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Assessment of Heavy Metal Contents in Automobile Workshops in Okengwe District in Okene Township, Kogi State, Nigeria

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Abstract

The investigations were carried out to assess the distribution of heavy metals from the selected soils collected from automobile workshops within Okengwe District in Okene metropolis, Kogi State, Nigeria. The samples were collected from eighteen (18) functional sample sites with three different areas collected at random to form a composite sample. Contamination factor, degree of contamination and pollution load index were jointly used to assess the level of heavy metals pollution. Soil samples were taken to the laboratory and analyzed for heavy metals such as Cr, Co, Pb and Ni using standard analytical method. The mean concentrations of the metals were Cr(167.18±7.93-2010.79±9.48), Co (20.68±1.91-220.96±8.88), Pb (118.66±2.25-1081.56±9.03)and Ni (159.07±9.97-1220.29±23.73). The average concentration of Cr was much higher than any other heavy metals while that of Co was the lowest. Heavy metal concentrations in the sampling locations were in the order Cr> Ni >Pb > Co. Heavy metals concentrations obtained in soil were above the permissible limit of FAO/WHO values. The contamination factor, degree of contamination as well as pollution load index for the heavy metals were greater than one (1) indicating severe contamination.

Key words: Assessment, Heavy Metals, Automobile and Workshops

Introduction

Indiscriminate disposal of used engine oil and vehicle scraps in the environment is one of the most important sources of environmental pollution. Frequent use of petroleum-based products such as gasoline, diesel, fuel, engine oil and lubricating oil especially in automobile mechanic workshops often contributed to extensive and inevitable spillage of most of these products in the environment [1]. Motor vehicle with various assembly wastes created in their maintenance, repairmen or dismantling of motor vehicle parts as well as indiscriminate disposal of damage parts which are not managed properly leads to environmental pollution. The artisans in auto-repairs usually spill used engine oils, lubricating oils and other solvents containing petroleum hydrocarbons on any vacant space within their workshops. These spent engine oils, lubrication oils, and solvents are potentially hazardous wastes often attributed to auto-repair workshops in most Nigerian cities [2]. The used engine oil comprises a mixture of chemicals and additives such as decomposition of products and heavy metals because of wearing off the engine parts [1]. Motor vehicle with various assembly wastes created in their maintenance, repairmen or dismantling of motor vehicle parts as well as indiscriminate disposal of damage parts which are not managed properly leads to environmental pollution. The artisans in auto-repairs usually spill used engine oils, lubricating oils and other solvents containing petroleum hydrocarbons on any vacant space within their workshops.

Automotive service and repair shops are one of the main contributors of hazardous wastes generating in the world today. Auto repair/automobile shops create a lots of various different wastes during their daily activities. Petroleum hydrocarbon oils are important because they become toxic to the human being, plants and animal resources. They spread overthe environment beyond measures. Wastes from automobile workshop activities can either be maintenance or materials handling wastes [3].

In urban soils and road dusts, the anthropogenic sources of heavy metals include traffic emission (vehicular exhaust particles, attribute tire and brake lining particles), industrial emission from power plants coal combustion, metallurgical industry auto repair shop, chemical industry, etc, weathering of building, domestic emission atmospheric deposit and so on [4]. They consist of heat transfer fluids, spent oil and lubricants, dirty shop rags, used parts, asbestos from brake pads and wastes from solvents used for cleaning parts [5]. Soils may be contaminated as result of accumulation of heavy metals and metalloids through emissions from the industrial areas, mine tailings, disposal of metal wastes, use of leaded gasoline, fertilizers on land, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals and atmospheric deposition [6]. Soils are the major sink for heavy metals released into the environment through anthropogenic activities. Many metals are neither undergoes microbial or chemical degradation and their concentrations in soils persist for a long time. The presence of toxic metals in soil posed a very serious biodegradation of organic contaminants which tends to risk, hazards to humans and the whole ecosystem through direct ingestion or contact with contaminated soil, food chain, drinking of contaminated ground water, reduction in food quality, reduction in land fertility for agricultural activities [7]. The growth of population has called for the increase in automobiles to assist human mobility and other activities [8]. Few heavy metals play a biological role as micronutrients instead of becoming bio toxic at certain levels [9]. The environment can be degraded by means of dumping of refuse, defecation on land and other activities [10]. Urban development contributes to land pollution through the expansion of existing villages into towns of towns into cities and mega cities. These activities are known as land pollution [11]. Literatures have reported soil pollution problems associated with spilling of automobile wastes in Nigeria [12]. In Nigeria, like other developing countries, improved road accessibility creates a variety of supplementary employments which range from vehicle repairs; vulcanize welders to auto electrician, battery charges and other facilitators of motor transportation. These activities contaminate soils with heavy metals [13, 14].

Studies have revealed that there was high increase in the level of heavy metals in soils and sediments in Nigeria and other developing nations worldwide attributed to activities of auto mechanics. In Nigeria, soil contamination associated with heavy metals has been reported [15]. That was why Mechanic Village is a branded new name given to a place where numerous auto mobile activities are performed. Mechanic villages are usually set up in villages and cities depending on the population density of both human and vehicle.

Materials and Methods

Description of study area

The study site is an automobile workshop (Lat 7.5557° and Lon 6.2145°) located in Okengwe district in Okene local government area of Kogi State. These workshops have several operations many years ago. Waste generated from these mechanic workshop activities include wasted oils, solvents, paints, spent heat, transfer fluids, hydraulic fluids, spent lubricants and stripped-oil sludge.

Sample collection and treatment

The assessment was carried out within four auto-mechanic workshops in Okengwe District located in the western geographical part of Okene metropolis, Kogi State, North-Central, Nigeria. Samples were randomly selected from various locations to form a composite sample with the aid of soil hang dug auger at a depth of 0-15 cm from each functional location. A control sample site was set up at a remote distance of 50 km where there was neither commercial activity. The air-dried sample soils were collected in a dry non- reactive polyethylene bag to avoid microbial decomposition, and fungal growths from the soil [16]. The sampled soils were crushed and with 2 mm laboratory sieved and prepared for analysis [17].

Sample preparation and analysis

Soil digestion

Exactly 1.0 g of air-dried soil was placed in a digestion tube in a fume cupboard. Add 3 cm^3 of concentrated HNO_3 acid. Placed the tube racks in a block digester at a temperature of 140°C for 45 minutes. Also, add 4 cm^3 of concentrated $HClO_4$ to a temperature of 230°C for another 45minutes. The tubes were removed from the block digester, allowed to cool and filtered with Whatman No. 9 filter paper to obtain clear and colorless filtrate. The volumetric flask was toped up to 50 cm^3 while the residue was washed away with deionized water. All chemicals and reagents were of analytical grade and standard procedures were used. The digests were analyzed for Cr, Co, Pb, and Ni.

Quality assurance

The quality assurance procedures and precautions were taken to ensure that reliability of the results was achieved. Also, soil samples were carefully handled to avoid any kind of chemical contamination. In addition, glassware was properly cleaned and reagents used were of analytical grades. Every time standards were run prior to sample run in the AAS [18].

Soil pollution index

The average concentrations of the metals were carefully assessed using Atomic Absorption Spectrophotometer (AAS). This study revealed the ecological risk parameters which include contamination factor, geo accumulation index, degree of contamination and pollution load index were applied to evaluate the heavy metals contamination within the selected auto mechanic workshops.

Geo-accumulation index (Igeo): By comparing the present heavy metals concentrations original in the soils.

$I_{geo} = Log_2\left(\frac{C_n}{1.5B_n}\right)$…....…….. *Equation (1)*

where Cn = total concentration of the element and n in the soil fraction, Bn = average concentration of element in (background) and 1.5 = factor compensating the background data [19].

Contamination factor

Contamination factor (CF) is defined as the contamination from anthropogenic activities with a single heavy metal [20]. It determines the ratio between the content of each heavy metal in the soil to the geochemical background value, calculated by equation 1:

CF = Csoil/Cbackground…………..Equation (2)

where: C_{soil}= Concentration of each metal in the soil samples and $C_{background}$= geochemical background value of each metal

Hakanson [20]categorized the contamination values into four classes:

Cf values (unitless) fall into the following four classes: no/low contamination (Cf < 1),
moderate contamination (1 _ Cf < 3), considerable contamination (3 _ Cf < 6), and very
high contamination (Cf _ 6)

Contamination degree: The sum of the contamination factors of all the elements in the sample gives the extent of pollution as indicated below

$C_{deg} = \sum C_f^i$ ……………..Equation *(3)*

Where C_f^i = contamination factor of the element concerned [21].

Pollution load index (PLI)

Pollution load index is estimated as the root number of overall contamination factor in a sampling location. They can be calculated for PI for each site.

PI = (Cf 1 x Cf 2 x Cf 3………Cf n)1/n …………………………………… Equation (4)

The PI of each element can be categorized as;
(PI ≤ 1) low, (1< PI ≤ 3) moderate, or (PI > 1) high contamination [22].

Results and Discussion

The heavy metals were determined to assess their potential levels in the automobile workshops within the vicinity that constitute the environmental pollution [23].

Mean concentration of chromium

The mean value of chromium concentration within workshop soil ranged from 167.18±7.93 to 2010.79±9.48. Chromium is an essential element which becomes toxic at high levels. At elevated levels, chromium causes health risks to humans since it is accumulated in the skin, lungs, muscles, liver and lead to various health conditions. Concentrations of chromium in the automobile workshop soil samples were higher than level recorded by Adebayo *et al.* [23]. The level of cadmium in the studied could be attributed to the disposal of polyvinyl chloride plastics, nickel-cadmium batteries, motor oil and disposal sludge in the mechanic workshops. Lower than those reported by [24].

Mean concentration of cobalt

Mean level of Cobalt concentration ranged from 19.21±1.91 to 220.96±8.88 which was above the standard permissible limit of (0.05 mg/kg) set by (FAO/WHO, 2011). This may be due to geological influences and anthropogenic impacts. Co metal indicates that the substantial proportion of it in soil is of geogenic origin and its mobility is always impossible [25]. Cobalt when ingested, could lead to vomiting, abdominal pain, allergic reactions in the skin, asthma, inflammation and fibrosis of the lung [26].

Mean concentration of lead

Lead has a relatively high concentration ranging from 118.66±2.25 to 1081.56±9.03 within auto-mobile workshops. Lead concentrations in most of the locations were generally above the standard limit of (85 mg/kg) set by (FAO/WHO, 2011). Thus, high values of Lead were caused by waste oil, presence of automobile liquid emissions and expired motor batteries discharged by battery chargers and auto mechanics in the study locations [27]. The level of Lead in this study is similar to that of the report heavy metal analysis of soil samples [27].Studies have shown that the application of tetraethyl lead as an anti-knocking agent in gasoline releases lead from fossil fuel combustion through emissions from automobiles.

Mean concentration of nickel

Ni ranged from 159.07±9.97 to 1220.29±23.73 mg/kg. The concentrations of Ni were generally far above the FAO/WHO values with (35 mg/kg) [28]. Therefore, higher values of Ni in the soil taken from the workshop could be attributed to indiscriminate disposal of spent automobile workshops chargers and various pains discharge on the soil [29]. This result confirmed the result reported by Udousoroet al. [29]. The maximum mean concentration of nickel obtained in this study is however higher than that reported by Adebayo *et al*. [23].

Geo-accumulation index for the soil sample apparently placed chromium and cobalt on high and extreme high pollution level of contamination. The recorded heavy metals revealed that the concentration of heavy metals is high in virtually all the sampling points and artisan workshops. The result showed that all the heavy metals fall under Uncontaminated to extremely contaminated ($0 \leq$ Igeo< 1). Degree of contamination were classified according to the use of anthropogenic activities of the environment [13]. Table 1 shows heavy metals were in sequential order of Co > Pb > Ni > Cr.

Contamination Factor

Contamination factor (CF) was used to determine contamination levels and estimate the anthropogenic contribution of heavy metal in soil [30]. The contamination factor values for these studies were mostly above the stipulated range thereby reaching a deteriorating condition. El-Sherbiny*et al*. [31] revealed that the soils areas were heavily contaminated with the selected heavy metals. The contamination levels of the heavy metals were the result of land use activities due to the automobile mechanic pressures in the sampled locations.

Degree of Contamination

It varies from moderate degree of contamination to very high degree of contamination due to anthropogenic processes and soil is highly contaminated by the land use activities. The result of contamination factor and pollution load index is> 1 which was an indication of high contamination level in all the sampling locations.

Table 1.0 Heavy metals level in soil in automobile workshops in Okengwe

SAMPLE ID	Cr	Co	Pb	Ni
AM	167.18±7.93	20.68±1.91	208.96±4.94	159.07±9.97
BC	317.69±2.42	27.19±2.82	1081.56±9.03	410.00±2.18
MK	345.46±3.32	19.21±9.21	142.29±1.22	470.79±6.55
HO	460.59±2.35	37.53±6.89	118.66±2.25	552.81±2.80
PM	615.50±4.33	48.50±1.23	172.85±4.55	724.10±6.10
AB	806.75±5.21	63.38±1.41	221.50±2.33	822.25±8.01
OS	963.56±1.95	72.38±1.51	332.88±1.09	908.88±5.43
PS	1014.81±3.74	95.13±1.00	270.44±2.89	925.88±7.74
IN	1108.20±2.03	94.80±3.41	318.80±3.66	966.60±6.87

CO	1208.10±1.48	98.00±7.74	343.65±1.04	1016.75±6.20
RT	1405.38±6.69	132.13±1.37	552.25±9.73	1050.50±4.34
WW	1178.31±4.50	134.75±2.64	745.94±34.09	846.19±4..57
RS	449.79±1.32	113.04±2.28	191.96±13.87	230.33±9.04
FL	1502.15±3.78	138.85±8.45	482.10±9.20	1098.70±10.27
SM	1674.00±3.79	176.20±9.85	544.05±2.25	1139.80±4.07
BS	1384.94±8.15	179.69±5.57	474.63±6.79	893.50±2.71
RD	1924.60±7.34	196.80±4.94	610.05±5.20	1187.25±1.17
FO	2010.79±9.48	220.96±8.88	624.96±1.31	1220.29±23.73
FAO/WHO	100	0.05	85	35

Conclusion

The study revealed that all the automobile workshops have the selected heavy metals such as Cr, Co, Pb, and Ni. There were specific variations in their concentrations as they were higher than the others. These were attributed to anthropogenic wastes of the automobile impacts formation of the locations. Meanwhile, contamination factor, degree of contamination and pollution load index is high might cause ecological threats to the environment. The level of heavy metal pollution in the locations were very high and can be linked with the continuous growth of the urban areas which lead to increase of environmental waste products due to mechanic activities. As a result of this study, it is recommended that strict adherence to the rule and regulations governing environment as well as compliance to indiscriminate disposal of spent oil to the environment.

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