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**Research article**

# Effect of oil spillage on abundance and diversity of soil mesofauna in Bodo city, Niger Delta Nigeria

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**Abstract:** The abundance and species diversity of mesofauna were surveyed in the unpolluted site, remediated site and crude oil polluted sites to examine the effect of crude oil on the abundance and diversity of mesofauna. The samples were collected on a line transect. Soil samples were collected and taken to the laboratory to isolate and identify mesofauna found in the soil samples. The pH, moisture content and moisture content of the soil samples were also obtained, where the unpolluted site has the highest pH followed by remediated site while the crude oil polluted site recorded the least pH. During the research work 37 individuals of mesofauna were encountered (distributed in 15 species) in the entire studied sites. Mesofauna abundance was highest in the unpolluted site (31 individuals) followed by the remediated site (4) while crude oil polluted site recorded the least abundance (2 individuals). Highest species diversity of mesofauna was also recorded in the unpolluted site (11). The results further explained that the effect of crude oil is significant ($P \geq 0.05$) on the abundance of mesofauna). The relationship between pH and mesofauna abundance and diversity showed that there were no significant differences ($P<0.05$). It was further observed that the pH of the unpolluted site with the mean value of 6.79 is higher than those of remediated (6.33) and crude oil polluted site (6.12). This work showed that abundance and species diversity of mesofauna in the study habitats were significantly different. Soil moisture content of the polluted site (32.29%) is higher than those of remediated (20.17%) and unpolluted site (20.32%). Soil temperature in the remediated site is the highest value (31.03°C) followed by the unpolluted site (29.14°C) while the crude oil affected site recorded the least temperature value (23.11°C).

**Keywords:** Hydrocarbon - Pollution - Contamination - Ecosystem.

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## INTRODUCTION

Crude oil, a complex mixture of hydrocarbon, liquid in their natural state is classified into aliphatic, alicyclic and aromatic compounds (Colombe *et al*. 2005). Most of these components are known to be toxic in nature to different biomass (Walker & Colwell 2000), and this has raised considerable concern on the subject of crude oil pollution especially on agricultural land. Though oil spillage is a widespread phenomenon, it is comparatively more frequent in the developing countries than in the technologically developed nations. According to Chindah & Braide (2000), over 6000 spills had been recorded in the 40 years of oil exploitation in Nigeria, with an average of 150 spills per annum. In the period 1976–1996, 647 incidents occurred resulting in the spillage of 2,369,407.04 barrels of crude oil. With only 549,060.38 barrels recovered, 1,820,410.50 barrels of oil were lost to the ecosystem. Oil spillage has been known to exhibit various deleterious effects on both plants and microorganisms. Crude oil spillage on soil generally retard plant growth to a large extent (Lundberg *et al*. 2003, Ekpo & Nwaankpa 2005), reduces aeration by blocking air spaces between soil particles hence create an anaerobic condition (Okiwelu 2011). Oil spillage is known to be a major environmental problem in Nigeria, most especially in the Niger Delta. It is reported that oil spillage has caused a constant threat to farmlands, crop plants and forest tree species by being deadly to plant roots through their interaction with soil fauna hence, the roots die due to a lack of oxygen (Ogri 2001, Agbogidi 2003). It destroys soil fertility, causes alterations in soil


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physicochemical and microbiological properties, thereby having detrimental effects on the terrestrial and aquatic ecosystems. The initial reaction of the microorganisms as it gets in contact with oil in the soil is a reduction of activity due to reduced air availability. This has been noted to arise from leaving the resistant and adaptive microbial strains to proliferate (di Leonardo 2007). This ability, however, depends on a number of factors which include temperature, the viscosity of the oil, and coarseness of the soil and the level of oil in the environment. Soil mesofauna exert strong regulatory control over the soil food web and have substantial effects on important soil characteristics, including the distribution of soil particles, the soils water-holding capacity and water infiltration rate, the availability of organic compounds and mineralization, immobilization, the availability of N and other nutrients, the transport of compounds. Species that feed on decaying plant material open drainage and aeration channels in the soil by removing roots. Faecal material of soil mesofauna remains in channels which can be broken down by smaller animals. The aims and objectives of this study were to examine the effect of crude oil on the diversity and abundance of mesofauna and to determine the relationship between pH, temperature, moisture content and diversity and abundance of mesofauna in Bodo city, Niger Delta.

## MATERIALS AND METHODS

*Study area*

The study area is located in Rivers state on the coast of the Gulf of Guinea, east of the city of Port Harcourt (Fig. 1). It extends across the local government's areas (Khana, Ghokana, Eleme and Tae). This study was carried out at crude oil spill site, remediated site and an unpolluted site *i.e.* Bodo city located within Latitude 4° 37′ North of the equator and longitude 7° 16′ east of the meridian.

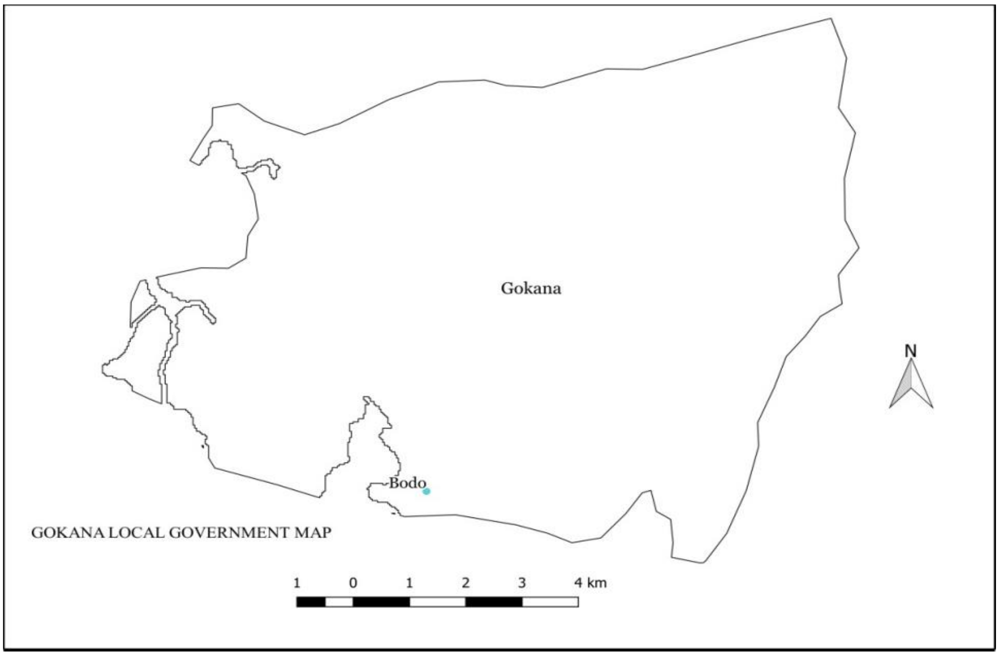


**Figure 1.** Gokana Local Government Map showing Bodo City Niger Delta, Rivers State, Nigeria

*Data collection*

In Bodo community, samples were collected on oil spill polluted site, Remediated site and unpolluted site. Each soil sample unit was carefully collected along a line transect, in each of the site, soil samples were collected and bulked for subsequent laboratory analysis. Each soil sample unit was carefully pushed into a polythene bag which was securely tied at the mouth to prevent desiccation and spilling of soil before reaching the laboratory. The soils samples were immediately brought to the laboratory where the mesofauna present were isolated and identified using the floatation method.

On each sample, pH of the soil was determined in water (a soil/water ratio of 2:1) using a pH meter with glass electrode from each of the six sampling points in each plot. Soil samples were also collected from each sampling point for determination of pH and mesofauna identification. All the data collected were subjected to analysis of variance test (ANOVA) at 5% level of probability to test for significance among the treatments.

*Mesofauna isolation and identification*

Extraction of soil mesofauna was done using Berlese funnel extraction technique (Berlese 1905). Samples were removed from bag and placed in Berlese extractor. The dirt were placed in an extractor, clouds were broken up so that the arthropods can emigrate properly from a sample of even consistency. Earthworms were removed to a separate specimen vial (worm skin mucus is terribly sticky and if the worms were not removed all of the little critters would get stuck on the worm skin). The clods were broken apart without squashing the soil. 2. 25 watt light bulb was turn on; extraction was carried out for 48 h. A jar was placed containing a small amount of antifreeze under the Berlese funnel. Antifreeze has the advantage that it does not evaporate. The extracted samples (critters, dirt, and alcohol or glycol) were placed into one (or more as needed) labeled small vials. Few drops of cooking oil were added to top of vial, enough to form a thin meniscus. Cap was replaced; the mixture was also agitated to force the oil into micro drops throughout the solution. The oil was slowly allowed to (10 min) rise to the top carrying nearly all the arthropods with it. Critters were pipetted from the oil layer into a Petri plate; the excess oil and glycol from the Petri plate were removed. The critters were sorted into piles of similar species. Identification was then made. Species were counted and data was put into spreadsheet.

*Soil pH determination*

The soil pH was determined with the aid of glass electrode pH meter in the soil solution 0.01 mol $L^{-1}$ chlorine. 10 grams of sieved soil samples was weighed into a container and 20 ml of distil water was added and stirred together. After stirring the samples the samples were left for one hour after which the samples were measured with pH meter and their corresponding values were carefully recorded.

## RESULTS

**Table 1**. Effect of oil spillage on the abundance of soil mesofauna in Bodo City, Niger Delta, Nigeria.

| S.N. | Species | Unpolluted soil (A) | Remediated soil (B) | Polluted soil (C) | Total |
|---|---|---|---|---|---|
| 1 | *Octolasion lacteum* | 2 | 0 | 0 | 2 |
| 2 | *Porcellio scaber* | 4 | 0 | 0 | 4 |
| 3 | *Allolobophora trapezoides* | 5 | 0 | 0 | 5 |
| 4 | *Aporrectade trapezoide* | 2 | 0 | 0 | 2 |
| 5 | *Ancistrotermis cavithorax* | 3 | 0 | 0 | 3 |
| 6 | *Allolobophora calignosa* | 4 | 0 | 0 | 4 |
| 7 | *Eudrilus eugeniae* | 1 | 0 | 0 | 1 |
| 8 | *Tucbergia granulata* | 4 | 0 | 0 | 4 |
| 9 | *Colpoda steinii* | 3 | 1 | 0 | 4 |
| 10 | *Centipede* | 1 | 0 | 0 | 1 |
| 11 | *Dorylus fimbriatus* | 2 | 1 | 0 | 3 |
| 12 | *Oniscus asellus* | 0 | 1 | 0 | 1 |
| 13 | *Folsomia candida* | 0 | 0 | 1 | 1 |
| 14 | *Isopod* | 0 | 0 | 1 | 1 |
| 15 | *Spider* | 0 | 1 | 0 | 1 |
| | **Total** | **31** | **4** | **2** | **37** |

Thirty-seven (37) individuals of mesofauna were encountered in all the study areas (Table 1). The Unpolluted site accounts for the highest abundance of mesofauna thirty-one (31) individuals in all, followed by the remediated site with four (4) individuals while the crude oil polluted site has the least abundance of two (2) individuals. The result also shows that *Allolobophora trapezoids* was found to have the highest number of individual mesofauna five (5) while *Eudrilus eugeniae*, *Oniscus asellus*, *Folsomia candida*, *Centipede*, *Isopod* and *Spider* were seen to have the least number of individuals (1 each) in their respective habitats. The result of the effect of oil spillage on mesofauna diversity is also presented in table 2. Fifteen (15) species were encountered in all the study area, unpolluted area has the highest diversity of 11 species followed by the remediated area four (4), while the least diversity was found in the crude oil polluted soil. Most of the species encountered in the study area are, *Allolobophora caliginosa*, *Tucbergia granulate*, *Dorylus fimbriata*, *Allolobophora trapezoids*, *Aporrectodae trapezoids*, *Colpoda stenii*, *Octolasion lacteum*, *Porcellio scaber*, *Folsmia candida and Isopod* were found only in the crude oil polluted soil while species like, *Oniscus asellus* and *spider* were found in the remediated soil.

**Table 2**. Effect of oil spillage on the diversity of soil mesofauna in Bodo City, Niger Delta, Nigeria.

| S.N. | Species | Unpolluted soil (A) | Remediated soil (B) | Polluted soil (C) |
|---|---|---|---|---|
| 1 | *Octolasion lacteum* | * | - | - |
| 2 | *Porcellio scaber* | * | - | - |
| 3 | *Allolobophora trapezoides* | * | - | - |
| 4 | *Aporrectade trapezoide* | * | - | - |
| 5 | *Ancistrotermis cavithorax* | * | - | - |

| | | | | |
|---|---|---|---|---|
| 6 | *Allolobophora calignosa* | * | - | - |
| 7 | *Eudrilus eugeniae* | * | - | - |
| 8 | *Tucbergia granulata* | * | - | - |
| 9 | *Colpoda steinii* | * | * | - |
| 10 | *Centipede* | * | - | - |
| 11 | *Dorylus fimbriatus* | * | * | - |
| 12 | *Oniscus asellus* | - | * | - |
| 13 | *Folsomia candida* | - | - | * |
| 14 | *Isopod* | - | - | * |
| 15 | *Spider* | - | * | - |
| | **Total** | **11** | **4** | **2** |

**Note:** * Represents the presence of mesofauna; - Represents the absence of mesofauna.

The effect of crude oil has been shown significant (P≥0.05) on the abundance of mesofauna in ANOVA (Table 3). Since F-cal is greater F-tab, then there is a significant difference at 0.05 levels.

**Table 3.** Effect of the crude oil on the abundance of mesofauna in Bodo city, Niger Delta, Nigeria.

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Treatment | 2.396085 | 2 | 1.198043 | 8.448049 | 0.017996 | 5.143253 |
| Error | 0.850878 | 6 | 0.141813 | | | |
| **Total** | **3.246963** | **8** | | | | |

There is significant (p≤0.05) difference in the mesofauna abundance of the three habitats based on the observed mean difference (Table 4). It also shows that there is significant (p≤0.05) difference between unpolluted soil, remediated soil and crude oil affected soils.

**Table 4.** Effect of crude oil on mesofauna abundance in Bodo city, Niger Delta, Nigeria.

| Treatment | Means($10^3$) |
|---|---|
| Unpolluted soil (A) | 1.2307[b] |
| Remediated soil (B) | 0.3662[a] |
| Crude oil polluted soil (C) | 0.0001[a] |

**Note:** Mean with the same alphabets are not significantly different at p≥0.05

The relationship between pH and mesofauna abundance (Y= -281.532X + 45.8131) is not significant (P≥0.05) (Table 5). The rate at which pH affects the abundance of mesofauna in the habitats is very high (R= 0.9712). The result further shows that a change in pH will cause as high as 94.41% change in mesofauna abundance.

**Table 5.** Regression relationships of physicochemical parameters on the abundance and distribution of soil mesofauna in Bodo City, Niger Delta, Nigeria.

| Relationships | Equation | R | $R^2$ | P-value | Remarks |
|---|---|---|---|---|---|
| Relationship between pH and Mesofauna abundance | Y = -281.532X + 45.8131 | 0.9712 | 0.9441 | 0.1519 | NS |
| Relationship between pH and Mesofauna diversity | Y = 13.7048X - 82.2423 | 0.9962 | 0.9924 | 0.0555 | NS |
| Relationship between MC and Mesofauna abundance | Y = -1.2652X + 43.0247 | 0.5431 | 0.2949 | 0.6345 | NS |
| Relationship between MC and Mesofauna diversity | Y = -0.4510X + 16.6079 | 0.6635 | 0.4403 | 0.5381 | NS |
| Relationship between TEMP and Mesofauna diversity | Y = 0.5531X - 9.6896 | 0.4843 | 0.2345 | 0.6781 | NS |
| Relationship between TEMP and Mesofauna abundance | Y = 1.3575X - 25.3504 | 0.3467 | 0.1202 | 0.7745 | NS |

**Note:** MC, Moisture content; TEMP, Temperature; pH, Hydrogen potential.

The regression equation showing the relationship between pH and mesofauna diversity (Y= 13.7048X - 82.2423) is not significant (P≥0.05). The rate at which soil pH affects the mesofauna diversity is very high (R=0.9962). This further shows that a change in pH will cause about 99.24% change in mesofauna diversity. The regression equation showing the relationship between moisture content and mesofauna abundance (Y= -1.2652X + 43.0247) is not significant (P≥0.05). The rate at which soil pH affects the mesofauna diversity is moderately high (R=0.5431). This further shows that a change in moisture content will cause about 29.49% change in mesofauna abundance. The regression equation showing the relationship between moisture content and mesofauna diversity (Y= -0.4510X + 16.6079) is not significant (P≥0.05). The rate at which soil moisture content affects the mesofauna diversity is high (R= 0.6635). This further shows that a change in moisture content will cause about 44.03% change in mesofauna diversity.

The regression equation showing the relationship between temperature and mesofauna abundance (Y= 1.3575X - 25.3504) is not significant ($P \geq 0.05$). The rate at which soil temperature affects bacteria diversity is low (R= 0.3467). This further shows that a change in temperature will cause about 12.02% change in bacteria abundance. The regression equation showing the relationship between temperature and mesofauna diversity (Y= 0.5531X - 9.6896) is not significant ($P \geq 0.05$). The relationship between temperature and mesofauna diversity is weak (correlation coefficient R=0.4843). This means that a change in temperature will lead to a small change in mesofauna diversity.

## DISCUSSION

The result showed that unpolluted soil has the highest abundance of mesofauna (31) individuals followed by the remediated soil (4), while crude oil polluted soil has the least abundance of 2 individuals in the study area. The low number of soil mesofauna recorded in the polluted site could be because the spills might have killed off many of the mesofauna by adversely affecting respiration. The oil might have adversely affected their food source, leading to reduced reproductive rate. Table 2 shows that the highest species diversity of mesofauna was also high in unpolluted soil (11) followed by remediated soil with 4 species while the least diversity is recorded in the crude oil polluted soil (2). This result implies that more species of mesofauna tends to live in unpolluted soil. This conforms to the observation of Rapport (1983) who reported that mesofauna lives where there is a minimum disturbance of the ecosystem. Which therefore means mesofauna is one of the indicator species of the unpolluted habitat.

Crude oil has significant effect on the abundance of mesofauna because there is a significant difference between the unpolluted, remediated and oil polluted soils, this may be due to varying factors that might favor their existence such as the soil pH, temperature or their microenvironment conditions, such as, humidity and air composition which may either be sufficient or insufficient around and within the mesofauna immediate habitat.

There is significant ($p \leq 0.05$) difference in the mesofauna abundance of the three habitats based on the observed mean difference. It also shows that there is significant ($p \leq 0.05$) difference between unpolluted soil, remediated soil and crude oil affected soils. The unpolluted soil has the highest mean value which makes it the best soil habitat. This is however similar to the reports of (Evans 1999), which stated that fauna is not necessarily more in the natural forest than reserves or plantations.

The summary of regression analysis shows that there is no significant ($p \geq 0.05$) interaction between soil pH and mesofauna abundance and diversity in the three habitats this may be due to the fact that the three habitats are subjected to the same climatic condition, since they are all within the same ecological zone (tropical rainforest). It was further observed that the pH of the unpolluted soil is higher than others, which indicates that the soils of unpolluted soils are more fertile. This suggests that soil pH might play a significant role in influencing the soil fertility; hence, the diversity and abundance of soil mesofauna are also affected. The result of this finding is similar to Badejo & Ola-Adams (2000) who reported that the soil pH of the Natural forest is higher than its surrounding plantations and cultivated land.

The unpolluted soils has the highest pH followed by the remediated soils while the crude oil polluted soils recorded the least pH, *i.e.* the pH values of the polluted samples obtained in this study were lower than those of unpolluted samples. These results are similar to the findings of Amadi *et al*. (1993) and Chukwuma *et al*. (2010). It is also contrary to the findings of Andrade *et al*. (2004) and Ayotamuno *et al.* (2004) who observed an increase in the pH of soils polluted with crude oil.

The polluted soil has the highest moisture content followed by the unpolluted soil while the remediated soil has the least moisture content. These values are in agreement with the findings of Bossert & Bartha (1984) in which they concluded that moisture contents ranging from 20% to 80% are generally optimum for hydrocarbon degradation. The remediated soil has the highest temperature followed by the unpolluted soil while the polluted soil recorded the least temperature.

## CONCLUSION

It can be concluded that oil spill adversely affected both abundance and diversity of soil mesofauna. The test results obtained from the soil analysis of the oil-spilled impacted sites (Bodo community) compared to the result of the unpolluted site shows that the total abundance of soil mesofauna from both the oil spilled sites and remediated sites have provided evidence of severe hydrocarbon contamination of the sites. These conditions imply reduction in soil fauna composition which is important in decomposition and mineralization, thereby affecting agricultural productivity.

**RECOMMENDATIONS**

Having successfully analyzed the soil samples in the Bodo community, it has shown that the crude oil has affected the diversity and abundance of soil mesofauna. Therefore, in order to minimize the rate of spills in this community, the following recommendations are suggested.

- Adequate security personnel should be provided to guard oil installation and such security arrangement should involve people from the host communities to work-in collaboration with government security forces to improve monitoring of oil facilities to avoid vandalization.
- The constant seminar, training workshop, public enlightenment campaign should be organized for host communities and other stakeholders in the oil industry to educate them on the negative impact of oil spillage on soil mesofauna.

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