American-Eurasian J. Agric. & Environ. Sci., 13 (11): 1541-1546, 2013
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2013.13.11.11046

Ameliorative Effects of Organic Manures on Soil Ph, Organic Carbon and Microarthropod Population

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Abstract: The study aims at evaluating the effect of organic manures on soil pH, organic carbon and microarthropod population in a polluted soil. The response of the soil chemical properties and microarthropods (Oribatid, Actinedid, Gamasid, Collembola and others) population to spent oil amelioration with organic manures fertilization was studied in the Federal University of Agriculture, Abeokuta farm. Soil pH, Organic Carbon (OC) and soil microarthropod population were studied in a soil contaminated with spent oil and ameliorated with different sources of organic manures. The experiment was a 4 X 4 factorial experiment in a Randomized Complete Block Design (RCBD) with four replications. Two factors, spent soil: (0%, 0.5%, 2.5% and 5%); and organic manures: (C=Control; CD=Cow Dong; PM=Poultry Manure; and SW=Swine Waste) were used. Data collected were subjected to analysis of variance using Genstat 5 release 3.2 and means separated using Least Significant Difference (LSD). The result shows that the soil pH decreased with increase in the level of spent oil while PM was found to increase the soil pH. Plots treated with 5% spent oil gave the highest (29.0 g/kg) OC which was significantly higher than that of the control (6.1 g/kg). Lowest OC was also observed in plots treated with PM. Soil microarthropod population decreased with increase in the level of spent oil while addition of PM significantly improved their population and particularly Collembola was improved by about 48.48% over that of the control plots. The result indicated a positive response with the use of organic manure on both chemical properties and microarthropod population density and hence, a means to restoration of polluted soils. There was therefore an indication that organic manures could be used to ameliorate soils contaminated with spent oil.

Key words: Amelioration · Organic manure · Microarthropod population · Spent oil

INTRODUCTION

The soil is the basis of agricultural production as it is the source of nutrient elements needed for plant growth apart from providing anchorage for the plant. The soil also serves as habitat for a diverse array of organisms that play a very important role in soil fertility restoration because of their ability in biochemical transformation. Soil organisms, the living part of soil organic matter, function as a transient nutrient sink and are responsible for releasing nutrients from organic matter for use by plants [1]. Given the importance of soil fauna in decomposition and nutrient cycling, factors affecting their disappearance, recolonization and maintenance must be better understood [2].

However, the higher organisms in the soil particularly soil microarthropods play important roles in mineralization process either directly through their participation in decomposition or indirectly by regulation of soil microbial biomass. The ability of microarthropods population on litter decomposition and nutrient release have been well documented by Adejuyigbe *et al.* [3], Robert, [4] and Tian *et al.* [5].

Microarthropods populations in the soil are affected by a number of factors such as moisture, pH, quantity and quality of organic matter content of the soil [6]. These factors are affected by addition of waste products from homes and industries. Wastes additions may either serve as substrate for organic matter and can be decomposed by the soil organisms or toxic substance that is harmful to

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the soil organisms responsible for the decomposition process. Therefore, resulting in the pollution of the soil and thus confirmed the findings of Perfect *et al*. [7]; Badejo and Akinyemiju [8] that the application of pesticide led to the reduction of microarthropods population.

Soil pollution therefore, has been viewed as activity resulting into the malfunctioning of soil as an environmental component due to contamination with certain compounds emerging from human activities [9]. This indicates that many accidental contamination of soil with fuel oil especially spent oil can pollute the soil. This pollution further, affect both the physical and chemical properties of the soil and hence, fertility status of the soil. Pollution as viewed by Amadi *et al.* [10] may reduce the amount of the organic carbon concentration of the soil and or soil organisms present in the soil. However, fuel oil can be toxic to many organisms, it is also an easily- available substrate for some groups of organisms [11].

Organic applications increased nutrients status, microbial activity and productive potential of soil while the use of only chemical fertilizers in cropping system resulted in poor microbial activity and productive potential of soil [12]. Research has shown that organic manures have the ability to degrade oil and enhance soil recovery [13]. This may result from the ability of the humic substrate of the organic matter to provide active sites for deactivation of some applied organic chemicals such as herbicides and hydrocarbons in the soil. Organic manures may also serve as a cost effective means of remediating contaminated soils. However, little is known about the ameliorative effects of organic manures on some chemical properties of the soil and microarthropods population in a soil contaminated with spent oil. The present investigation was therefore conducted with the aim of assessing the effects of organic manures on soil pH, organic carbon and microarthropods population on polluted soils.

MATERIALS AND METHODS

The study was carried out at the University of Agriculture, Teaching and Research Farm, Abeokuta. The location is between Latitude 7.12°N and Longitude 3.23°E in the Southwestern part of the derived savanna ecozone of Nigeria. The area has a bimodal rainfall pattern with rain usually commencing in Late March or early April and ending in late October or early November with a short dry spell in August. The mean annual rainfall is about 1470mm with the maximum rainfall in July and September with the mean monthly temperature range between 28°C and 32°C. The pre-treatment data of the experimental plots are shown in Table 1.

The experiment was arranged in a 4x4 factorial in a Randomized complete Block Design (RCBD) with four replications. Two factors, namely, organic manure and spent oil were used to treat the soil. Four levels of spent oil were used as follows: 0%, 0.5%, 2.5% and 5%. Also, three organic manure sources- poultry manure (PM), cow dung (CD), swine waste (SW) and control (00) no treatment. Thus, there were sixteen treatments in all.

Table 1: Selected properties of the experimental plot, organic wastes and spent oil before the treatment was applied

Parameter	Units	Soil	CD	PM	SW	SP
Sand (2000-50μm)	g/kg	836	-	-	-	-
Silt (50-2 μm)	"	48	-	-	-	-
Clay (< 2μm)	"	116	-	-	-	-
Texture	-	Sandy loam	-	-	-	-
pH (H_2O)	-	5.8	6.4	6.7	7.5	-
OC	g/kg	8.3	2.4	39.5	13.2	30.7
Total N	"	0.71	0.97	4.0	1.30	2.66
C:N ratio	-	11.7	12	9.9	10.2	11.5
Ava. P	mg/kg	7.4	126.5	143.4	74.8	0.1
Ca	cmol/kg	6.09	103.4	116.8	75.0	-
Mg	cmol/kg	2.21	105.8	129.4	75.8	-
K	cmol/kg	1.24	0.9	1.1	0.9	-
Na	cmol/kg	1.13	10.5	3.6	3.0	-
Exch. Acidity	cmol/kg	0.6	0.2	0.1	1.2	-
ECEC	cmol/kg	11.27	-	-	-	-

CD = Cow Dung; PM = Poultry Manure; SW = Swine Wastte; SP= Spent Oil

Source: (Adesodun *et al*., [19]).

Microarthropods Sampling: Microarthropods sampling was done by taking soil cores from each experimental plot using a core sampler of surface diameter 9cm and to the depth of 7.5cm. Thus a total of 64 samples were collected from the experimental field while four samples were taken from the adjacent plot which is under forest. Each soil core was pushed with a peg from the core sampler into a polythene bag and transported to the laboratory.

Laboratory Extraction and Identification of Soil Microarthropods: Microarthropods were extracted from the soil samples in the laboratory using modified Berlese-Tullgren Funnel Extractor [14]. Heat and light from a 25W bulb was used to drive the microarthropods out of soil through the wire mesh base of a soil core container that rested on a funnel which opened into a specimen tube containing 4% formalin solution with 70% Ethanol.

The extraction lasted for 5 days after which the extracted microarthropods were poured into a petridish and then sorted into different taxonomic groups and counted under a stereomicroscope.

Soil Analysis: Surface soil samples (0-15cm) were collected from each experimental plot. The soil samples were dried, sieved and analyzed. Organic carbon (OC) was determined by the chromic acid oxidation method [15] while pH was measured by glass electrode pH meter in a 1:2 soil water ratio. Data collected includes change in pH, Soil organic carbon and Microarthropods Population.

Data Analysis: Data collected were subjected to analysis of variance using the Genstat [16] 5 release 3.2 statistical package while the treatment means were separated using least significant difference (L.S.D) at P=0.05.

RESULTS AND DISCUSSION

Effects of Organic Wastes and Spent Oil on Soil pH

The result (Table 2) showed a decrease in the status of the soil pH as the level of spent oil increases (Table 2). The soils treated with 0% spent oil (5.7) had the highest soil pH while the lowest was observed in soils treated with 5% spent oil (5.2). Though the pH status of the soil did not vary significantly, soils supplemented with poultry manure (PM) appeared to have highest pH (5.5) perhaps on the account of the kind of feed given to the poultry birds. The result is in line with the findings of Stockdale *et al*. [17] whose work reveals the direct impacts of farmyard manure usually raises the pH and returns organic matter that further stimulates /reduce mineralization.

Table 2: Effects of Spent Oil and Organic Wastes on Soil pH

Manure	0%	0.5%	2.5%	5%	Mean
Control	5.5	5.2	5.2	5.1	5.3
CD	5.8	5.4	5.4	5.1	5.3
PM	5.8	5.7	5.4	5.3	5.5
SW	5.6	5.6	5.4	5.2	5.2
Mean	5.7	5.5	5.3	5.2	

L.S.D: Oil = 0.2; Manure = 0.2; Oil/Manure = 0.4

Note: CD = Cow Dung; PM = Poultry Manure; SW = Swine Waste.

Table 3: Effects of Spent Oil and Organic Wastes on Soil Organic Carbon (g/kg)

Manure	0%	0.5%	2.5%	5%	Mean
Control	4.8	12.8	25.6	27.8	17.7
CD	5.1	13.4	21.8	29.1	17.3
PM	6.5	12.6	16.8	27.5	15.8
SW	8.1	18.0	24.1	31.7	20.5
Mean	6.1	14.2	22.1	29.0	

L.S.D: Oil = 2.8; Manure = 2.8; Oil/Manure = 5.7

Note: C = Control; CD = Cow Dung; PM = Poultry Manure; SW = Swine Waste.

Table 4: Effects of Spent Oil on Microarthropod Population

	Spent oil level				
Microarthropod Group	0%	0.5%	2.5%	5.0%	F.pr
Oribatid	2010	1484	1029	207	NS
Actinedid	64	77	20	36	NS
Gamasid	61	149	13	38	NS
Collembolan	101	17	7	3	**
Others	130	73	48	8	**
Total	4000	2674	2110	1192	**

Note: NS - Not Significant; ** = Significant

Data were normalized using Log (x+1) before analysis of variance.

Table 5: Effect of Organic Manure on Microarthropod Population

	ORGANIC MANURE				
Microarthropod Group	C	CD	PM	SW	F.pr
Oribatid	1359	509	1747	1031	NS
Actinedid	33	34	46	68	NS
Gamasid	61	32	43	53	NS
Collembolan	17	4	49	11	**
Others	51	38	72	23	NS
Total	2686	1423	3035	2318	NS

Note: NS - Not Significant; ** = Significant; C = Control; CD = Cow Dung

Effects of Organic Wastes and Spent Oil on Soil Organic Carbon: The result presented in Table 3 shows that organic carbon of the soil increased with increase in the level of the spent oil added. Soils treated with 5% spent oil had the highest organic carbon (29.0 g/kg) which was significantly higher than that of the soil treated with 0% spent oil (6.1 g/kg). The effects of organic wastes amendments showed that cow dung (CD) contributed significantly to the OC of the soil than all other sources.

The lowest value of organic carbon observed in plots treated with PM (15.8 g/kg) as against the highest value in SW (20.5 g/kg) might result from the kind of feed been given to poultry birds which perhaps may narrow the C/N ratio of the soil. This observation is in line with the earlier reports made by Amadi *et al.* [13] and Glimaur *et al.* [18] that C/N ratio of the animal waste is narrowed and that the rate of biodegradation of oil and soil recovery is also enhanced by these organic manures [13]. Also, Adesodun *et al.* [19] had reported that PM could improve soil contaminated with oil better than other organic manures. The observed response of the manures is similar with the work of Stockdale *et al*. [17] that the differences in the quality as much as the quantity of organic matter input have a driving impact on the microbial community in soil and on decomposition of C and N.

Effects of Spent Oil on Microarthropods Population: The effects of spent oil on microarthropods population shows that microarthropods population (Oribatid, Collembola, Other and total population) decreased with increase in the level of spent oil (Table 4). Though the result of analysis of variance (ANOVA) for Oribatid mites was not significant, the highest population was observed under 0% spent oil, that is 2010 while only 407 was observed in soils treated with 5% spent oil. Actinedid and Gamasid did not vary significantly. However, Collembola and others respond significantly to the addition of different levels of spent oil. The reduction in microarthropods population as a result of spent oil may be due to the fact that presence of petroleum compounds interferes with soil aeration which might have reduced the oxygen content in the soil needed by these soil organisms. This observation according to Anoleiefo and Vwioko [20] may be as a result of waxy texture of the soil which could lead to the blockage of soil pores, thus contributing to reduced oxygen content in the soil.

In addition, some soil organisms (petroleum utilizers) can tolerate oil contaminated environments because they possess the capacity to utilize oil as energy sources while other species may not and are gradually eliminated. Hence, those that cannot utilize petroleum hydrocarbon show a decrease in their populations when present in oil contaminated environment.

Effects of Organic Manure on Microathropods Population: The result in Table 5 shows that soils ameliorated with PM had highest population of soil microarthropods except Actinedid and Gamasid. Total population was also improved by PM amelioration, Collembola population was significantly improved by the organic manures and the highest population (72) was observed in soils with PM amelioration while CD (4) had the lowest population. Furthermore, PM improved Collembola population by about 48.48% relative to the soils with no organic amelioration (control); perhaps on account of improvement of the soil microclimate which might have enhanced their build-up. This may result in high rate of biodegradation of oil and enhancement of soil recovery.

Table 6: Effect of Spent Oil and Organic Manure on Microarthropod Population

Treatment				Microarthropod Group			
Oil	Manure	Oribatid	Actinedid	Gamasid	Collembola	Others	Total
0.00	C	1003	64	23	192	491	3171
0.50	C	1863	146	373	20	77	3200
0.00	PM	3632	152	296	1779	852	8691
0.50	PM	2255	100	106	171	118	3991
0.00	SW	3042	448	113	31	22	5284
0.50	SW	1539	108	179	23	133	3351
0.50	CD	1473	5	20	15	33	1767
0.50	CD	747	22	72	1	25	1198
2.50	C	1375	6	23	6	32	2297
5.00	C	1325	24	72	5	6	2229
2.50	PM	1715	5	7	18	64	2208
5.00	PM	663	72	18	1	5	1063
2.50	SW	1719	33	7	6	26	24.61
5.00	SW	141	15	64	5	5	665
2.50	CD	276	241	29	5	100	1515
5.00	CD	221	64	26	1	26	1283
L.S.D		NS	NS	NS	NS	NS	NS

Note: C = Control; PM = Poultry Manure; SW = Swine Waste; CD = Cow Dung; NS = Not Significant.

Effects of Spent Oil and Organic Manure on Microarthopods Population : The underlying principle for the protection of soil organisms should be to limit or prevent exposure of organisms to unacceptable hazards [21]. From the result (Table 6), microarthropods population did not vary significantly although Oribatid mites decreased with increase in the level of spent oil in soils ameliorated with PM and CD (Table 6). However, soils treated with 0% spent oil but ameliorated with PM produced the highest population of Oribatid (3632). This assertion corroborated with the findings of Kang *et al*. [12] that organic farming practices have a positive effect on soil microbial numbers, processes and activities. It is also important to note that Collembola decreased with increase in the level of spent oil under all sources of organic amelioration except in soils treated with 0.5% spent oil and CD amelioration. Total microarthropods population was also observed to decrease with increase in the level of spent oil for all treatments except soils in the control and those ameliorated with CD which did not vary significantly.

CONCLUSION

The study reveals that the presence of spent oil in the soils could greatly reduce the population of microarthropods population which are useful in nutrient cycling in the soil. However, amelioration of such soil with some organic manure especially poultry would greatly restore the soil back to its original state prior to the pollution. In addition, the organic manures were also observed to have contributed to the organic carbon content of the soil and improved the soil pH. The study, further confirmed the ability of the organic manure to improve the population build up of the soil microarthropods which in turn enhanced the rate of nutrient cycling in the soil. Thus, the presence of soil microarthropods particularly Mites and Collembola in a degraded soil could therefore be used as an indicator of soil quality and ensures its sustainability. Hence, it can be concluded that some farm management practices (addition of manures) on below ground biodiversity and ecosystem function have simple and/ or generalizable impacts on ameliorating oil polluted soils.

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