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Environmental Impact of Vehicle Service Centres on Soils in Ogbomosho Nigeria

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ABSTRACT

Soil samples collected within the vicinity of Vehicle Serving Centres (VSCs) in Ogbomosho Township were characterised to evaluate the level of heavy metals presence in the samples. The service centres were categorised into diesel and petrol service centres and samples collected from different locations were analysed using Atomic Absorption Spectrophotometer (AAS) to determine the presence and concentrations of Lead (Pb), Zinc (Zn), Chromium (Cr), Cadmium (Cd) and Silver (Ag). The results showed that the soils samples from both Petrol Engine Vehicle Service Centres (PEVSCs) and Diesel Engine Vehicle Service Centres (DEVSCs) are polluted with Pb, Zn, Cr, Cd and Ag. The metals concentrations measured in the collected samples from both PEVSCs and DEVSCs were found to follow the decreasing order Pb>Zn>Cr>Cd>Ag and Zn>Pb>Cr>Cd>Ag, respectively. The concentrations of Pb at PEVSCs were higher than European Union (EU) and Federal Environmental Protection Agency (FEPA) limits while the concentrations of all the metals detected in DEVSCS were below these limits. This study suggests that Premium Motor Spirit (PMS) used in Nigeria may contain lead (Pb) and may be one of the sources through which environmental of these vehicle services centres are contaminated with heavy metals.

Key words: Heavy metals, petrol, diesel, vehicle service centres

INTRODUCTION

Soil has become the reservoir for environmental pollutants resulting from various processes such spill, leaching and deposition (Outridge *et al.*, 2002; Akinola and Adedeji, 2007). Important pollutants found in the soils includes heavy metals which are released into the environment through natural and, majorly, anthropogenic sources (Jung, 2008). The concentrations of these metals in the soil in a particular place are influenced by its elemental constituents and quantity of heavy metal of the soil as well as the elements of the vegetation (Popa and Jitaru, 2005). Furthermore, the poor degradation and bioaccumulation strength of these metals entrench their sequestration in the environment (Ram *et al.*, 2000; Okunola *et al.*, 2007). Though, they are less harmful at certain concentrations however, when the standard limits are exceeded, some of them may be carcinogenic, mutagenic and tetragenic to man and animals (Byrdy and Caruso, 1995; Heitkemper and Caroso, 1991; Olson *et al.*, 1992).

Urban developments accompanied with increasing anthropogenic activities have shown direct environmental impact on urban soil pollution (He *et al.*, 2004; Okunola *et al.*, 2007; Onweremadu *et al.*, 2007). Urbanization consequently increases the population of middle and high class of workforce which is generally mobile with various types of light and heavy vehicles for private and public service purpose. The presence of high number of vehicles in urban centres demand establishment of vehicle service centres for their repairs and maintenance. In the course of repairs and maintenance, oil and fuel are employed for rinsing and lubricating the engine parts and the used fluids spilt on the ground and, in most cases, poured indiscriminately on the soils within the vicinity of the Vehicle Service Centres (VSCs). Many studies in Nigeria have focused on the environmental impact of oil spills on Nigerian soils particularly in the Niger Delta areas and other places susceptible to oil spills; however, less study was reported on the extent to which these VSCs in Nigerian cities polluted the urban soils (Amusan and Adeniyi, 2005). The age of such centres and the types of vehicle attended, can be of great significance to the concentration of the heavy metals found within the vicinity of these centres. The objective of this study was to assess the level of contamination of the soils within the vicinity of selected VSCs in Ogbomosho Township, Oyo State, Nigeria due to its recent rapid development. The town is fast growing in urbanization due to establishment of a state university, Ladoke Akintola University of Technology, nearly two decades ago. The school system is off-campus and this increasingly affects expansion of human activities within the town and expansion of the township boarder for construction of cottage industries which include the vehicle service centres.

MATERIALS AND METHODS

Study area and sampling: Surface soil samples were taken by hand auger from eight selected Vehicle Service Centres (VSCs) within Ogbomosho Township. Three points of equidistant (30 cm) was marked at each spot and the samples were obtained at the apex of the equilateral triangle drawn on the sampling spot. The topography terrain and the texture of the sampled soil were considered during the sampling process. Furthermore, the depths of oil penetration were equally measured with tape rule (Table 1). The stainless spoon used in scooping was washed with detergent, rinsed with copious amount of distilled water and allowed to air-dry in the sun, for subsequent extractions. Control sample was collected from a farmyard within the campus of Ladoke Akintola University, Ogbomosho where vehicle interference is very rare. All samples were collected in triplicate, packed in properly labelled polythene bags, transported to the laboratory and stored in the refrigerator for further processing.

Table 1: Properties of soil samples

	Properties of soil samples				
Sample spots	Topography	Texture	Depth of oil penetration	Vehicle type	Location
OAA	Lowland	Silt	2	Petrol engine (Car)	Oke-Anu
SOA	Lowland	Silt (loamy)	4	Petrol engine (Car)	Sabo Oke-Ado
OKD1	Highland	Clay	2	Petrol engine (Car)	Oke-Ado akintola
TSA1	Highland	Clay	1.5	Petrol engine (Car)	Township stadium
SBA	Lowland	Silt	1.5	Petrol engine (Truck)	Sabo
OKD2	Highland	Silt	5	Petrol engine (Truck)	Oke-Ado akintola
TSA2	Highland	Silt	3	Petrol engine (Truck)	Township stadium
IGA	Highland	Silt	4	Petrol engine (Truck)	Isale general
CNT	Highland	Silt (loamy)	NA	NA	Township stadium

OAA: Oke anu area; SOA: Sabo Oke Ado, OKD1: Oke Ado akintola; TSA1: Township stadium area; CNTS: Control sample; SBA: Sabo area, OKD2: Oke Ado akintola; TSA2: Township stadium area; IGA: Isale general area; NA: Not applicable

Table 2: Soil sample character before and after digestion

Sample	Digestion colour before digestion	Colour after digestion	Volume after digestion (cm^3)
OAA	Dirty orange	Dirty brown	5
SOA	Dirty brown	Deep brown	8
OKD1	Dirty brown	Brilliant brown	8
TSAI	Light yellow	Brilliant brown	8
SBA	Dirty yellow	Deep brown	7
OKD2	Dirty brown	Deep brown	8
TSA2	Light yellow	Deep yellow	9
IGA	Dirty brown	Deep brown	5
CNTS	Dirty brown	Deep brown	8

OAA: Oke Anu area; SOA: Sabo Oke Ado; OKD1: Oke Ado akintola; TSA1: Township stadium area; CNTS: Control sample; SBA: Sabo area; OKD2: Oke Ado akintola; TSA2: Township stadium area; IGA: Isale general area

Sample preparation: The soil samples from each location was homogenized, air dried in an air-circulating oven at 30°C to a constant weight and sieved to 10 mesh (<2 mm) (Okunola *et al.*, 2007). One gram of each of the sieved sample was weighed into a 100 mL breaker and 10 mL of HNO_3 was added followed by 2 mL of HCl. This was left to stand for 5 min in order to observe the colour of the mixture after which the mixture was heated to a temperature of 120°C in sand bath placed on a hot plate for about 2 h in fume cupboard and the colour change was noted (Table 2). The digested mixture was left to cool for 5 min and then filtered after shaking using Whatman filter paper into a 100 mL measuring cylinder, in order to determine the volume after digestion. The filtrate was then made up to the mark with deionised water and the quantitation of the metallic content of the digested samples was carried out using atomic absorption spectrophotometer (Alpha 4 Model). Means of all the heavy metal concentration ($\mu g\ g^{-1}$) were calculated for all the sample sites.

RESULTS AND DISCUSSION

The concentrations of the heavy metals varied significantly across sites under the study. Concentration of Lead (Pb) in Vehicle Service Centres (VSCs) (Table 3) attending to petrol engine vehicles ranged from 135.25 to 586.24 $\mu g\ g^{-1}$ while the range was 10.72 to 38.61 $\mu g\ g^{-1}$ at VSCs attending to diesel engine vehicles while the concentration of the control sample was 1.133 $\mu g\ g^{-1}$. Furthermore, Pb concentrations detected in the sample collected at the Petrol Engine Vehicle Service Centres (PEVSCs) were well above the critical limit level of 100 $\mu g\ g^{-1}$ recommended by Federal Environmental Protection Agency (FEPA) (Onweremadu *et al.*, 2007). Similarly, Pb concentration from site OAA (536.24 $\mu g\ g^{-1}$) was higher than the upper limit of 300 $\mu g\ g^{-1}$ recommended by European Union (EC, 1986). Moreover, Pb concentrations detected in soil samples from the Diesel Engine Vehicle Service Centres (DEVSCs) were above the world average of 15 $\mu g\ g^{-1}$ (Jung, 2008) except at TSA (10.72 $\mu g\ g^{-1}$). In comparison with the concentration of Pb (1.133 $\mu g\ g^{-1}$) in the Control Sample (CNT), it can be deduced that all the soil samples contaminated Pb which can be attributed to Pb reposition from either the wearing engine, the fuel itself and or other anthropogenic intrusion means. Chromium (Cr) concentration in soil samples from the PEVSCs ranged from 2.397-8.89 $\mu g\ g^{-1}$ while a range of 3.48-8.77 $\mu g\ g^{-1}$ was recorded for samples obtained from DEVSCs (Table 3). This shows an even distribution of Cr in the two types of sites studied and probably source of Cr from the vehicles are due to wears of engine and other parts that are electroplated with chromium. In addition, the presence of Cr may be due to dissolved

Table 3: Heavy metal concentration (μg g^{-1}) in vehicle service centres (VSCs) soil samples

		Heavy metals				
		Pb	Cr	Cd	Zn	Ag
Vehicle service centres	Sample spots	(μg g^{1})				
Petrol engine	OAA	586.24±0.24	3.8±0.01	0.066±0.003	80.91±0.46	0.045±0.001
	SOA	220.64±0.22	2.397±0.002	0.113±0.01	33.37±0.06	0.024±0.001
	OKD1	192.32±0.02	6.358±0.001	0.188±0.002	125.44±0.04	0.084±0.000
	TSA1	135.25±0.01	8.089±0.001	0.256±0.01	92.82±0.01	0.088±0.002
Diesel engine	SBA	32.72±0.02	3.48±0.003	0.086±0.01	45.60±0.0	0.020±0.000
	OKD2	18.39±0.09	8.77±0.01	0.23±0.0	59.54±0.04	0.069±0.001
	TSA2	10.72± 0.03	4.82±0.01	0.108±0.001	41.00±1.04	0.066±0.000
	IGA	38.61±0.0	4.76±0.02	0.06±0.0	56.00±0.1	0.035±0.000
Control sample	CNT	1.13±0.026	1.73±0.026	0.00±0.0	21.01±0.017	0.041±0.000

OAA: Oke Anu area; SOA: Sabo Oke Ado; OKD1: Oke Ado akintola; TSA1: Township stadium area; CNTS: Control sample; SBA: Sabo area; OKD2: Oke Ado akintola; TSA2: Township stadium area; IGA: Isale general area; Pb: Lead; Cr: Chromium; Cd: Cadmium; Zn: Zinc; Ag: Silver

Cr from catalyst used during crude oil refining process when compared with the concentration detected in the control sample (1.73 μg g^{-1}). Though the study showed relatively high concentrations of Cr, yet these are lower than the average concentration range (8.1-16.3 μg g^{-1}) obtained by Onweremadu *et al*. (2007) in a similar study. Similarly, these values were below the critical level (16 μg g^{-1}) legislated by the Taiwanese Government (Onweremadu *et al*., 2007). The low difference between the Cr concentration in CNT (1.73 μg g^{-1}) and maximum concentration (8.77 μg g^{-1}) recorded at OKD2 suggests that the soils of the study town, Ogbomosho, is naturally characterized by Cr. The concentration range of Cd detected at the PEVSCs and DEVSCs were 0.066-0.256 and 0.06-0.23 μg g^{-1}, respectively and these concentration ranges fell well below the concentration limit (1-3 μg g^{-1}) set by European Union (EC, 1986). However, the low concentration of Cd in all the samples investigated does not suggest that the soil is not polluted with Cd because similar study showed a high concentration of Cd well above the EU standard (Onweremadu *et al*., 2007). This could be due to the solubility of cadmium in soil under oxidized condition (Wang and Liao, 1999). Generally, Cd found in urban soil are attributed to used lubricating oil which are products of oil refining processes where Cd is employed as catalyst (Okunola *et al*., 2007).

Zn concentrations detected in soil samples from the PEVSCs ranged from 33.37-125.44 μg g^{-1} while the concentrations of samples from DEVSCs range from 41.10-59.54 μg g^{-1}. There was relative uniform distribution of Zn concentrations in all the samples detected at DEVSCs which suggest that less amount of Zn is available in diesel fuel or in the parts available in diesel engine vehicles. The distribution of Zn concentrations in PEVSCs were uneven and higher than those detected in soil samples obtained from DEVSCs, though they all fall within the range of 41.66-237.96 μg g^{-1} detected in related study reported by Okunola *et al*. (2007). Zn concentration in the control sample was 21.01 μg g^{-1} which is higher than the range (4.75-16.16 μg g^{-1}) reported for similar control sample soil in another study (Pasquini and Alexander, 2004). Higher concentrations of Zn in all the soil samples with respect to the concentration of the controlled sample may have resulted from the lubricating oil which contains Zn as an important additive during its production (Okunola *et al*., 2007). Concentration of silver (Ag) was significantly low in all the soil samples and the range of concentration of samples from PEVSCs was 0.024-0.088 μg g^{-1} whiles the range 0.020-0.69 μg g^{-1} was obtained for samples from DEVSCs. The concentration of Ag detected

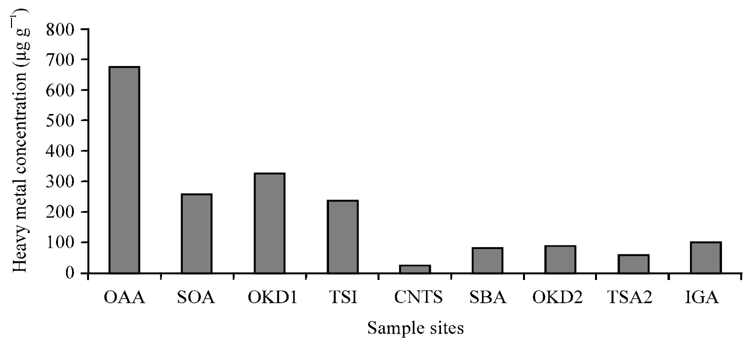

Fig. 1: Sum of heavy metals concentration (μg g^{-1}) in vehicle service centers soils. OAA: Oke anu area, SOA: Sabo oke ado, OKD1: Oke ado akintola, TSA1: Township stadium area, CNTS: Control sample, SBA: Sabo area, OKD2: Oke ado akintola, TSA2: Township stadium area and IGA: Isale general area

in the control sample (0.041 μg g^{-1}) was higher than the lowest concentrations detected at PEVSCs (0.024 μg g^{-1}) and DEVSCs (0.02 μg g^{-1}). However, Ag which is comparatively rare earths metal crust has high leaching rate from soil into groundwater (ATSDR, 1990) may be responsible for the low concentration detected in all the soil samples, though, high concentration of Ag (31 μg g^{-1}) was detected in some Idaho soils (USA) (ATSDR, 1990).

The sum of heavy metal pollutants present in each of the sample soil is shown in Fig. 1. The sum concentration of heavy metal in all the PEVSCs are more than the sum concentration detected at all the samples from DEVSCs. The least sum concentration (236.503 μg g^{-1}) detected for PEVSCs is more than twice the highest sum concentration (99.465 μg g^{-1}) heavy metals detected for DEVSCs. The sum concentration of heavy metals in DEVSCs was found in the decreasing order; OAA>OKDI>SOA>TS1>IGA>OKD2>SBA>TSA2.

CONCLUSION

The results of this study generally revealed the presence of Pb, Cr, Cd, Zn and Ag in the soils available within the vicinity of Vehicle Servicing Centres (VSCs) in Ogbomosho Township. The concentrations of these metals in the soil samples from Petrol Engine Vehicle Service Centres (PEVSCs) were found to follow decreasing order; Pb>Zn>Cr>Cd>Ag while order of concentrations in the soil samples from Diesel Engine Vehicle Service Centres (DEVSCs) was Zn>Pb>Cr>Cd>Ag. The sum concentration of the metals detected at all the PESVSCs were more than twice the sum concentration of those metals in soil samples from DEVSC). The age of such centres and the types of vehicle attended to can be of great significance to the concentration of the heavy metals found within the vicinity of these centres. Besides Pb concentrations which exceeded some acceptable limits such as FEPA and EU, the concentrations of all other elements studied were below these limits. However, their accumulation could increase with the age of the VSCs, the numbers of vehicles attended to and continuous indiscriminate disposal of oil at these service centres. Although the impact of the pollutants emphasized more on the soils within the vicinity of the VSCs, there may be risks for ground water quality in that vicinity as well. The overall implication of this study demands an effective management of used oil and fuel at these service centres through proper engineering service, awareness and improved collection system of the used fuel for recycling and proper containment.

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