JASEM ISSN 1119-8362

Full-text Available Online at www.ajol.info and www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage. *September 2014*
Vol. 18 (3) 411-416

Effect of Spent Lubricating Oil on the Composition and Abundance of Arthropod Communities of an Urban Soil

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KEYWORDS: Arthropods, composition, lubricating oil, soil, southern Nigeria

ABSTRACT: The effect of spent lubricating oil on the composition and abundance of soil arthropods in impacted sites compared with natural control sites was assessed in Benin City, Southern Nigeria. The Modified Berlese-Tullgren Funnel method was used for the extraction of soil arthropod fauna. The results showed that altogether, 476 specimens were collected and sorted into four arthropod groups, namely Acarina, Collembola, Hymenoptera and Myriapoda in successive order of abundance at both sites studied. Soil arthropod taxa and abundance were significantly lower ($u_{(2)} = 51$, $P<0.05$) at the impacted sites where 10.92% (52) of the total number occurred compared to 89.08% (424) recorded in the natural control site. Significant differences were detected in pH and total hydrocarbon content (THC) between the impacted and control sites, the values of pH and THC were significantly higher ($P<0.05$) at the impacted site; inversely, the arthropod faunal abundance were lower at the impacted sites. Basically, Myriapoda were most sensitive while Acarina, Collembola and Hymenoptera showed trends of population fluctuation. In general, abundance and richness of species were negatively affected by habitat transformation caused by spent engine oil application. © JASEM

http://dx.doi.org/10.4314/jasem.v18i3.7

The soil is a natural body consisting of layers that are primarily composed of minerals, mixed with atleast some organic matter, which differ from their parent materials in their texture, structure, consistency, colour, chemical, biological and other characteristics. It is the unconsolidated or loose covering of fine rock particles that covers the surface of the earth (Birkeland, 1999). The soil can be referred to as a world of its own life and biodiversity, consisting of various forms of life in an endless series of interlinked caves with lots of food and stable environmental conditions like a rain forest (Williams, 1999). The nature of soils influences the health of the soils fauna and movement of gases into and out of the soil. Arthropods are the main components of soil inhabiting invertebrate fauna and they play important role in soil nutrient fluxes (Levelle, 1997). Concerns about the changes to ecosystems due to anthropogenic input into the environment have led to the need to detect variations in biological integrity of different habitats. In developing countries where urbanization occurs at a fast rate, habitat degradation appears to be the leading cause of biodiversity loss (Mckinney, 2006). An important cause of soil biodiversity loss in urban areas is the pollution of soils by petroleum products.

Engine lubricating oil is a major product of petroleum which helps the engine move smoothly. Spent or waste engine oil is oil that has been used, and as a result contaminated by chemical impurities which contribute to chronic hazards including mutagenicity and carcinogenicity as well as environmental hazards with global ramifications (Udeani *et al*., 2009). Waste engine lubricating oil is oil that has served its service properties in a vehicle withdrawn from the meant area of application and considered not fit for initial purpose (Ameh *et al.*, 2012). Waste engine oil is a mixture of several different chemicals including low and high molecular weight aliphatic hydrocarbons, aromatic hydrocarbons, polychlorinated biphenyls, chlorodibenzofurans, lubricative additives, decomposition products and heavy metal contaminants such as aluminum, chromium, lead, manganese, nickel and silicon that come from engine parts as they wear down (Wang *et al.*, 2000).

Nigeria accounts for more than 87 million litres of spent oil annually and adequate attention has not been given to its proper disposal (Osubor & Anoliefo, 2003). A common practice, especially by motor mechanics that changes oil is the indiscriminate disposal of spent oil into the environment which results in an increase in pollution incidents in the environment (Anoliefo *et al*., 2001). Consistent with the idea of high sensitivity of soil arthropod fauna to anthropogenic perturbations and their use as reliable

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indicators of alterations of their supporting systems, this study was undertaken to ascertain the effects of waste engine lubricating oil on the composition and abundance of soil arthropod fauna in contaminated soils compared with natural control sites in Benin, Southern Nigeria.

MATERIALS AND METHODS

Sampling sites: Soil samples for physico-chemical analysis and arthropod fauna were taken from three stations, each station contained two portions designated as site A and site B. The size of each site measured 45m^2 separated by 5 metres. The portions of both sites were of the same soil type (sandy-loam) well drained, uncultivated and having grasses dominated by *Sida acuta*. 1 litre of waste engine oil was applied to site A while site B was left in its natural state to serve as control.

Materials: The waste engine oil used as treatment agent was obtained from an automobile mechanic workshop located in Benin City. The oil was taken from the cars that came in for engine service after one month of regular driving as recommended by Osubor & Anoliefo (2003).

Methods : Collection of soil and extraction of fauna: Soil samples from the stations were collected with a split core sampler. The collection of the samples was done between 900hrs to 1000hrs fortnightly for three months (May-July, 2013). The split core sampler was used to collect soil samples from 1m^2 area, three soil cores were taken randomly by pushing the sampler into the soil to a level of 10cm. To ensure that all the soil in each range was collected, the split core sampler was rotated clockwise and anti-clockwise until the entire soil was taken. Soil samples were placed in labelled black polythene bags on the site of collection and these samples were taken to the laboratory for analysis, by a 3-stage process (extraction, sorting, and identification).

The extraction method was designed to suit the size, behaviour and body structures of the organisms (Wallwork, 1970). The modified model of the Berlese-Tullgren funnel was used for extraction (Lasebikan, 1974). The extractor complex consisted of two 6-unit rows, enclosed in a metallic cabinet. The duration of extraction was 2 days (48hrs) and the extracts containing soil micro arthropods in 50% alcohol were placed in Petri-dishes and viewed under a dissecting binocular microscope; the micro arthropods were carefully removed by means of carmel hair brush. Specimens were sorted and taxonomically identified using literature (Christiansen *et al.,* 2004) and reference materials from the International Institute for Tropical Agriculture (IITA) Ibadan.

Measurement of Soil Physico-chemical Parameters: Soil temperature was taken using mercury-in-bulb thermometer. This was done by digging a small hole (10cm depth) and the thermometer was placed in the ground and covered, reading was taken after 2 minutes (in ^{0}C).

Soil pH was measured using Bate (1954) procedure, 20g of air dry soil from each station was put in a 50ml beaker and 20ml of distilled water was added and allowed to stand for 30-minutes. The mixture was stirred occasionally with a glass rod. Then the electrodes of the pH meter was inserted into partly settled suspension and reading was taken.

Total Hydrocarbon Content (THC) was determined by taking 5g of soil and the hydrocarbon content extracted using 25ml n-hexane, the extract was placed in Spectrophotometer for absorbance reading. The THC concentration in ppm was calculated as: THC =Spectrophotometer reading x slope reciprocal x $\frac{25ml}{5g}$ Where slope reciprocal = 4.99

Statistical Analysis: The statistical evaluation of the results was done using Microsoft Excel 2007 program and SPSS version 16. Statistical differences in faunal abundance between the spent oil treated sites and control was determined using Mann-Whitney test (μ) (Ogbeibu, 2005). Level of significance was set at 0.05. Bar graphs were also used in representation of assessment endpoint.

RESULTS AND DISCUSSION

Soil Physico-Chemical Parameters: The variation in physico-chemical condition of soil at the study sites is presented graphically in figure 1, Soil temperatures at the oil treated sites fluctuated between 26.50^{0}C and 27.50^{0}C. The value was highest in the month of June (27.50^{0}C) and lowest in July (26.50^{0}C). The mean values of soil temperature were relatively lower in the sites not treated, soil temperature values at the sites not treated varied from 26.80^{0}C to 27.20^{0}C. On the overall, there was no significant difference ($P > 0.05$) in the values between the treated and untreated sites.

Soil pH values varied from 5.42 to 5.62 at the treated site and between 5.19 to 5.36 at the untreated sites.

Significant difference ($P < 0.05$) was detected in the values between the treated and untreated sites.
The values of total hydrocarbon content were generally higher at the oil treated sites than the untreated sites in all the months. THC values at the treated site ranged from 39.96% to 40.11%, while the values ranged from 0.59% to 1.29% at the untreated sites. Extremely significant difference ($P < 0.001$) was detected in THC between the oil impacted site and the natural control site.

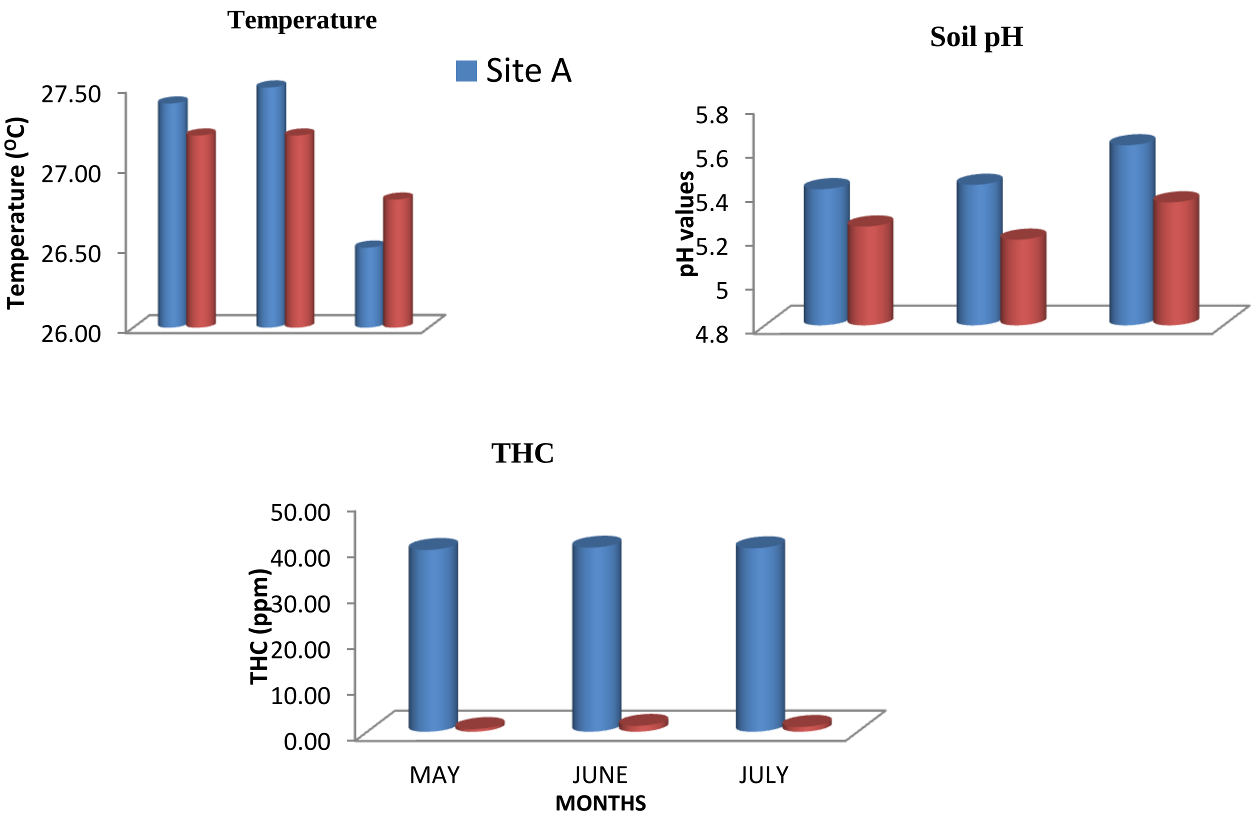

Fig. 1: Variation in physico-chemical parameters of soils in the study sites

Species Composition and Abundance **:** Altogether, 476 individuals representing 9 taxa were collected at the two study sites. The numbers of individuals from the spent oil treated sites was 52 (10.92%) and the numbers at the untreated site was 424 (89.08%). The total taxa was composed of 7 and 9 species at the oil treated and untreated sites respectively. The species composition and abundance is presented in Table 1.

The overall abundance of the different arthropod groups collected in the untreated site showed that Acarina accounted for the highest abundance with 185 individuals (43.63%) followed by Collembola with 136 (32.08%), Hymenoptera, 53 (12.05%) and Myriapoda, 50 (11.79%). In contrast, the oil impacted site contained only Acarina, Collembola and Hymenoptera, while Myriapoda was not represented; in this site 33 (63.46%) of the arthropods were Acarina, 13 (25.0%) were Collembola and 6 (11.54%) were Hymenoptera. The total abundance of the arthropod groups collected from the two sites is represented graphically in Figure 2. The mean variation of fauna at the different sites is given in Figure 3. Mean abundance at the polluted site was 5.776 ± 1.898, while the value at the natural control site was 47.111 ± 5.877. Mann – Whitney test revealed a significant difference ($U_{(2)} = 51$, $P < 0.05$) between the two sites

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Table 1: Species list and Abundance (individuals/m^2) of soil arthropod fauna at the study sites.

Taxa	Number of Individuals	
	Site A	Site B
Hymenoptera		
Solenopsis geminata	6	53
Collembola		
Isotomurus unifasciatus	3	47
Lepidocyrtus orientalis	5	44
Sminthurinus niger	4	45
Acarina		
Amblyseius cucmeris	19	85
Amblyseius sp 2	8	48
Amblyseius sp 3	7	52
Myriapoda		
Brachydesmus superus	-	25
Scutigerela immaculate	-	25
Total	52	424

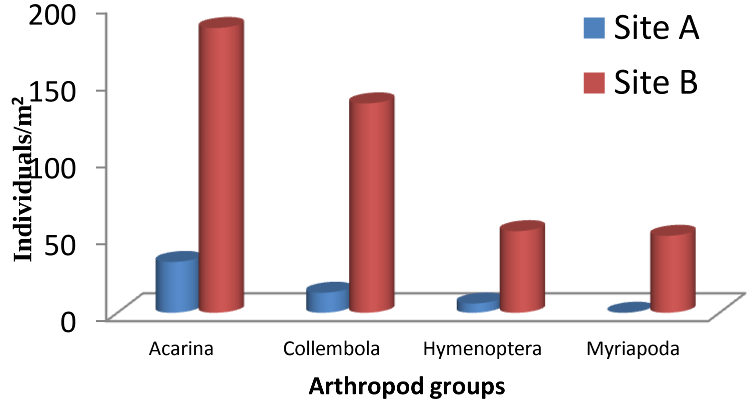

Fig 2: Variation in Species Abundance of Soil Arthropods Collected from the Spent Engine Oil Treated Site (A) and the Untreated Site (B)

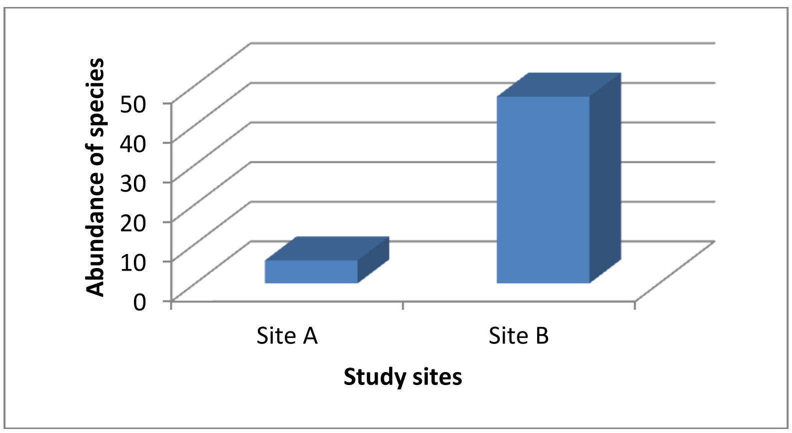

Fig. 3: Mean variation of soil arthropods in species abundance at the different study sites ($U_{(2)} = 51$, $P < 0.05$, Site A, Mean = 5.778±1.898, Site B, Mean = 47.111±5.877).

This study examined the effect of spent engine lubricating oil on the composition and abundance of soil arthropod fauna in contaminated soil compared with natural sites.

Analysis of the physico-chemical condition of the study sites depicted a clear contrast between the contaminated and natural site. Physicochemical parameters (soil temperature, pH and total hydrocarbon content) were generally higher in the waste engine oil treated sites than the natural control site. The influence of the waste engine oil could be the causative factor contributing to this elevation of these parameters.

Overall, the abundance of soil arthropod species was significantly lower in the oil impacted sites (10.92% of total) compared to the natural control site which had 89.08%. This low species abundance of impacted site is a reflection of the adverse effect of the waste engine oil. This is expected as there are relatively large amount of hydrocarbon in used oil including the highly toxic polycyclic aromatic hydrocarbons and heavy metals such as Vanadium, Lead, Aluminum, Nickel and Iron which have been reported to give high values in waste oil (Vwioko, *et al.,* 2006). Waste engine oil has also been shown to create an unsatisfactory condition for life in the soil (Achuba & Peretiemo-Clarke, 2008). The disturbance hypothesis of Connell (1978) might provide an explanatory framework for the pattern observed in this study. Hilt and Fiedler (2005) however found that habitat disturbance may frequently increase diversity. Kitching, *et al.,* (2000) indicated that a substantial fraction of Arctid ensembles benefit from habitat disturbance, such species can even serve as disturbance indicators. Our results however suggest that this does not apply in the case of spent oil disturbed site where abundance was lower compared to natural control site. In consonant, Carrete *et al.,* (2009) also found the abundance of some species decreasing with habitat degradation.

Overall, in this study, soil arthropods were dominated by Acari and Collembola in both oil treated and natural control sites. This is expected as these groups are amongst the most numerous and widespread arthropods in soils (Budgett, *et al.,* 1993; Curry, 1994; Ritz, *at al.,* 2009).

Although, Acarina species occurred in reduced numbers in the polluted site, they were able to survive at the oil contaminated site probably because of their structural features. Markwiese, *et al.,* (2001) have asserted that adult oribatid mite usually have strong exoskeleton and are consistently active in extreme environment. Another basis for their abundance in soil ecosystem could be due to their omnivorous nature (Macfayden, 1963). They have a diversity of feeding habits, hence it may be difficult for them to run out of food as well as operating a more or less monopolistic tendency in feeding beside the absence of competition. Uwagbe, *et al*. (2014) also found Acarina as the most abundant species in unimpacted natural soil as well as soils polluted by hydrocarbon.

Next in abundance to Acarina was the collembolans, they were very low in abundance in the polluted station and this could be because they succumb to adverse conditions. Their low abundance in the polluted station could also be as a result of their high degree of selectivity in feeding (Shaw, 1988).

The abundance of the hymenopterans and the myriapods were almost the same in the control station but while some hymenopterans were still present in the polluted station, no myriapods was found and this could be due to the mobile nature of myriapods, these arthropods may migrate deep into the soil during unfavourable condition. Cloudsely-Thompson (1968) reported that the first instar of *Symphyla* never migrate to the soil surface and older *Symphyla* which do visit the soil surface retreat rapidly into the soil if disturbed. The rapid recovery in the rainy period suggests that suitable conditions prevail to maintain their population. Iloba and Jarret (2007) reported hymenopterans as one of the most abundant groups in soils contaminated by soil spill. On the other hand they found myriaphods as the least abundant.

Conclusion: In conclusion, this study has shown that local habitat condition were strong enough to allow for a differentiation between arthropod assemblages from natural sites. At the impacted site arthropod assemblage and abundance was much lower, suggesting that spent lubricating oil from car engines demonstrated profound effect on the arthropod species. The absence of myriapod species as well as the generally low individual numbers of other arthropods at the contaminated sites may be explained by habitat transformation which resulted in biodiversity loss and elimination of species in the habitat. Furthermore, species response toward the state of the habitats was context dependent being profoundly affected by spent engine oil application, the abundance of species decreased with habitat degradation.

Acknowledgement We thank the authorities of The International Institute for Tropical Agriculture (IITA) for allowing the use of reference materials in the identification of some fauna.

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