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Effect of Automobile Paint Wastes Disposal on Soil Health Indices

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Abstract

In this investigation, the effects of paint waste disposal on the receiving soil in Owo Local Government Area, Ondo State. Samples of soil were collected from the painter workshops using soil auger and transported to the laboratory for further processing. The microbial population was determined using pour plate method and some biochemical tests while the physicochemical parameters of the soil samples were analyzed using standard methods. The total heterotrophic bacterial count of the paint contaminated soil in Owo ranged from 65.10 to 185.50 x 10^5 CFU/g. Sample from Owo 2 recorded the highest heavy metal resistant bacteria count (248.33 x 10^5 CFU/g). The organisms isolated from the soil samples were *Klebsiella* spp., *Escherichia* spp., *Staphylococcus* spp., *Proteus* spp., *Pseudomonas* spp., *Esherichia coli, Staphylococcus* spp., *Klebsiella* spp., *Bacillus* spp. and *Serratia* spp. The physicochemical analysis results revealed that Conductivity was significantly higher ($P<0.01$) in contaminated soil samples (1.67, 1.82 and 1.27 mS/cm) than uncontaminated (0.21 mS/cm) soil sample. Also, heavy metals obtained from the experimental sites were found to be more than the control. Based on the results of this study, it is advised that paint effluents should be subjected to screening and possible remediation processes in order to avoid contamination of the environment with the toxic metals.

Keywords: Paint waste, heavy metal, soil, bacteria, physicochemical properties

1.0 Introduction

In Nigeria, automobiles are usually maintained by mechanic auto workers whose shops are located within the residential areas. The disposal of wastes generated from theses workshops are usually released directly into the environment leading to pollution of the sites. In these land uses, fossil fuel products of different types are used leading to excess accumulation of heavy metals in these soils and their surroundings. The effect of discharges from automobile workshops on the immediate environment have been on an increase especially in the urban areas in recent years. These pollutants according to Campbell et al. (2005) have a way of spreading in the soil and remaining in the surroundings for a long time in such a way that affects organisms inhabiting the soil including plants and animals. The accumulation of heavy metals in the environment as a result of human activities in this millennium has been on the rise leading to disturbance of microbial communities and in some cases elimination of specific populations (Ogbonna and Okeke, 2010) thereby altering the microecosystem dynamics.

Paints wastes usually contain metallic compounds which are major components in their production, when these wastes are discharged into the soil, the level of heavy metals in the soil increases significantly. These then get transported in the rain storm water into other water bodies or seeps into the lower layer of soil where they can reach the ground water. Other investigators have reported the negative effect of automobile wastes on farmlands and its environs as increase in heavy metal content are usually associated with the wastes discharge (Mbah and Ezeaku, 2010, Maynard and Turer, 2003).

Paints used in adding colours, improving texture and protection of materials against corrosion are mostly synthetic. Those used in painting automibiles are manufactured from a combination of several chemicals comprising of pigment, solvent, binder and protective according to Ulbrich and Kalendova (2013). The paints employed in the decoration of automobiles are made up of coatings of many layers which include the following: a corrosion preventing primer, followed by the colour paint itself and then another layer to improve the radiance of the paint on the vehicle. These chemicals contain many reactants most of which are metals that contribute to environmental contamination.

Presently, the number of automobiles are on the increase around the world, particularly in Nigeria. Most of the vehicles coming into the country are used cars or those that have been used earlier before being imported. Often, these vehicles require some maintenance and body repairs which ends with painting before they are sold in the market. All these activities releases the volatile organic compounds like the Tributyltin which according to Dalmazzo *et al*. (2016) have known high level of toxicity to the ecosystem especially, the aquatic habitat.

Effluents from painting workshops have been categorized as hazardous wastes because they usually release volatile organic compounds (VOCs), carbon dioxide (CO_2), and heavy metals (Salihoglu and Salihoglu, 2016). Owning to the fact that there are limited studies on the effect of automobile paints on soil thus, this prompts the current investigation of the effect of automobile paint on soil physicochemical and microbiological properties found in automobile workshops.

The primary aim of this study is to examine the effect of automobile paint on soil health and fertility indices.

2.0 Materials and Methods

2.1 Sample Collection

Soil samples were collected randomly from disposal point of battery chargers wastes at mechanic villages in Owo and Akure cities of Ondo state, Nigeria from 0 – 15cm depth into sterile wide-mouthed screw cap bottles because oil penetration to the soil is very slow and hardly exceeded 13.5cm.

2.2 Physicochemical Analysis

Properties like the pH, temperature, water retention capacity, transparency, colour, total dissolved solid (TDS), hardness, organic matter, C, N, P and moisture were determined using the method described by CEC (2016).

2.3 Determination of Minerals and Heavy Metals

The minerals and heavy metals present in the samples were assayed using the Atomic Absorbance Spectrophotometer (AAS) method.

2.4 Microbial Analysis

Samples were subjected to serial dilution in ten folds. Total heterotrophic counts was done by adopting pour plate method. Nutrient agar, Salmonella-Shigella agar, Manitol salt agar, MacConkey agar, Eosin Methylene Blue agar and Luria-Bertani agar at 45 ^{0}C were poured into the Petri dishes containing 1mL of the appropriate dilution for the isolation of the total heterotrophic bacteria, *Salmonella* spp and *Shigella* spp, Staphylococcus group, Enteric bacteria, *Escherichia coli* and heavy metal resistant bacteria respectively. They were homogenized, allowed to solidify and incubated invertedly at 35 ºC for 24 hours. Preliminary identification was done using colonial and biochemical characteristics (Akinnibosun *et al*., 2020).

3.0 Results and Discussion

The microbial count is presented in Table 1. The total heterotrophic bacterial count of the soil contaminated with paint in Owo ranged from 65.10 to 185.50 x 10^5 CFU/g with Owo 2 having the highest count while Owo 3 had the least value against the control soil (130.00 x 10^5 CFU/g). Owo 2 recorded the highest heavy metal resistant bacteria count (248.33 x 10^5 CFU/g) while Owo 1 recorded the least (187.33 x 10^5 CFU/g) even though the values of the three sites were significantly higher compared with the control which was expectedly low (94.33 x 10^5 CFU/g). The indication of these results is that the microflora of the tested soils are forming resistance to the paint constituent present in the polluted soil which might help in remediation. Higher THB counts in battery waste contaminated soils may be linked with the occurrence and bio-availability of higher level of nitrogen and phosphorus in the soil which influenced the the growth of the soil microbial community. The availability of these elements as revealed in the physicochemical properties suggests that they are sources of nutrients for the growth and maintenance of the organisms (Brevik *et al*., 2017).

Table 1: Total heterotrophic bacterial count on paint contaminated soil (x 10^5cfu/g)

Sample	THBC	HMRB
Control	130.00±2.50^b	94.33±1.60^a
Owo 1	154.33±5.15^c	187.33±15.07^b
Owo 2	185.50±3.88^d	248.33±11.00^c
Owo 3	65.10±1.25^a	196.50±10.87^b

THBC = Total heterophilic bacterial count, HMRB = Heavy metal resistant bacteria, values are Mean±SEM, those followed by different alphabeth along columns are significantly different at P<0.05

The values in this study were high as a result of automobile paint pollution and in agreement with those of Janet and Vivian (2017) which ranged (211.43 – 325.83 x10^5 CFU/g) although they are all still below permissible limit of 500 CFU/g.

The probable organisms isolated were *Klebsiella* spp., *Escherichia* spp., *Staphylococcus* spp., *Proteus* spp., *Pseudomonas* spp., *Esherichia coli, Staphylococcus* spp., *Klebsiella* spp., *Bacillus* spp. and *Serratia* spp. Their characteristics are shown in Table 2. These are similar to a report by Ashwini and Anchana (2018) that *Pseudomonas* species, *Staphylococcus* species as well as *Lactobacillus* species involved in degradation of paint. In another related study, Opperman and Goll (2004) identified similar organisms in addition to species of Micrococcus, Clostridium, Serratia and Enterobacter as part of organisms responsible for degradation of water based paint.

Table 3 presented the physicochemical parameters of the paint contaminated soil samples such as Moisture content (%), pH, Organic matter (%), Phosphorus (g/kg), % Carbon, % Nitrogen, Calcium (ppm), Magnesium (ppm), Potassium (ppm), Conductivity (mS/cm), Bulk density, Cation Exchange Capacity (CEC) (ppm), Sand %, Clay % and Silt %. Electrical conductivity was recorded higher in soil samples contaminated with paints (1.67, 1.82 and 1.27 mS/cm for Owo 1, Owo 2 and Owo 3 respectively) than uncontaminated (0.21 mS/cm) soil sample which indicates a high level of free ions in soils contaminated with paint. It has been observed earlier that conductivity in a material corresponds to the level of the dissolved substances in such material. The high level of conductivity in these soil samples may be linked with the high level of metallic ions released from the metal salts in the automobile paint pollutants.

The pH value obtained from the automobile paint contaminated soil samples is quite acidic in nature and lesser than both the control (7.42±0.05) in this study and WHO permissible limit of 6.5-8.5.

Table 2: Preliminary identification of the isolates

Isolate code	Plate morphology	Gram reaction	Shape	Cat	Lac	Suc	Fru	Mal	Glu	Man	VP	GH	Probable organism
CI1	Large, circular, opaque, fruity smell	-	Rod	+	+	-	+	+	+	+	+	+	*Klebsiella* spp
CI2	Circular, opaque, smooth, glistering	-	Rod	+	+	+	+	+	+	+	-	+	*Escherichia* spp
CI3	Round, entire edge, convex, yellowish	+	Cocci	+	-	+	+	+	+	+	-	+	*Staphylococcus* spp
CI4	Whitish, round, entire, convex surface	-	Rod	+	+	-	+	+	+	+	+	+	*Proteus* spp
CI5	Dotted surface, whitish, opaque	-	Rod	+	-	+	+	+	+	+	-	+	*Pseudomonas* spp
PI1	Whitish, round, chain-like	-	Rod	+	+	+	+	+	+	+	-	+	*Esherichia coli*
PI2	Raised, milky, entire, round	+	Cocci	+	+	+	+	+	+	+	+	-	*Staphylococcus* spp
PI3	Circular, rough surface, flat with fine margin	-	Rod	+	+	-	+	+	+	+	+	+	*Klebsiella* spp
PI4	Circular, milky, smooth surface	+	Rod	+	+	+	-	+	+	+	+	-	*Bacillus* spp
PI5	Transparent, rhizoidal margin, flat surface, mucoid	-	Rod	+	-	-	+	+	+	+	-	+	*Pseudomonas* spp
PI6	Circular, rough edges, opaque	-	Rod	+	+	-	+	+	+	+	-	+	*Serratia* spp

Key: - =negative, += positive

Table 3: Physicochemical parameters of paint contaminated soil samples

Parameter	Control	Owo1	Owo2	Owo3
Moisture content (%)	11.19±0.01^{d}	10.02±0.05^{c}	9.11±0.08^{b}	7.97±0.50^{a}
pH	7.42±0.05^{b}	6.51±0.01^{a}	6.53±0.00^{a}	6.45±0.01^{a}
Organic matter(%)	2.39±0.01^{b}	2.31±0.00^{b}	2.21±0.02^{a}	2.12±0.04^{a}
Phosphorus (g/kg)	5.22±0.20^{c}	3.41±0.01^{b}	2.42±0.04^{a}	2.32±0.02^{a}
%Carbon	4.67±0.15^{b}	3.53±0.00^{a}	3.51±0.01^{a}	3.62±0.01^{a}
%Nitrogen	0.31±0.02^{b}	0.23±0.00^{a}	0.22±0.01^{a}	0.25±0.00^{a}
Calcium (ppm)	11.00±0.25^{a}	24.41±0.02^{b}	22.41±0.01^{b}	21.37±0.15^{b}
Magnesium (ppm)	1.9±0.05^{a}	3.71±0.01^{b}	3.43±0.00^{b}	3.45±0.05^{b}
Potassium (ppm)	1.4±0.08^{a}	6.52±0.00^{b}	6.43±0.02^{b}	7.44±0.00^{c}
Conductivity (mS/cm)	0.21±0.00^{a}	1.67±0.01^{c}	1.82±0.02^{d}	1.27±0.01^{b}
Bulk density	1.22±0.08^{b}	1.10±0.01^{a}	1.11±0.03^{a}	1.07±0.00^{a}
Cation Exchange Capacity (CEC) (ppm)	301.2±15.02^{a}	347.61±10.04^{c}	326.88±0.03^{b}	372.41±10.00^{d}
Sand %	48.61±1.20^{c}	42.10±1.22^{a}	42.49±1.08^{a}	46.07±1.10^{b}
Clay%	26.72±3.00^{a}	28.32±1.18^{c}	27.79±0.02^{b}	27.04±1.06^{a}
Silt%	24.67±1.00^{a}	29.57±3.00^{b}	29.72±1.02^{b}	26.89±1.20^{a}

values are Mean±SEM, those followed by different alphabeth across rows are significantly different at $P<0.05$

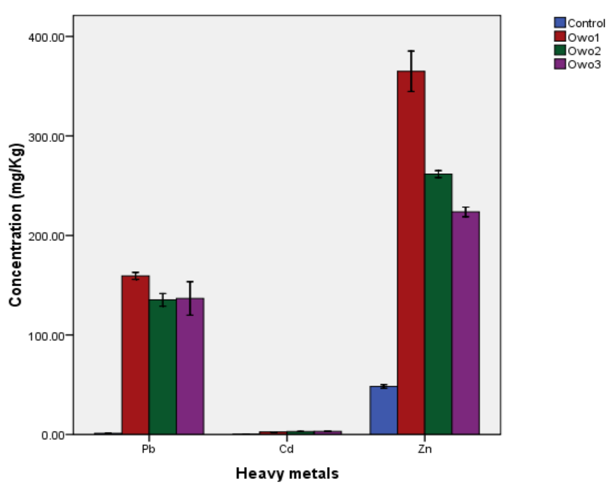

Figure 1: Selected heavy metal content of paint waste contaminated soil

Since the survival of most microbial species is dependent on a certain pH range, soil pH is essential. Moreover, availability of nutrients can be affected by soil pH.

This result agrees with the work of Orjiakor and Atuanya (2015), Pam *et al*. (2013) and Ajai *et al*. (2016). The number and diversity of soil microbial community is greatly influenced by the soil pH, and by extension soil, plant and animal's health are determined by these factors. Moreover, the availability of the heavy metal ions for uptake is heavily influenced by the hydrogen ion concentration of the particular soil.

Other physicochemical factors like organic C, Ca, CEC, bulk density, etc were recorded to be significantly different in the contaminated soil compared with the control site soil sample. Furthermore, the particle size scattering of the contaminated soil samples varies respectively from 42.10 to 46.07, 27.04 - 28.32 and 26.89 - 29.72 for sand, clay and silt in the three sites used for this study while the control were 48.61, 26.72 and 24.67 for sand, clay and silt respectively. This is supported by the report from Nwakife *et al*. (2022) where they obtained similar result for soil distribution in automobile paint polluted soil points and sites.

Nitrogen and carbon concentrations were higher in uncontaminated soil (0.31 % and 4.67 %) than contaminated soil (0.23, 0.22and 0.25 %, and3.53, 3.51and 3.62% respectively) and may be linked with the presence of automobile paint waste introduced by human activities in the polluted soil; thus, the automobile wastes could lead to soil nutrient loss. P was found to be lower in the paint contaminated soil compared to the contaminated sample (5.22 g/kg). This may be associated with leaching/percolation of dissolved nutrients probably due to excess water during raining season as well as hydrolytic enzymes of microbial origin according to Barel and Barsdate (2014).

Selected heavy metal content of paint waste contaminated soil samples were presented in Figure 1. The values of zinc in the various sites in Owo were extremely higher than that of the control and the permissible limit (0.01 mg/kg) of World Health Organization which revealed that the lead concentration in the contaminated soil is high. This is an indication of heavy contamination and is similar to the work of Nwakife *et al*. (2022) who also reported similar result.

Lead contents in the three different sampling points were higher than the control and were extremely higher than WHO permissible limit (5 mg/kg) which indicates a gross contamination of the receiving soil around the automobile paint workshop. This could be as a result of the additives which are part of ingredients used to produce the automobile paints (Abenchi *et al*., 2010). When lead finds its way into the aquatic environment, it is associated with the destruction of aquatic lives.

The cadmium content in Owo 1, Owo2 and Owo 3 were only found to be in trace amount which falls in the permissible limit (0.5 mg/kg). Though the continuous accumulation of this heavy metal in the sampling areas can cause serious hazard to man, plants and animals.

4.0 Conclusion

The results obtained in this investigation revealed that waste effluent from automobile paint workshop altered the microbial quality, physicochemical properties and heavy metals in the contaminated soil. In order to salvage the potential environmental crises that may arise from the disposal of the waste paint, remediation protocol maybe adopted for the treatment of the paint waste before they are released into the environment. In addition, sensitization campaign should be carried out to educate the automobile repairers on the dangers of indiscriminate disposal of their wastes into the soil.

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