling sites. Weather parameters such as relative humidity and temperature were determined by Pearson Correlation Coefficient (r) in relation to arthropod abundance.

Results

Sixteen orders of arthropods containing 186 species were recorded from the study site. The Hymenoptera and Diptera had the highest occurrence of 39.6% and 31.0% respectively (Table 1). In Apete, nine orders with 156 species were recorded with the order Coleoptera being the most abundant (44.8%), followed by the order Diptera (38.7%), order Hymenoptera (6.5%), and order Dictyoptera (5.9%) (Fig.2 and 3). Eleven orders were recorded in the control site, of which the Hymenoptera was the most abundant (40.3%) followed by the Dermaptera (31.0%), Hemiptera (24.0 %), Orthoptera (19.1%) and Diptera (6.9%) (Fig.3 and 4) in descending order of percentage.

Soil parameters analysed from the three sampling sites were shown in table 2. Sand and silt collected from the three sites showed significant differences. However, clay, moisture content, organic matters and nitrogen were not significantly different across the sites. There were significant differences in water holding capacity, bulk density and porosity in samples from Apete compared with other two sites, while pH, phosphorus, potassium, calcium, magnesium iron were significantly different ($p<0.05$) in control site compared with the two dumpsites.

Relative humidity correlated negatively with sand, moisture content, and water holding capacity, bulk density, organic matter, calcium and magnesium. Temperature also correlated negatively with organic matter, pH, calcium, silt, clay, moisture contents, water holding capacity bulk density iron and zinc. Temperature has a direct positive correlation with sand, porosity, phosphorus, nitrogen, potassium and magnesium (Table 3). Pearson's correlation coefficient (r) relationship between weather data and arthropod abundance showed that relative humidity and Temperature had an inverse relationship with arthropod abundance, species richness and evenness of arthropods collected in the three sites (Table 4).

Table 1: Summary of mean, sum total, percentage of total sum and number of arthropod collected at Aba-Eku land fill

ORDER	MEAN	SUM	TOTAL %	N
Araneae	0.85	41	4.2%	48
Coleoptera	3.77	113	11.6%	30
Dermaptera	0.33	2	0.2%	6
Dictyoptera	9.17	55	5.7%	6
Diptera	25.08	301	31.0%	12
Hemiptera	0.50	3	0.3%	6
Hymenoptera	21.33	384	39.6%	18
Isopoda	0.33	2	0.2%	6
Ixodida	2.00	12	1.2%	6
Lepidoptera	4.00	24	2.5%	6
Orthoptera	2.00	24	2.5%	12
Polydesmida	0.17	1	0.1%	6
Scolopendromorpha	0.17	1	0.1%	6
Siphunculata	0.17	1	0.1%	6
Spirobolida	0.33	2	0.2%	6
Symphypleona	0.67	4	0.4%	6
TOTAL	70.87	970	100.0%	186

Table 2: Summary of Analysis of variance (ANOVA) for soil samples physico-chemical parameters collected at the three sites

Soil Sample	**Soil sample collection sites**		
	Apete	**Aba-Eku**	**Control site**
Sand	55.760*	58.655*	71.140*
Silt	27.650*	23.388*	11.200*
Clay	27.650	17.965	16.590
Moisture Content	0.3470	0.3471	0.3476
Water Holding Capacity	0.3906*	0.4165	0.4115
Bulky Density	1.130*	1.202	1.184
Porosity	57.330*	54.660	55.320
Organic Matter	33.501	28.672	30.400
pH	7.093	7.070	6.485*
KCl	5.281	5.269	5.035*
P	33.48	37.84	21.20*
N	5.225	4.643	3.050
K	4.744	4.139	2.595*
Ca	3.149	3.505	3.969*
Mg	3.459	3.038	3.040*
Fe	173.52	189.43	60.11*
Zn	151.09	216.25	50.32*

***Significant Relationship at $p < 0.05$**

Table 3: Pearson correlation coefficient (r) values between soil sample parameters and weather data (relative humidity and temperature) in the three sites

Phisico-chemicaproperties	Relative Humidity	Temperature
Sand	-0.17268	0.07414*
Silt	0.15073*	-0.04666
Clay	0.00405*	-0.05439
Moisture Content	-0.06825	0.06870
Water Holding Capacity	-0.06779	-0.13255
Bulky Density	-0.01246	-0.10724
Porosity	-0.014*	0.10471*
Organic Matter	-0.12504	-0.09252
P_H	0.07567*	-0.07572
KCl	0.23744*	0.07565*
P	0.32339*	0.18111*
N	0.22746*	0.17275*
K	0.04733*	0.01552*
Ca	-0.03512	-0.05461
Mg	-0.06100	0.12936*
Fe	0.15756*	-0.06793
Zn	0.14350*	-0.10322

*** Significant Relationship at < 0.05**

Table 4: Pearson correlation coefficient (r) between the arthropod abundance, relative humidity and temperature of the three sites

	RELATIVE HUMIDITY	TEMPERATURE	ABUNDANCE
Relative Humidity	1,00000	-0.51130	-0.17532
Temperatures	-0.51130	1.00000	-0.07673
Abundance	-0.17532	-0.07673	1.00000

Discussion

The investigation revealed that landfills have positive effects on the abundance and diversity of arthropods, which may be as a result of moderate mean temperature between (27-28) ^{o} C across the experimental and control sites. Samuel (2000) reported a decrease in Orders of arthropods when temperature is extremely high. The species number was recorded in Aba Eku compare to in Apete and the control sites without any significant difference may be due to the adaptation of arthropods to the *dumpsite*s, despite their being polluted. The high pH value of the dumpsites may be as a result of the ash generated from open burning of the waste. Annon (2004) had reported that highest pH ^{in} dumpsites is as a result of open burning and this usually favours plants and animals. However, Pidwarny (2006) showed that when pH of the soil is less than 5.5, such soils easily leach their nutrients which become soluble for absorption by plants and animals hence increasing their abundance. The experimental and control sites showed significant differences in the sand content of the soil samples. Aba-Eku (18%) and Apete (22%) were significantly lower compared to the control site (30%), yet there was no differences in arthropod abundance of the three sites. Nevertheless there was no significant differences in the clay contents between the experimental dumpsites and the control which may have accounted for the no significant differences in the abundance of arthropods collected from the three sites. Duncan's multiple range test analysis showed no significant differences in moisture content of the experimental sites and control site ($p > 0.05$).This may have contributed to the insignificant differences in the arthropods abundance in the three sites because the nutrient availability of the soil is controlled by moisture content. This observation was in accordance with the findings of Sera (2001) and Alteiri (1994), they reported that insects (arthropods) growth and development are often governed by temperature and moisture content.

The insignificant differences in the values of water holding capacity obtained within the experimental and the control sites confirmed insignificant differences in the abundance of arthropods orders. This observation contradicts

Zvereva *et al.,* (2009) who reported that abundance of terrestrial arthropods near point polluters decreased in general and this decrease resulted from strong adverse effects of pollutants on soil arthropods, especially decomposers and predators.

There were significant differences in bulk density and porosity across the three sites but lowest value of bulk density was recorded in Apete which could be responsible for the abundance of arthropods in the site. This result agrees with James (2005) who reported that low bulk density usually brings about highest level of soil organic matter content, hence low bulk density represents condition that favoured the abundance of soil arthropods. Insignificant differences shown in the values of Nitrogen and organic matter content across the sites may be responsible for the indifference in abundance of the arthropods across the sites because the soil parameters are needed for growth and development of organisms (Alteiri, 1994).The three sites showed significant differences ($p<0.05$) in Magnesium and Potassium contents which are necessary nutrients in the soil highest percentage values were recorded in control site. The experimental and control sites showed significant differences ($p<0.05$) in Iron and Zinc contents of the soil, low level of Zinc and Iron in control site indicates that it was not polluted but higher percentages recorded in the two dumpsites confirmed that they were polluted. This was in line with Oshode *et al.,* (2008) who reported highest values of heavy metals like Lead, Iron, Zinc, Calcium, and Manganese in Aba- Eku dumpsite. Ogbonna (2002) reported that bioaccumulation of toxins and heavy metals on the landfills or dumpsites can bring about reduction of organisms that are there present. Results of this research is in contrary to the above report because higher abundance of arthropods were recorded in the dumpsites compared to unpolluted (control site).The month with highest relative humidity recorded the highest number of arthropods. Moreover, temperature ranges 27-28^{o}C recorded across the sites was moderate for survival of arthropods which led to their abundance. As observed and reported by Sera (2001), microorganism functioning in the soil are very active at temperature range between 27-32^{o}c. Temperature and relative humidity have effect on the abundance of arthropods. The highest percentage of Dipterans especially *Musca domestica* recorded in Apete and Aba-eku dumpsites showed that dumpsites support their breeding. Dave *et al.,* (2005) had reported that Calyptrate flies notably *Musca domestica* has rising population which are often associated with domestic waste disposal facilities such as dumpsite where, the accumulating organic matter provides suitable breeding conditions for a range of species. The highest abundance of arthropods was recorded in Apete, followed by Aba-Eku which showed that the sites were very rich with high diverse species compared to the control site. This may be due to the fact that the dumpsites contains organic materials being deposited from residential areas around the dumpsites and abundance of nutrient availability for their breeding. It may be concluded that some dumpsite soil properties may be have effects on the abundance of arthropods, with the exception of higher variation in the Zinc and Iron contents that confirmed pollution. Furthermore, higher percentage occurrence of dipterans in the dumpsites indicates high level of pollution of the sites, especially Apete dumpsite. And this has implication on the health of people living very near to the dumpsites because dipterans are vectors for diseases such as yellow fever, malaria, cholera and typhoid fever.

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