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Impact of waste vehicle tyres incineration and heavy metals contamination of soil in some locations in Lafia, Nasarawa State

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This study was carried out in Lafia, to determine metallic pollution in soils due to incineration of tyre on the soils at different layers and the effect of pH on the heavy metals leaching. Soil composite samples were collected from 5 identified locations (Shabu, Wakwa Alhaji, Ombi1, Tudun Amba and Akurba) manually at various depths, 0-10, 11-20 and 21-30 cm using a stainless-steel hand auger. Atomic Absorption Spectrophotometer (AAS) was used for the analysis of the selected heavy metals. The samples showed elevated amounts of metallic depositions compared to the control sample. It was also observed that the heavy metals concentrations in the soil samples decreased with soil depth. The distribution pattern was in the following order Zn > Fe > Pb > Cd > Cu. Across all the sampling locations and profiles, Zn and Cu showed the highest (9.380 mg/kg) and least (0.003 mg/kg) mean concentrations respectively. The pH values ranged from slightly acidic to slightly alkaline with 7.3 - 8.4 (0 - 10 cm), 7.1 - 7.4 (11 - 20 cm) and 6.9 - 6.7.4 (21 - 30 cm). The waste tyre burning serves as a potential source of heavy metals pollution to the environment.

Key words: Heavy metals, Lafia, atomic aborption spectrometer, soil, tyre.

INTRODUCTION

Heavy metals get into the earth's crust through natural and anthropogenic activities. Natural sources could be weathering of earth's crust and anthropogenic activities including mining, soil erosion, industrial discharges, urban runoff, sewage effluents, application of pests or disease control agents to crops, air pollution etc. (Ming-Ho, 2005; Bando et al., 2023). The concentration of these heavy metals varies across different ecological environments or regions and have tendency to be cycle in the order: Industry, atmosphere, soil, water, foods and human (Morais et al., 2012). Their distribution in the environment is governed by the specific properties of the metals (Khlifi and Hemze-Chaffai, 2010). The sole purpose of designing tyres is for vehicles and not to be burned as a fuel. They constituents of tyres are hazardous to the environment and carcinogens. Tyre-

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Figure 1. Map of Nasarawa state showing Lafia local government area.
Source: Ezekiel et al. (2021).

derived fuel (TDF) also contains remnants of wire that are difficult to totally remove. In Nigeria, there is little or no records of the quantity of scrap tyres but their uses on old vehicles, burnt as fuel or either to obtain iron and steel frames and other purposes such as roasting animal skin is encountered in various parts of the country (Beetseh and Onum, 2013; Bando et al., 2023).

Indiscriminate habit of burning of waste tyres is of public health concern and a potential threat to environmental. There is high tendency of emission of heavy metals to the soil, water and air through uncontrolled, open, waste tyre incineration, its effect in the ecosystem is a major concern (Mashi et al., 2005, Bando et al., 2019). Unlike other organic toxic substances that can be destroy in the environment either through biological or chemical processes, heavy metals possess these characteristics of being persistent in the environment (Beetseh and Onum, 2013; Bando et al., 2023). Some of the metallic contaminants such as Pb, Cd, Hg, Cu and As, which are mostly found in the ecosystem are of no beneficial value in humans (Draghici et al., 2010; Vieira et al., 2011). These metals are generally considered as injurious to humans and animals as even at low concentrations they have potentials of causing adverse effects to human and animal health (Jomova and Valko, 2011; *Tokar* et al., 2011).

The severe degradation of air, water and soil quality in most parts of the world are attributed to the growth in the number of industries and urbanization (Bando et al., 2019). Elevated levels of heavy metals depositions in urban environments are as a result of increase of anthropogenic activities. In today's industrial society, there is no escaping exposure to toxic substances and metals. Therefore, there is need for government and other non-governmental organisations to ensure or implement monitoring programmes that will ensure the quality and safety of water, food, soil and air and the environmental health. This study aimed to evaluate the impact of vehicle tyre incineration and metallic depositions of soil in some locations in Lafia, Nasarawa State (Figure 1).

MATERIALS AND METHODS

Study area description

Lafia is the capital city of Nasarawa state in central Nigeria region which lies geographically 8°29'30''N and 8°31'0''E. The human population of Lafia is placed at 330,712 according to the 2006 census. It is the largest town in Nasarawa State.

Sampling locations

The soil samples were collected from 5 identified locations of open incineration of tyres within Lafia. Table 1a shows the specific locations.

Sample collection

Two types of soil samples were collected manually as described by

Table 1a. Sampling locations.

Incineration sites	Location	Specific address	Latitude	Longitude
A	WakwaAlhaji	Behind Project Quarters, Shendam Road Lafia	08º30’27.1’’N	008º33’47.3’’E
B	Akurba	Near precious FM	08º31’29.8’’N	008º33’34.8’’E
C	Ombi 1	By Nasarawa State Polytechnic	08º32’23.1’’N	008º31’55.5’’E
D	TudunAmba	Behind NTA,Doma road Lafia	08º28’25.7’’N	008º31’32.4’’E
E	Shabu	Shabu Dumpsite	08º32’20.1’’N	008º31’65.3’’E

Prajapati and Meravi (2014), in each location. The first from the contaminated soil at depth 0-10, 11-20 and 21-30 cm in triplicates respectively. The second were collected from a control site that appeared free from any burning activity at 250 m interval. All the soil samples were separately put in airtight transparent low-density polyethylene pouch and taken to laboratory for sample preparation and analysed.

Sample preparation

Soil sample preparation was done in the soil science laboratory of Nasarawa State University. The soil samples were dried in an oven at 50°C for 3 days. The dried soil samples were then sieved with 5 mm mesh to remove stones, coarse materials and other debris. Twenty grams portion of the sieved soil samples were ground in a mortar and then stored in airtight polythene pouches in a desiccator (Xiandong et al., 2004).

Sample digestion and extraction

The stock solution of each of the ground soil samples was then prepared and heavy metal analysis was carried out using a strong acid digestion method. Approximately 1.0 g of each of the prepared soil sample was weighed and placed in pre-cleaned Pyrex test tubes. Thirty-two millilitre concentrated HNO_3 and 8 ml concentrated $HClO_4$ were added. The mixtures were heated at 50°C for 3 h, 75°C for 1 h, 100°C for 1 h, 125°C for 1 h, 150°C for 3 h, 175°C for 2 h and 190 for 3 to 5 h until completely dried. After the test tubes are cooled 40 ml of 5% HNO_3 was added and heated for 1 h with occasional stirring. On cooling, the mixtures were decanted into polythene tubes and centrifuge at 3500 rpm for 10 min. Metal concentrations of the solutions were measured using Inductively Coupled Plasma-Atomic Adsorption Spectrometry (ICPAAS). The major heavy metals analysed were Cu, Pb, Cd, Fe and Zn.

Data analysis

The data generated from the laboratory analyses of the selected heavy metals were subjected to inferential statistics using ANOVA at a significance level of $P \leq 0.05$.

RESULTS

Table 1b shows the mean concentration of selected heavy metals from the 5 sample sites. Zn has the highest mean concentration in mg/kg in all the sites when compared with other heavy metals, in order of C>A>B>E>D with mean values of 9.38±0.16, 0.02±0.41, 8.84±0.71, 7.18±0.90, 7.15±0.08 respectively. The second metal with high mean concentration values is Fe, in the order of E>C>B>A>D with values of 2.06±0.62, 1.55±0.36, 1.48±0.34, 0.82±0.01 and 0.78±0.26, respectively. Pb mean concentration in mg/kg is high in site A (0.40±0.20) and lowest in site C (0.00±0.00). Fe mean concentration in mg/kg is high in site E (2.06±0.62) and lowest in site C (0.78±0.26). Zn mean concentration in mg/kg is high in site C (9.38±0.16) and lowest in site E (7.15±0.08). Cu mean concentration in mg/kg is high in site B (0.0347±0.01794) and lowest in site D (0.00±0.00).

Table 2 shows the pH values of the soils at varied depth and in different sites. The pH of the soil at depth 1 to 10 cm is higher than pH at any depth with highest value of 8.410 in site C. The lowest value of the pH was recorded at site E (6.898).

DISCUSSION

Generally, this study shows elevated amounts of all the heavy metals in the contaminated sites when compared to their controls. Zn has the highest concentrations in all sites. This implies that Zn is relatively higher in concentration in the chemical metal components of the tyres. This is in concordance with the research of Beetseh and Onum (2013). Fe is the second metal with high mean concentration in all the sites. This can be attributed to being abundant natural element of the soil in that region. The difference in the concentrations of these metals between sites could be as a result of the re-occurrence of this activity more often in one site than the others. Contaminated sites have higher concentrations compares to the control. This may be attributed to the open incineration of tyre.

The amount of the metallic deposition in site A at various depths shows high level concentration of the metals at the depths of 1 to 10 cm, and low-level concentration was observed at the depths of 21 to 30 cm. This disagrees with the submission of Raju et al. (2013) which reported an increase in the heavy metals as the depth of the sampled soil increases. However, the finding of the present study, agrees with that of Jean-Philippe (2012) which shows a remarkable decrease in heavy

Table 1b. Concentration of selected heavy metals from different sampling sites.

Sites (cm)	Mean concentration of heavy metals (mg/kg)				
	Pb	Fe	Zn	Cu	Cd
Site A					
1-10	0.40±0.20 [b]	0.82±0.01[a]	9.02±0.41[b]	0.02±0.01[a]	0.25±0.00[b]
11-20	0.37±0.16 [b]	0.81±0.01[a]	9.01±0.28[b]	0.01±0.01[a]	0.23±0.00[b]
21-30	0.33±0.11 [b]	0.81±0.01[a]	8.67±0.31[b]	0.01±0.01[a]	0.20±0.00[b]
Site B					
1-10	0.34±0.17[ab]	1.48±0.34[ab]	8.84±0.71 [b]	0.04±0.02[a]	0.30±0.05[b]
11-20	0.31±0.12[ab]	1.42±0.28[ab]	8.73±0.64 [b]	0.04±0.01[a]	0.29±0.04[b]
21-30	0.31±0.07[ab]	1.37±0.25[ab]	8.72±0.47 [b]	0.03±0.02[a]	0.29±0.04[b]
Site C					
1-10	0.00±0.00[a]	1.55±0.36[ab]	9.38±0.16 [b]	0.02±0.01[a]	0.13±0.06[ab]
11-20	0.00±0.00[a]	1.49±0.21[ab]	9.18±0.14 [b]	0.02±0.01[a]	0.13±0.04[ab]
21-30	0.00±0.00[a]	1.47±0.18[ab]	8.78±0.08 [b]	0.01±0.00[a]	0.12±0.04[ab]
Site D					
1-10	0.03±0.00 [a]	0.78±0.26[a]	7.15±0.08[ab]	0.00±0.00[a]	0.12±0.06[ab]
11-20	0.03±0.00 [a]	0.73±0.26[a]	7.12±0.06[ab]	0.00±0.00[a]	0.12±0.06[ab]
21-30	0.02±0.01 [a]	0.68±0.16[a]	7.10±0.05[ab]	0.00±0.00[a]	0.11±0.04[ab]
Site E					
1-10	0.06±0.00[ab]	2.06±0.62[b]	7.18±0.90[ab]	0.01±0.01[a]	0.25±0.13[b]
11-20	0.07±0.01[ab]	1.97±0.52[b]	7.17±0.80[ab]	0.01±0.01[a]	0.23±0.12[b]
21-30	0.04±0.00[ab]	2.01±0.54[b]	7.15±0.78[ab]	0.01±0.01[a]	0.22±0.08[b]
Control	0.00±0.00	0.72±0.10	4.69±0.59	0.00±0.00	0.00±0.00

Mean with the same letter within a column are not significantly different at $p<0.05$; *All values are means of triplicate determinations.

Table 2. pH Values of soil samples at varied depth and sites.

Site	Depth (cm)	pH
Site A	0 - 10	7.85±0.26
	11 - 20	7.38±0.36
	21 - 30	7.20±0.13
Site B	0 - 10	7.60±0.21
	11 - 20	7.24±0.13
	21 - 30	7.24±0.13
Site C	0 - 10	8.41±0.12
	11 - 20	7.42±0.61
	21 - 30	7.42±0.93
Site D	0 - 10	7.30±0.57
	11 - 20	7.24±0.13
	21 - 30	6.99±0.56
Site E	0 - 10	7.81±0.61
	11 - 20	7.12±0.10
	21 - 30	6.90±0.46

metals with regards to the soil depths.

The concentrations of heavy metals at varying depth in sites B, C, D and E followed similar pattern to site A. The pH value in general ranges from slightly acidic to slightly alkaline. This slight difference of the soil characterization may not have effect on the distribution of the heavy metals at varying depths. This agrees with the submission of Jean-Philippe (2012) which observed that the effect of pH on the bioavailability in close range is insignificant.

When compared to set standards, all the results of the present study are within maximum permissible levels by WHO/FAO. By implication, they cause no harm, but since the burning activity is continuous, soil accumulation of heavy metals may occur, and hence available to be transported by run-off water and taken up by plants.

Conclusion

Open incineration of used tyres is not a sustainable environmental waste management practice. The heavy metals where within the acceptable set limits of WHO/FAO. However, their presence in the contaminated soil calls for concern as accumulation over time may increase the level of these metals above set limits.

Recommendation

1. Uncontrolled burning of tyres should be discouraged.
2. Better waste management practice should be adopted.
3. Agricultural activities within the vicinity of contaminated area should be discouraged as the heavy metals may change the properties of the soil that might affect it uptake of minerals by plants and reduce crop productivity and its consumption might promote ill health in humans.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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