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Full Length Research Paper

Assessment of heavy metal levels in soil and water contaminated with used engine oil in Port Harcourt, Nigeria

A. G. Warmate[1], T. J. K. Ideriah[2]*, I. T. Tamunobereton A. R. I.[1], U. E. Udonam Inyang[1] and T. Ibaraye[1]

[1]Department of Physics, Rivers State University of Science and Technology, P. M. B. 5080, Port Harcourt, Nigeria.

[2]Institute of Pollution Studies, Rivers State University of Science and Technology, P. M. B. 5080, Port Harcourt, Nigeria.

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The concentrations of heavy metals (Cu, Ni, Pb, Zn) in soils and water receiving used engine oil were investigated. Soil and water samples were collected at discharge and control points at each study site. The heavy metals were analyzed using atomic absorption spectrophotometer. The results show that about 80% of used engine oil was disposed of directly into the environment and 20% was recycled via use in civil works. The concentrations of metals in test soil and water samples exceeded permissible limits. The concentrations of heavy metals ranged from 20 µg/g (Ni) to 493 µg/g (Pb) in soil and 0.019 mg/l (Ni) to 0.147 mg/l (Pb) in water. It was suggested that curbside collection and re-refining of used engine oil should be encouraged and appropriate legislation should also be put in place to prevent widespread pollution of the environment by these metal ions.

Key words: Used engine oil, pollution, soil, water, heavy metals.

INTRODUCTION

Motor oils have been used since the development of steam engines as a buffer between moving and static engine components. The basic work of the lubricants being to prevent metal-to-metal contact and to transfer heat from friction away from the contact points.

Numerous chemicals such as Zinc- Diphosphate (ZDP) have been added to the original base oil (paranapthalene and aromatics) to improve on the functionality of the oil (Alloway and Ayres, 1997; Johnson et al., 2002). Other chemicals are formed when the oil is exposed to high temperatures and pressures inside the engine. Used oil contains metals such as copper, aluminium, chromium, iron, lead, manganese, nickel, silicon and tin which come from engine parts as a result of wear.

The chemicals found in used engine oil vary according to the brands and types of engine used, the mechanical condition of the engine that it comes from, the various sources (automobile, airplanes, trains, ships, tractors or lawn mowers) of the used oil and the number of kilometers driven between oil changes (Alloway and Ayres, 1997; Draggan, 2007).

Used oil is less viscous than unused oil; when disposed of into the soil, it adsorbs to the soil particles, reduces porosity and therefore reduces aeration of soil (Alloway and Ayres, 1997; Plummer and McGeary, 1993) . In virtually all the cities of advanced countries, there are legally established regulations that stimulate government, corporate organizations, manufacturers, retailers and the public to fully participate in the effective collection and proper disposal of used oils. The rop-off method of disposal of used oil by participants, which is usually voluntary, involves collection by licensed contractors at specified locations on specified days. On the other hand, curbside method of disposal of used oil involves scheduled collection conducted by contract collectors, usually 1 to 4 times yearly. It has been suggested that out of the two methods the latter, though expensive is more convenient for participants (US EPA, 1994). Also used are controlled landfill, re-refining and recycling methods. Oil filters are significant sources of used oil, therefore, should be collected and disposed of or recycled properly to check other pathways of used oils into the environment (Arner, 2007).

*Corresponding author. E-mail: itubonimi@yahoo.com. Tel: +2348033390885.

Table 1. Concentrations of heavy metals in soil (µg/g) and water (mg/l) at discharge point.

Sample names	Cu	Ni	Pb	Zn
S_A	58.60 ± 1.20	49.81 ± 2.10	188.40 ± 2.50	102.62 ± 1.60
S_B	49.20 ± 0.90	34.73 ± 1.70	493.13 ± 4.30	290.71 ± 3.70
S_C	54.50 ± 0.80	52.00 ± 1.50	214.60 ± 2.70	113.40 ± 1.80
S_D	39.30 ± 1.00	20.11 ± 0.70	108.50 ± 1.10	68.43 ± 0.65
W_A	0.036 ± 0.001	0.019 ± 0.001	0.147 ± 0.001	0.077 ± 0.001
W_B	0.034 ± 0.001	0.028 ± 0.001	0.109 ± 0.001	0.064 ± 0.001
W_C	0.032 ± 0.001	0.023 ± 0.001	0.098 ± 0.001	0.075 ± 0.001

S – Soil; W – Water; A, B, C, D – Site Location.

Nigeria as a developing country faces a serious challenge on how to manage its used oil. Simply reflecting on the fact that one oil change, for an average saloon car, releases four quarts of used oil, used engine oil not properly disposed of would contaminate and/or pollute soil and water, thereby adversely impacting on flora and fauna. Some contents of the pollutants may be stored, through bioaccumulation. When fishes, animals or plants that store these pollutants are ingested and/or consumed, human beings are indirectly exposed to serious health hazards, such as kidney and liver damage, skin and lung cancer, neurotic effect and anaemia from lead poisoning, gingivitis as well as alteration of body metabolism (Aigbedion, 2005; Fergusson, 1990; Wilkinson and Philips, 2003; Zakrzewski, 2002).

The hazards caused by pollutants, some of which have been mentioned above, call for urgent attention. Awareness must be created by bringing to the fore the concentration levels of some heavy metals in our soils and water. The study area, Port Harcourt, is a typical city in Nigeria with marine, land and air transport systems. It is situated between latitude 4° 43' 07 and 4° 54' N, and longitude 6° 56' 04 and 7° 03' 20 E with an average temperature of 29°C and average rainfall of 2000 mm (Ideriah et al., 2008). The automobile and autobike densities are very high. It is a city with a population of about two million, a quarter of which may be said to have saloon cars or autobikes (used for commercial transportation). The public utilities (especially electricity) are far from what is expected so that nearly half of the population uses their own portable electricity generators.

This study is aimed to evaluate the contribution of used engine oil to the levels of Cu, Ni, Pb, and Zn in soil and water and to create awareness on effect of improper disposal of used engine oil in Port Harcourt and suggest appropriate method of collection and disposal.

MATERIALS AND METHODS

Four sites were chosen within the study area viz:

Site A: Trailer park at Onne junction, Eleme – a major centre for heavy duty mechanics.

Site B: Ikoku/Olu-Obasanjo road junction – a major centre for auto mechanics.

Site C: Mechanic Village, Diobu – a major centre for auto-mechanics.

Site D: Banham Street, off Aggrey Road – a major centre for auto-bike repairs and servicing.

Sample collection, preparation and analyses

Soil and water samples were collected at downstream (discharge point) and upstream (control). Four soil samples from sites A-D were collected into polyethylene bags using trowel. The soil samples were then taken to the laboratory for analyses. The soil samples were oven-dried, ground to fairly uniform size and sieved with 2 mm sieve. They were then digested with nitric acid to desorb and extract the metal contents adsorbed to the soil particles. After the acid digestion, the solutions were centrifuged at 2000 rpm for 10 min to separate the clear solution from the residue. Thereafter, the clear solutions were filtered through whatman No. 1 filter papers and used as test samples for analyses (Fuentes et al., 2004).

Water samples were collected from sites A, B and C using sterilized polyethylene bottles. The samples were acidified with concentrated nitric acid for preservation before analyses. Both soil and water samples were analyzed for Cu, Ni, Pb and Zn using flame Atomic Absorption spectrophotometer (FAAS) following procedures reported elsewhere (Fuentes et al., 2004; Ideriah et al., 2007).

RESULTS AND DISCUSSION

The results of the analyses are presented in Tables 1 and 2. Tables 1 and 2 show that the concentrations of heavy metals in both soil and water samples at the discharge point are higher than those at the upstream site. This observation indicates contamination of the environment. The least concentration of Cu was measured at site D (autobike mechanics shade). This low value may be attributed to lower volume of used engine oil change at the site in comparison to others. The concentration at this site (site D) though low, exceeded the acceptable limit (Table 3). Ni shows a similar trend for Cu (A>B<C>D). The concentration falls within the acceptable limit for Ni (Table 3). It was observed that though Ni concentration falls within acceptable limit it is non-the-less close to the upper limit. Pb has a wide range of concentration

Table 2. Concentrations of heavy metals in soil (µg/g) and water (mg/l) upstream of study sites.

Sample names	Cu	Ni	Pb	Zn
S_A	32.00 ± 1.00	26.00 ± 1.00	90.60 ± 1.00	70.00 ± 0.65
S_B	30.00 ± 1.00	21.00 ± 4.70	97.00 ± 1.10	64.00 ± 0.65
S_C	31.00 ± 1.00	22.00 ± 3.70	95.00 ± 1.10	65.00 ± 0.65
S_D	33.00 ± 1.00	27.00 ± 0.70	102.00 ± 1.10	66.00 ± 0.65
W_A	0.017 ± 0.001	0.010 ± 0.001	0.033 ± 0.001	0.042 ± 0.001
W_B	0.015 ± 0.001	0.009 ± 0.001	0.040 ± 0.001	0.035 ± 0.001
W_C	0.016 ± 0.001	0.008 ± 0.001	0.035 ± 0.001	0.040 ± 0.001

Table 3. Comparison of concentrations of heavy metals with acceptable limits.

Elements	Acceptable limit (µg/g)	Wave length (nm)	FAAS Dekition limit (mg/l)
Cu	30–40	324.80	0.077
Ni	30–70	232.00	0.140
Pb	85 – 450	217.00	0.190
Zn	135 - 150	213.90	0.018

Source: Fuentes et al. (2004).

variation. Tables 1 and 2 show that there is contamination of the soils by Pb, ranging from twice upstream value (site C) to as much as four times upstream value (site B). Site B is, not only a major service centre for light and medium vehicles, but also a centre for autobike and electricity, generator repairs and service. It also serves as retail outlets for engine oil and possible spill from the retail outlets could have caused the high level of concentration of Pb at site (B). In spite of the high level of Pb concentrations, it is still within the acceptable level except at site B where sudden increase occurred. The soil samples, from Tables 1 and 2, show Zn contamination. Tables 1 and 3 show that the concentrations of Zn in both soil and water fall within acceptable limits except at site B in soil at the discharge point. This may be attributed to the volume of used engine oil change.

The water samples showed a general trend of increased concentrations of heavy metals for all the sites. The concentration of Cu was observed to decrease from A to C. The concentrations of Cu are about twice the upstream values. This may be attributed to run-offs from the sites though the topography and quantities introduced at the sites deferred. Ni showed almost the same value for sites B and C and it was observed low at site A. Thus no particular trend was observed for Ni and Zn. A plausible reason for this low value could be that there is bioaccumulation by organisms and possible preferential absorption and adsorption of Ni by bottom sediments of the water body. Pb in water sample at site A (W_A) is higher than W_B and W_C. Whereas water sample W_A has a

higher concentration of Pb it is soil sample S_B that has a higher concentration of Pb. The high heavy metal concentration is attributed to run-offs into the water body Zn concentrations in water at all the sites were higher than the upstream concentrations and the values exceeded the acceptable limit.

Table 4 obtained through oral interviews show the collection profile of used engine oil. It is observed that the popular mode of collection is collection at service stations. Curbside collection is either not known or unpopular. It has been suggested (US EPA, 1994) that curbside collection, though expensive, is a more convenient and effective method of used engine oil collection. However the disposal method that is observed to be popular is disposal directly into the environment. This is environment unfriendly. About 80% of used engine oil is disposed off in this way while about 20% of used engine oil is re-cycled. Re-refining of used oil is not practiced. Refining could cut down the used oil released into the environment by about 30 to 50%.

This would, undoubtedly reduce the heavy metal load in the soils and waters. Though in some cases, the metal load and/or mobile metal content is within internationally acceptable limits, continuous exposure to them could be harmful to humans; different persons respond differentlyto these metals (Alloway and Ayres, 1997; Draggan, 2007)

Conclusion

The findings of this study have shown that heavy metals such as Cu, Ni, Pb and Zn are found in high enough

Table 4. Collection and disposal profile of used oil obtained at various sites.

Sample sites	Collection profile			Disposal profile		
	Drop-off (%)	Curbside	Collection at service stations	Disposed of into the environment (%)	Recycled (%)	Re-refined
A	11	-	87	75	21	-
B	10	-	85	69	27	-
C	16	-	79	68	24	-
D	6	-	90	92	4.5	-

concentrations to cause concern since some metals exceeded acceptable limit, while others are close to upper limits. The variations in concentrations of the metals were influenced by the volume of used engine oil and run-offs. It is, therefore, recommended that both curbside collection and re-refining be popularized through appropriate enlightenmen of stake-holders. There should also be appropriate legislation to ensure effectiveness in the disposal method.

REFERENCES

Aigbedion LN (2005). Environmental Pollution in the Niger Delta, Nigeria. Inter-Disciplinary J. Enugu Niger., 3 (4): 205-210.

Alloway BJ, Ayres DC (1997). Chemical Principles of Environmental Pollution, 2nd Ed. Blackie Academic and Professional, Glasgow, UK, pp. 10-30.

Arner R (2007). Used Oil Recycling: Closing the Loop http://wwwuser.shentel.net/lyncrum/rob%20Arner/side%20pages/u02.htm.

Draggan S (2007). Health effect of Used Mineral-Based Crankcase Oil, Encyclopaedia of earth http://www.earth.org/article /Health effect of used mineral-base crankcase oil.

Fergusson JE (1990). The Heavy Elements; Chemistry of Environmental Impact and Health Effects. Pergamon Press, England, pp. 20-35.

Fuentes A, Llorens M, Saez J, Aguilar MIU, Ortuno JF, Meseguer VF (2004). Phytotoxicity and heavy metals speciation of stabilized sewage sludges. J. Hazard. Mater., 108: 161.

Ideriah TJK, Omuaru VOT, Osaisai CB (2007). Concentrations of heavy metals in leachates and water around solid waste dumpsites in Port Harcourt, Nigeria. Curr. Top. Toxicol., 4: 45-50.

Ideriah TJK, Warmate AG, Alabraba MA (2008). Effect of Naked lamp on levels of Air Pollutants in Port Harcourt, Nigeria. Medwell Res. J. Appl. Sci., 3(1): 77-80.

Johnson DL, Rhodes B, Allen R (2002). Canola-based Motor Oils. http://www.purduce.edu/newcrop/ncnu02/v5-029.html.

Plummer CC, McGeary D (1993). Physical Geology, 6th Ed. Wmc. Brown Publishers, California, USA, pp. 1-30.

United States Environmental Protection Agency (US EPA) 1994: Environmental planning for small communities. A guide for local decision makers 625/ R-94 / 099.

Wilkinson JM, Philips CJC (2003). Proceedings of the UK Nutrition Society, 62: 267.

Zakrzewski SF (2002). Environmental Toxicology. 3rd Ed. Oxford University Press. USA, pp. 5-45.