Properties of Soils and Plants Uptake within the Vicinity of Selected Automobile Workshops in Ile-Ife Southwestern, Nigeria

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Abstract

Backyard farming is becoming popular among the auto mechanics near their workshops where spent engine oil and carcass of vehicles are continuously dumped in Nigeria. The properties of soil and maize plants sampled from the vicinity of selected auto mechanic workshops in Ile-Ife, Nigeria were investigated. The results showed that heavy metal contents in the soils from the sampled sites were (range, mg kg^{-1}) Fe 1238.12 to 1564.25, Zn 18.10 to 24.75, Pb 1.21 to 3.43 and Hg 0.48 to 0.74. These values were significantly ($P< 0.05$) higher than the control (non auto mechanic site) with Fe 37.50, Zn 0.70, Pb 0.15 and Hg 0.13 mg kg^{-1}. Also, these soil parameters reduced in values in the sub-soil. The mean concentrations of heavy metals (Fe, Zn, Pb and Hg) in maize plants were significantly ($P < 0.05$) higher while N and P were significantly ($P < 0.05$) lower in those from the experimental sites within the vicinity of automobile workshops than in the control. Higher accumulation of these heavy metals was obtained in soil and shoots of maize from older workshops than in the younger ones. The study therefore concluded that edible crops, particularly the phytoplants should not be cultivated on polluted soils as this may pose a threat to human health, if the heavy metals enter the food chain.

Keywords: Backyard farming, automobile, spent engine oil, carcass of vehicle, plant uptake, phytoplant.

Introduction

Pollution of soil ecosystem is the introduction of excessive amount of substances which impair the health of living organisms or interfere with the legitimate use of the soil environment. Pollution of the soil ecosystem is a major source of soil degradation (Mbagwu, 2008). Soil ecosystem is an essential component of life and man depends on it for food and natural resources while plants depend on it for their growth. It is also a medium for the biochemical cycling of soil nutrients. So, as the soil is being contaminated with all manner of pollutants, the life process is being disturbed and hence there may be imbalance in the whole system.

Wide varieties of wastes generated from human activities are dumped on soil (Adeoye *et al*., 2005). Soils have long being used as dump sites for household and commercial wastes (Uchegbu, 2008). Wastes containing heavy metals; if disposed on agricultural soils or around residential areas can enter into the food chain (Ademoroti, 1996). Animals that forage on the vegetation of the heavy metals polluted soils are also in danger. Soils affected by heavy metals suffer degradation due to impairment of physicochemical, biological and mineralogical properties; hence undermine its agricultural potential (Mbagwu, 2008).

Presently in Nigeria, one of the major sources of increase in heavy metals concentration of the soil ecosystem is auto mechanic activities (Odjegba and Sadiq, 2002). During activities like overhauling of vehicle engines, metal fabrication and automobile panel beating, reasonable amount of spent engine oil and metal fillings are deposited on top soil (Uchegbu, 2008). Painting of vehicles and tyre vulcanizing are other activities that negatively affect the qualities of soils around automobile workshops.

Soils polluted with spent engine oil had reduced soil microbial activity and reduced soil fertility status (McGrath *et al*., 1995). Heavy metal toxicity and insufficient soil aeration to growing plants are associated problems to soil polluted with spent engine oil (Anoliefo and Vwioko, 1995). Spent engine oil runoff indirectly increases the native concentrations of some heavy metals. The growing crops take-up these heavy metals and thereafter transport them to different parts of the plants (Adewole, 2006). The degraded soil leads to low crop yield (Rainbow, 2007) and reduced crop quality (Adeoye *et al*., 2005). Unfortunately, many of the available soils near these workshops are being cultivated, particularly with maize, cassava and vegetables.

Apart from the fact that many of these crops have ability to remove these inorganic chemicals, especially the heavy metals from the soil and store them in different parts of the plants (Adewole *et al*., 2008), they are also dangerous to human health, if ingested (Pirkle *et al*., 1998). Ademoroti (1996) worked on okro and bitter leaf and reported the appreciable concentrations of heavy metals removed and stored by these crops when they were planted on contaminated soils.

Backyard farming in the immediate vicinity of the automobile workshops is

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increasing in Nigeria. These mechanics engaged in this farming exercise whenever they have no auto-repair work to do. Currently, there is a dearth of information on the quality of soils and cultivated crops in the vicinity of automobile workshops in the humid tropics of Africa. The experiment therefore aims at providing information on the quality of soils as affected by human activities around some selected auto-mechanic workshops and the bioaccumulation of selected heavy metals in the shoots of maize plant.

Materials and Methods

Experimental site identification

The study area, Ile-Ife, lies within latitude 07º 28.00´ and 07º 30.03´N longitude 004º 32.00´ and 004º 34.23´E with elevation range of 260-300 m above the sea level in Ife Central Local Government Area of Osun State. It falls within the tropical forest of southwestern Nigeria (LRS, 1976) and of the basement complex soil origin. The rainfall pattern is bimodal and falls from late March to late November each year. Preliminary survey was carried out to identify auto-mechanic workshops whose surrounding vacant lands were being cultivated with edible crops in April 2008. From the eight auto mechanic workshops identified, out of a total of fifteen in Modakeke, Ile-Ife, only three were randomly selected (37.5 % of the auto mechanic whose surrounding vacant land are cropped) and a control location (non-auto mechanic workshop) were used as experimental sites.

The workshops were in different locations and were established at different times, viz: Oke-Ayo (12 years ago), Ajebandele (9 years ago) and Modakeke (17 years ago). These workshops still function till now. Maize (yellow maize) grains purchased from the local markets were planted on the vacant land near each of the auto mechanic workshops and the control site (65 m away from a mechanic workshop) by these mechanics. Each of the established plot size was 4 x 6 m^2, including the control plot, mapped out from the mechanic farms. No soil amendments were applied.

Soil sampling and sample analyses

From each of the experimental plots, including the control, four composite soil samples each to the depths 0-15 cm and 15-30 cm were taken using simple random technique to give a total of 32 soil samples were collected. The samples were air-dried for 7 days to stop all microbial activities and passed through 2 mm sieve for pre-soil test physico-chemical analyses. Soil analyses carried out included: Soil pH using a pH meter in 1:1 soil-H_20 suspension (Mclean, 1982), particle size analysis by hydrometer method and Total nitrogen by macro Kjeldahl apparatus. Others are: available phosphorus by Bray's I method (Black, 1965), organic carbon using Walkley-Black wet oxidation method (Nelson and Sommers, 1982), micro nutrients (Fe and Zn) extracted using 0.1M HCl (Juo, 1982) and extractible heavy metals (Hg and Pb) using mixture of conc. HNO_3 and Conc. $HClO_4$ in the ratio 2:1 with Conc. H_2SO_4 (Odu *et al.*, 1986). The concentrations of Fe, Zn, Hg and Pb in the soil extracts were read on Atomic Absorption Spectrophotometer (AAS) Perkin-Elmer Model 403.

Plant sampling and sample analyses

With a clean razor blade, four representative samples of maize plant shoots from each experimental site were taken at six Weeks After Planting (WAP) to give a total of sixteen samples. The plant samples were thoroughly washed with de-ionized water dried in an oven for 48 hours at 70^0C, weighed, ground and analyzed for nutrients and heavy metals uptake. Analyses on plant samples carried out included: Total nitrogen by micro Kjeldahl apparatus, phosphorus using vanado molybdate yellow complex formation (Juo, 1982), concentrations of Fe and Zn using mixture of Conc. HNO_3 and conc. $HClO_4$ in the ratio 2:1 to digest the samples and heavy metals (Hg and Pb) using mixture of Conc. HNO_3 and Conc. $HClO_4$ in the ratio 2:1 with 5 ml of Conc. H_2SO_4 were used (Odu *et al.*, 1986). The concentrations of Fe, Zn, Hg and Pb in the plant extracts were read on AAS. The data were subjected to analysis of variance and Duncan Multiple Range Test was used to separate the means that were significant.

Results and Discussion

Properties of the topsoil of the automobile workshop area

Table 1 (a and b) showed the characteristics of soils of the four experimental locations. The soils were sandy clay loam. The mean soil pH ranged from 7.2 to 8.3, indicating a relatively neutral to slightly alkaline. The control soil had mean soil pH of 6.8 which was slightly acidic, typical of humid tropical soils (Kang, 1993). Total nitrogen (0.35 to 0.86 g kg^{-1}), organic carbon (10.48 – 18.96 g kg^{-1}) and P (9.34 15.74 cmol kg^{-1})

values obtained were respectively in the medium, high, and high ratings of soil fertility classes of soils in Nigeria (FMANR, 1990) despite the anthropogenic activities in the vicinities of the farm locations.

Also, the selected heavy metal concentrations were (range, mg kg^{-1}) Fe 1238.12 to 1564.24, Zn 18.10 to 24.75, Pb 1.21 to 3.43 and Hg 0.48 to 0.74; which were significantly ($P < 0.05$) higher than the control soil values which were: Fe 37.50, Zn 0.70, Pb 0.15 and Hg 0.13 mg kg^{-1}. These significant differences suggested soil contamination. Fe and Zn are plant micro-nutrients which are needed for good physiological plant growth in small amount (Banjoko, 1979) but have been grossly increased due to improper disposal of spent engine oil and carcass of motor vehicles. However, Pb and Hg concentrations have also increased mildly over the years. There were indications that the older the automobile workshop, the higher were the values of Fe, Zn, Pb and Hg possibly due to the longer period of deposition of spent engine oil and motor vehicle carcass on the nearby open vacant land.

Properties of the sub-soil of the automobile workshop area

Most of the soil properties reduced in concentrations down the soil profile, though with varied rates of reduction. Table 2 (a and b) showed the range of Total nitrogen (0.20 to 0.53 g kg^{-1}), P (9.36 to 15.96 cmol kg^{-1}) and K (0.03 to 0.26 mg kg^{-1}) while heavy metal contents of the sub-soil (range, mg kg^{-1}) Fe 982.55 to 1002.37, Zn 13.55 to 23.25, Pb 0.85 to 2.66 and Hg 0.43 to 0.68. These values were significantly ($P< 0.05$) higher than the control which was: Fe 3.57, Zn 0.56, Pb 0.12 and Hg 0.12 mg kg^{-1}.

Concentrations of N, P and some heavy metals in the shoots of maize plant

Table 3 showed the nutrients uptake in the maize shoots from the 4 locations. The mean concentrations of N, P and some heavy metals in the shoots of maize plant samples were: N 2.33 – 2.64 g kg^{-1}, P 0.24 – 0.30 cmol kg^{-1}, while others (range, mg kg^{-1}) P 0.24 to 0.30, Fe 126.56 to 179.03, Zn 11.51 to 14.83, Pb 0.43 to 2.17 and Hg 0.20 to 0.46. These values were significantly ($P < 0.05$) higher than the control values which were (mg kg^{-1}) Fe 23.69, Zn 1.47, Pb 0.10 and Hg 0.05. The N and P values were, however, significantly ($P< 0.05$) lower in the contaminated soils of the automobile workshops than the control. The high concentrations of these heavy metals were as a result of improper disposal of spent engine oil generated and deposits of rusted iron from carcass of vehicles from the auto mechanic workshops. Adewole *et al*. (2009) reported that when these plant nutrients, including heavy metals are taking up by plants with theirs roots; they are transported to various parts of the plants.

Age of the service station played significant role also as the oldest of them (Modakeke station) had significantly ($P < 0.05$) highest mean concentrations of Fe, Zn, Pb and Hg in the plant samples at 6 WAP. However, this increase did not cut across board as the Oke-Ayo station which was the second oldest only had Zn and Pb mean concentration values next to Modakeke station. The workshop station at Ajebandele established 9 years ago had mean concentration values of Fe, Pb and Hg next to Modakeke. This may not be unconnected with different volumes of servicing and repair works being carried out in these workshops and the records of which are not being kept by any of them.

Conclusion

The oldest automobile workshop had the highest accumulation of Fe> Zn> Pb > Hg, in that order, when compared with the youngest. The control site (none-automobile workshop) had metal concentrations typical of agricultural soils. It is therefore recommended that any attempt to cultivate an open vacant land near automobile workshops to edible crops, especially maize should be discouraged. These heavy metals, if ingested may affect the health of man (Pirkle *et al*., 1998).

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Table 1a-Mean values of the soil properties (0-15 cm depth) of different auto mechanic sites.

Source	pH in H_2O	Sand	Silt g kg^{-1}	Clay	OC g kg^{-1}	TN
Ajebandele	7.2	630	100	270	13.29	0.76a
Oke-Ayo	7.4	650	130	220	10.48	0.35c
Modakeke	8.3	610	120	270	18.96	0.86a
Control	6.8	630	130	240	12.86	0.64b

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test at P <0.05

Table 1b-Mean values of the soil properties (0-15 cm depth) of different auto mechanic sites.

Site Source	P cmol kg^{-1}	K	Fe	Zn mg kg^{-1}	Pb	Hg
Ajebandele	9.34c	0.39a	1238.12c	18.10c	1.30b	0.48b
Oke-Ayo	14.76a	0.04c	1256.05b	20.18b	1.21b	0.48b
Modakeke	15.74a	0.06c	1564.24a	24.75a	3.43a	0.74a
Control	11.90b	0.13b	37.50d	1.70d	0.15c	0.13c

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test at P <0.05

Table 2a Mean values of the soil properties (15 – 30 cm depth) of different auto mechanic sites.

Site Source	pH in H_2O	Sand	Siltg kg^{-1}	Clay	OC gkg^{-1}	TN
Ajebandele	6.8	570	150	280	8.61	0.39b
Oke-Ayo	7.0	600	150	250	7.07	0.20b
Modakeke	8.1	520	180	300	9.74	0.53a
Control	6.3	600	140	260	7.38	0.30b

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test at P <0.05

Table 2b Mean values of the soil properties (15 – 30 cm depth) of different auto mechanic sites.

Site Source	P cmol kg^{-1}	K	Fe	Zn mg kg^{-1}	Pb	Hg
Ajebandele	9.36c	0.26a	983.55b	13.55c	1.09b	0.43b
Oke-Ayo	14.50a	0.03b	1000.93a	17.46b	0.85c	0.44b
Modakeke	15.95a	0.05b	1002.37a	23.25a	2.66a	0.68a
Control	11.86b	0.10b	3.57c	0.56d	0.12d	0.12c

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test at P < 0.05

Table 3-Mean values of bioaccumulated N, P and selected heavy metals in the shoots of maize

Source	N g kg^{-1}	P cmol kg^{-1}	Fe	Zn mg kg^{-1}	Pb	Hg
Ajebandele	2.64b	0.24b	152.86b	11.51c	0.67b	0.20b
Oke-Ayo	2.46b	0.29b	126.56c	13.60b	0.43c	0.23b
Modakeke	2.33b	0.30b	179.03a	14.83a	2.17a	0.46a
Control	3.17a	0.67a	23.69d	1.47d	0.10d	0.05c

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test at P < 0.05