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Impact of auto-mechanic activities on the surrounding soil environment in Bauchi Metropolis

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Abstract
The increasing numbers of contaminated sites within residential areas in Bauchi metropolis could result in serious environmental pollution and health risks to humans. This study was conducted to assess the impact of auto-mechanic activities on the surrounding environment. Soil samples were collected at the depth of 30cm and analysed using the Atomic Absorption Spectrophotometer. All the metals investigated were present in the soil at very high concentrations compared to their background samples, World Soil Average and the Department of petroleum resources target values. The range of the calculated geoaccumulation indices for the study metals were Cd: 1.000 – 90.32, Cr: 1.150 – 11.216, Cu: 0.554 – 3.882, Pb: 1.00 – 31.976, Mn: 1.312 – 4.170, Ni: 0.000 – 4.772, while the pollution indices results for each metal ranged from 0.000 for Ni to 450.00 for Cd, indicating different pollution levels. The Pollution load indices (PLI) for the various study sites were all extremely high (PLI > 1) and followed the hierarchical order NJ (23.96) > AB (21.31) > YT (10.00) > JR (5.26). With these high levels of pollution, the auto-repair sites therefore constitute a serious threat to their environs and should as a matter of urgency be re-developed or relocated very far from residential areas.

Keywords: Pollution Indices, Hazardous wastes, artisans, background samples, auto-mechanic activities

Introduction

The operations of artisans in auto-mechanic servicing and repairs facilities in Nigeria have remained an important part of the society since they assist in solving problems associated with transportation in societies. Unfortunately, these facilities are poorly designed to manage the enormous amount of wastes generated in them and has continued to raise environmental concerns among environmentalists and researchers. Bauchi state in North East, Nigeria has continued to witness rapid influx of new and fairly used motor vehicles within its borders in the past twenty years. With the number of motor vehicles in Bauchi L. G. A., the state's capital, the business of repairs and maintenance of these vehicles has become very lucrative; leading to an increase in the number of these workshops and garages within and outside residential areas. Hazardous wastes such as automobile used oil, weared machinery, heavy metals from organic and inorganic chemicals etc. are dumped on the soil indiscriminately, causing soil and water contamination/pollution problems. Pollutants generated in these facilities affect the quality of storm water runoff; contribute significantly to elevated pollution levels of heavy metals in surface and subsurface soils; cause substantial alteration in the chemical composition and pH of soil; and soil quality, which consequently affect the plant growth, microbial population and human health (Lenntech, 2005; Nkanu *et al*., 2020 [14]; Nzeakor *et al*., 2022) [17].

In Nigeria, pollution problems associated with mechanic workshops have been reported by many researchers. (Pam *et al*., 2013 [23]; Iyabo *et al*., 2015 [10]; Ekeocha and Anunuso 2016; Nkanu *et al*., 2020) [14]. Usman *et al*., (2013) reported that the elevated levels of some heavy metals in some ground water of North Central Nigeria compared to the maximum allowable limits set by WHO for drinking water were attributed to the larger scale mechanic activities taking place there. Heavy metals such Cu, Pb, Cd, Cr, Mn and Ni are among the toxic metals most frequently associated with automobile waste (Demie, 2015 [3]; Nkanu *et al*., 2020 [14]; Okeke *et al*., 2022) [19]. High level of cadmium in exposed individuals may interfere with cerebral pyruvate metabolism and this may lead to thiamine deficiency, emphysema and proteinuria in the occupationally exposed individuals (Okeke *et al*., 2018). Chromium is essential for the utilization of amino acids, carbohydrate and lipid metabolism. Low level of chromium or its under-utilization has been linked with the causes of diabetes mellitus and glucose intolerance. However, excessive amount can cause toxicity (Victor *et al*. 2006) [29]. Copper was confirmed as an essential element for plants in the 1930's. It is one of the most abundant trace metals. For almost all organisms it is an essential micronutrient (Alloway 1990 [1]; Duffus 1980) [4]. Copper deficiency is attributed to anaemia and low level of HDL cholesterol. It is a widespread contaminant in soils and was the first metal to be linked with failures in reproduction. Lead is known to exert its most significant effect on the nervous system, including motor disturbances, sensory disturbances, the hematotiopic system and the kidney and ultimately, major brain damage (Macrea, 1993 [13]; Arinola and Akinbinu, 2006) [2]. Manganese is one of the essential micronutrients but at high levels (above 5mg/day), it can cause damage to vital organs of the body, developing fetus and respiratory tract. Manganese may be released to the environment through the use of gasoline containing Methylcyclopentadienyl manganese tricarbonyl (MMT) as an additive, erosion of manganese-containing soils and burning of fossil fuel (Ipeaiyeda and Dawodu, 2007 [8]; Rusydi *et al*., 2021) [24]. Nickel occurrence in the environment is very low. Humans are exposed to nickel by inhalation and eating contaminated food. High doses of nickel in humans can result to health problems such as cancer, birth defects, heart failure and allergies.

The impact of automobile repair workshops on the surrounding soil environment within Bauchi State is yet to be understood. No attention has been given to these automobile facilities in Bauchi State. No awareness is been created to check this menace in Bauchi State by concern bodies. Though very few studies have been carried out in automobile workshops by researchers in Bauchi (Okeke *et al.*, 2014a [20], 2018), none of these studies have been able to show the level of environmental contamination/pollution with regards to heavy metals generated in these facilities. This may have resulted in poor legislation by concerned government agencies and inadequate policy formulation regarding auto-mechanic waste management in the state. This study is therefore aimed at assessing heavy metal contamination/pollution status of soil in auto-mechanic facilities in Bauchi, North–East Nigeria and to ascertain the impact of the activities within these facilities on the surrounding environment. The outcome of this present study will furnish concerned agencies such as Bauchi State Environmental Protection Agency (BASEPA), Nigerian Environmental Standards and Regulations Enforcement Agency (NESREA) and other stakeholders on environment with adequate data on pollution status of these facilities, for the infrastructural redevelopment/remodelling of auto-mobile facilities in Bauchi State.

Assessing levels of pollution

To measure the metal pollution levels in soil in the study areas, the concentrations of heavy metals obtained in the auto-sites were compared to their respective background samples.

Index of geo-accumulation

Index of geo-accumulation (Igeo) is used to assess the degree of pollution per metal in environment (Tijani and Onodera, 2009).

Igeo = log $2C_x$ / 1.5 C_y.

In this study, C_x is the level of the heavy metal in the study sites while C_y is the level of heavy metal in the background samples. Seven pollution classes have been used to categorise the degree of metal pollutants in soils (Huu *et al.* 2010).

Igeo < 0 means unpolluted
0 ≤ Igeo <1 means unpolluted to moderately polluted
1 ≤ Igeo <2 means moderately polluted
2 ≤ Igeo <3 means moderately to strongly polluted
3 ≤ Igeo <4 means strongly polluted
4 ≤ Igeo <5 means strongly to very strongly polluted
Igeo >5 means very strongly polluted

Pollution index (Pi)

Pollution index (Pi) is also a single pollution index normally used to measure pollution level per metal. A metal is considered a significant pollutant when the Pi > 1. The Pollution index of a metal is given as follows;

$Pi = C_m / C_b$

Where C_m is the concentration of a metal pollutant in the polluted sites and C_b is the background concentration of the metal pollutant (Nwachukwu *et al*., 2010) [16]

The Pollution Load Index (PLI)

The pollution load index proposed by Tomllinson (1980) [27] is an integrated index used to measure the overall metal pollution in a particular site. It is also very useful to compare pollution level among several sites. The pollution load index can be determined using:

$PLI = (C_F1 \times C_F2 \times C_F3 \times \ldots \times C_FN)^{1/N.}$

Where N is the number of metals under investigation and C_F is the contamination factor of the various metals; C_F gives the ratio of the concentration of the heavy metals in the study sites to that of the background samples ($C_F = C_s / C_o$). A PLI <1 shows perfect site quality while PLI > 1 shows that the quality of the site is deteriorating (Sam *et al*. 2015).

Materials and Method

Study area

The study was conducted in 4 auto-mechanic facilities in Jos road (JR), Yelwa Tudun (YT), Nasarawa Jahum (NJ) and Amadu Bello way (AB). These sites comprise of mechanic, welding and vehicle painting units. The locations chosen are all within residential areas to reflect the possible risks auto-repair sites may be posing ithin these localities.

Sample Collection and preparation

Fifty nine soil samples were collected from the three different units within the study areas and the control sites at a depth of 30 cm. The samples were air dried, sieved and stored in a labelled polythene bag before transporting to the laboratory for subsequent analysis.

Determination of metals

In a 100 cm^3 cornical flask, 1.0g of ground soil samples were digested with 20 cm^3 aqua regia ((HNO_3: HCl, 3:1 ratio) and left to stand overnight. The digested mixture was boiled gently for 2 hours at 95ºC, allowed to cool and then filtered. The filtrate was diluted to 100 cm^3 with 2M HNO_3 in a 100ml standard volumetric flask. The digests used for the heavy metal determination using the atomic absorption spectrophotometer (Bulk Scientific 210, VGD) (Iwegbue *et al.*, 2013 [9]; Nor *et al*., 2012) [15].

Results and Discussion

The concentrations of the heavy metals in the auto-sites were higher than those of the background samples (values in parentheses) (Table 1). In JR, the levels of the studied metals were higher than the world soil average (WSA), except Mn (288.8±6.92 mg/kg). In YT and NJ respectively, all the metals except Ni (6.05±1.02mg/kg, 13.53±3.12mg/kg, 20.45±2.01 mg/kg) were higher than the WSA, while Cu (26.50±2.04 mg/kg) and Ni (6.00±2.06 mg/kg) were found to be lower than the WSA in AB.

Table 1: Mean heavy metals concentration (mg/kg) in the study sites

Sites/ Metal	JR	YT	NJ	AB	WSA[a]	DPR[b]
Cr	126.6±1.49	379.1±2.83	540.43±4.21	100.50±6.30	59.50	100.00
	(20.30±0.56)	(22.10±1.77)	(9.67±0.27)	(10.03±0.03)		
Cu	67.66±1.06	51.20±1.19	57.74±2.00	26.50±2.04	38.90	36.00
	(23.70±2.18)	(3.49±0.69)	(4.90±0.03)	(9.60±0.42)		
Cd	13.99±0.13	15.62±1.84	12.00±2.04	9.00±2.12	0.41	0.80
	(2.84±0.68)	(2.15±0.18)	(0.22±0.02)	(0.02±0.50)		
Pb	87.67±4.54	107.47±3.95	79.60±3.10	140.00±2.52	27.00	85.00
	(3.00±0.14)	(22.0±2.02)	(7.50±1.02)	(4.41±0.03)		

Ni	34.87±5.45 (BDL)	6.05±1.02 (0.53±0.08)	20.45±2.01 (0.86±0.32)	6.00±2.06 (0.48±0.02)	29.00	35.00
Mn	288.8±6.92	949.0±19.4	800.00±4.36	380.50±10.00	488.00	473.00
	(35.00±3.78)	(97.33±5.08)	(38.5±3.01)	(20.15±0.35)		

(JR= Jos road; YT= Yelwa Tudu; NJ = Nasarawa Jahum; AB= Adamu Bellow Way. Values in parentheses are levels in
control sites; BDL= Below Detection Limit, WSA – World Soil Average, DPR - Department of petroleum resources target values, [a] Eze, 2014; [b] DPR, 2002)

The levels of the heavy metals in these study were similarly higher than the target values for metals set by the DPR, except for Cu (26.50±2.04 mg/kg) in AB; Mn in JR (288.8±6.92 mg/kg) and AB (380.50±10.0 mg/kg); and Ni in all the sites. The Levels of Pb in NJ was not substantially lower than the DPR value for Pb. The elevated metal concentration for these sites within residential areas calls for serious public concerns.

Table 2: Geoaccumulation Index of the heavy metals in the study sites

Workshop	Cd	Cr	Cu	Pb	Mn	Ni
JR	1.000	1.252	3.000	5.865	1.312	0.000
YT	1.458	1.150	3.000	1.000	2.000	2.291
NJ	10.95	11.22	2.365	2.130	4.170	4.772
AB	90.32	2.011	0.554	6.371	3.790	2.509

JR= Jos road; YT= Yelwa Tudun; Nasarawa Jahum; AB= Adamu Bellow Road

The geo – accumulation index (I_{geo}) presented in Table 2 shows that the various sites investigated are polluted by the heavy metals at different degrees, except Ni in JR. For AB and YT, the pollution level of Ni was moderate (2.509 and 2.291). All the sites except JR and YT (with moderate pollutions) were very strongly polluted with Cd. Cr moderately polluted JR, AB and YT while very strongly polluting NJ. All the sites were strongly polluted with Cu, except AB and NJ, with moderate pollution. Pb pollution was very strong in JR and AB while for Mn, the pollution range from moderate to strong pollution in all the sites.

Table 3: Pollution index for heavy metals in mechanic workshops

Element	JR	YT	NG	AB
Cd	4.93	7.27	54.55	450.00
Cr	6.24	17.15	55.89	10.02
Cu	2.86	14.67	11.78	2.760
Pb	29.22	4.89	10.61	31.74
Mn	8.25	9.75	20.78	18.89
Ni	0.00	11.42	23.78	12.50

JR= Jos road; YT= Yelwa Tudun; Nasarawa Jahum; AB= Adamu Bellow Road

The I_{geo} obtained for the metals in this study are higher than those reported in Ololade (2014) [22] but compares favourably with those in Pam *et al*. (2013) [23] and Ekeocha and Anunuso (2016) and Nkanu *et al*. (2020) [14] for some of the heavy metals in the study auto-repair sites. The pollution index (Pi) values for each of the metal are shown in Table 3. With Pi values greater than 1, all the sites are polluted with the study metals except Ni in JR. Pi values indicated here are higher than those in Nwachukwu *et al*. (2010) [16]. The calculated pollution load index (PLI) values for the various sites also exceeded unity (1) (Figure 1). This indicates that the mechanic workshops are heavily polluted with respect to the study metals.

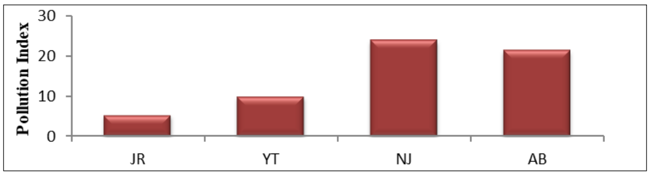

Fig 1: Pollution Load Index of each mechanic workshop

The PLI in the sites followed the hierarchical order NJ > AB > YT > JR. The relatively very low PLI values in JR could be due to the large number of trees and other plants within this workshop. Plants have the ability to bio-accumulate heavy metals in their tissues (Wu, 2004; Kannan and Kanimozhi, 2009; Okeke 2014a [20], 2014b) and are more likely to have reduced the levels of the heavy metals in this site. The PLI recorded in this work is higher than those in Ololada (2014) and Sam *et al*. (2015) [25].

Conclusion

The study showed that the soils in the auto-repair sites studied are grossly polluted. Results from the different pollution assessing indices for Cu, Cr, Ni, Cd, Mn and Pb are consistent with each other, indicating significant degrees of pollution. The metal pollution in the sites is caused by the activities carried out by artisans in these sites. The levels of pollution in these sites, which are within the residential areas possess a great threat to both humans and animals in these localities. Concerned agencies such as BASEPA, NESREA and stakeholders in environmental issues should therefore pay serious attention to auto-repair activities and as a matter of urgency advocate for the relocation of these facilities to non-residential areas or re-develop them in order to check these threats.

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