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Verification of vehicular emitted aerosol components in soil biochemical characteristics in Owerri west local government area, Imo State, Nigeria

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Abstract

The study was carried out in Avu Junction in Owerri West L.G.A. at a graded distant from the tarred road with an average vehicular flow between 10,000 to 12,000 per day. Soil samples were taken at a distant of 50m, 100m, 150m and 200m respectively. And auger soil samples were taken at the depths of 0-30 cm and 30-45 cm accordingly. Soil factor, heavy metals and microbial populations were investigated at graded distances. From the result of soil factors, pH values indicated acidity with decreased distant, from the tarred road ranging between 4.52 – 6.32, soil temperature on the topsoil was higher than subsoil ranging between 19- 25 ^{0}C and 18 – 22 ^{0}C and soil moisture increases with increased distant from the tarred road ranging between 10.00 – 13.3. Heavy metal concentrations in the soil increased with decreased distant in the order of Pb < Zn < Ni < Cu < Cd. Overall results revealed that Cd in the soil constitutes the highest percentage of 91.7%, Ni 90.9%, Cu 90.1%, Pb. 84.7% and Zn. 81.7%. Significantly, higher fungi and bacterial populations were recorded at increased distant from the tarred road. This then called for proactive measures to checkmate soil contamination due to pollutants from vehicular flows.

Keywords: Aerosol, Biochemical, Vehicular, Soil Factors and Heavy Metals

Introduction

Roads form the main system of transportation of the region. Driving a car is the most air polluting act, an average citizen commits. Roadside soils often show a high degree of contamination that can be attributed to motor vehicles (Weckwerth, 2001). This is because car exhaust is toxic at the ground level. Trace heavy metal contamination in the soils is a major concern because of their toxicity and the threat to human life and environment (Barbhuiya *et al.,* 2008*)*. This has led to the loss of forest cover and subsequent loss of soil fertility. Heavy metals such as Cu, Cd, Ni, and Pb are potential soil and water pollutants (Mander, 1983; Pagotto *et al* (2001). Vehicular discharge of numerous gaseous and trace metals contaminants, due to incomplete combustion of petroleum fuel adversely affects the microbial population and their activities in soil. Contamination of litter and soil with metals can result in reduced rates of litter decomposition, soil respiration, nitrogen mineralization and soil enzyme activity (Tyler *et al*, 1989**)**. Moderate soil contamination by metals has been shown to reduce the soil microbial biomass and certain indices of its activity (Brooks *et al.*, 1986). The interactions of chemical, physical and biochemical factors are responsible for holding the complex soil system in a dynamic equilibrium. Population dynamics of soil microorganisms is largely regulated by vegetation and soil characteristics. Soil micro flora exerts considerable influence on soil fertility and plant growth (Post & Beeby, 1996). Biochemical processes provide better estimates of the functional attributes of the microorganisms in an ecosystem. These are generally determined by the estimation of the rate of biochemical processes involving microbial enzymes, and soil factors. Enzymes in soil are biologically significant as they are involved in cycling of nutrients and can influence the availability of nutrients to plants, thus, playing an important role in the initial phase of decomposition of organic matter (Joshi, 1991).Tropical and sub-tropical soils have received less attention in relation to microbial dynamics as affected by disturbances (Joshi *et al*, 1992; Barbhuiya *et al*, 2008*)*. The present study aims to understand the influence of roadside pollution caused by vehicular flow/density on population and activity of microorganisms and physicochemical properties of the soil in Owerri West local government area of Imo State.

Materials and methods

Study area

The research study is carried out in Owerri west local government area of imo State. It is located in the southern part of the state within a latitude of 060 52' E and 07^0 05' E, longitude 05^0, 15' N and 05^0 34' N of the south east zone of Nigeria. It comprises about 16 autonomous communities and share a common boundary with villages like Ohaji/Egbema, Mbaitoli, and the area has a total landmass of about 3,787 square km. The area is sandy-loamy and some sandy-clay loam that has made the zone good for agriculture. It has a mean annual rainfall of about 2250-3000mm that begins from the months of March to October, and the temperature ranges from 35^0C-37^0 C. It is situated within the tropical rainforest that has evergreen broad leaves. Traffic flow in this area is very slow coupled with the police checkpoint that retarded the flow and vehicles spent 30-45 minutes with their engines steaming.

Soil samples collection techniques

The study site considered for the present study was Avu- Port Harcourt Roads with heavy vehicular flow where soil samples were collected at a graded distance of 50m, 100m, 150m and 200m away from the road side, and two soil samples were collected from each points at the depths of 0.30 and 30 - 40 m respectively. Samples collected were analyzed for the following:

Soil Factors such as soil pH, soil temperature and soil moisture

1. Heavy Metals such as Lead (Pb), Cadmium (cd), Copper (cu), Zinc (zn), and Nickel (Ni)
2. Microbial population include fungal, and bacteria.

Laboratory analytical techniques

For analyses in the laboratory, soil factor such as soil pH, soil temperature (ST), and soil moisture content (SMC), and bacterial counts (BC) were also observed. pH of sampled soils were determined from the supernatant obtained after 1:1 (w:v) mixture of the soil, samples were made with sterile distilled de-ionized water. The pH was further measured using a PYE UNICAM model 291 mkz pH meter with a combined glass electrode. The temperature of each soil sampled was measured using Mercury-in-glass thermometer that was inserted into the affected soil for 20-30cm beneath the soil for 5minutes to stabilize for accurate reading, and was done onsite. For the determination of soil moisture content of each soil sample, Apha (1985) was used for the measurement. 10 gms of each soil sample was heated in hot air for 8-12 hours at 80^O C till constant weight was obtained. The difference between the original weight and the consistent final weight obtained was taken as the weight of the moisture content of the soil samples. Fungal populations were estimated by Warcup's soil plate method using rose bengal agar medium. The inoculated plates were incubated at 25±1°C and colony forming units were enumerated after 5 days. Dilution plate method was used to estimate bacterial populations developing on nutrient agar medium. The inoculated plates were incubated at 30±1°C and colony forming units were enumerated after 24 h from the plate of higher dilutions (Prescot *et al.*, 1988).

Results and Discussion

From Table. 1, the result shows that the soil factors such as pH, soil temperature and soil moisture varied considerably. At the distant of 50m with the depth of the soil within 0-45cm soil, pH varied between 4.52-5.10, soil temperature 21-25^0C, and 10-10.1%. At 100 cm, soil pH at the same depth ranged between 5.15-5.17, soil temperature 21-23^0C, and soil moisture 10.01 - 10.1%. At 150 cm and 200 cm, soil Ph ranged between 5.75-5.96, soil temperature 18-19^0C, Soil moisture 10.6-11.1% and soil pH range between 6.25 – 6.32, soil temperature 22 – 24^0C, and soil moisture ranged between 13.1 -13.3% respectively. The results further indicated that soil pH from the main road is more acidic than soil sampled away

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Table 1: Variations of Soil factors at the graded distance

S.No	Sample Points	Depth (cm)	pH	Soil Temperature (^{0}C)	Soil Moisture
1	50	0-30	4.52	25	10.1
		30-40	5.10	21	10.00
2	100	0-30	5.15	23	10.1
		30-40	5.17	21	10.01
3	150	0-30	5.75	19	10.6
		30-40	5.96	18	11.1
4	200	0-30	6.25	24	13.1
		30-40	6.32	22	13.3

Table. 2: Heavy metal concentrations in the soil at graded distance

S.No	Sample point (m)	Depth (Cm)	Pb (Kg)	Cd (Kg)	Cu (Kg)	Zn (Kg)	Ni (Kg)
1	50	0 -30	4.95	1.65	1.74	4.78	2.51
		30-45	1.95	1.15	1.72	2.40	1.75
2	100	0 -30	2.40	0.85	1.01	3.43	1.95
		30-45	0.91	0.95	1.65	1.51	1.31
3	150	0 -30	1.90	1.15	0.94	1.51	0.41
		30-45	0.85	0.78	0.94	1.48	0.56
4	200	0 -30	1.90	0.62	0.48	1.51	0.52
		30-45	0.65	0.62	0.86	1.62	0.55
Total			15.51	7.74	9.34	18.24	9.10
Mean			1.94	0.94	1.17	2.28	1.14
STD			10.16	11.0	10.8	9.78	10.9
Coefficient			84.7%	91.7%	90.1%	81.6%	90.9%

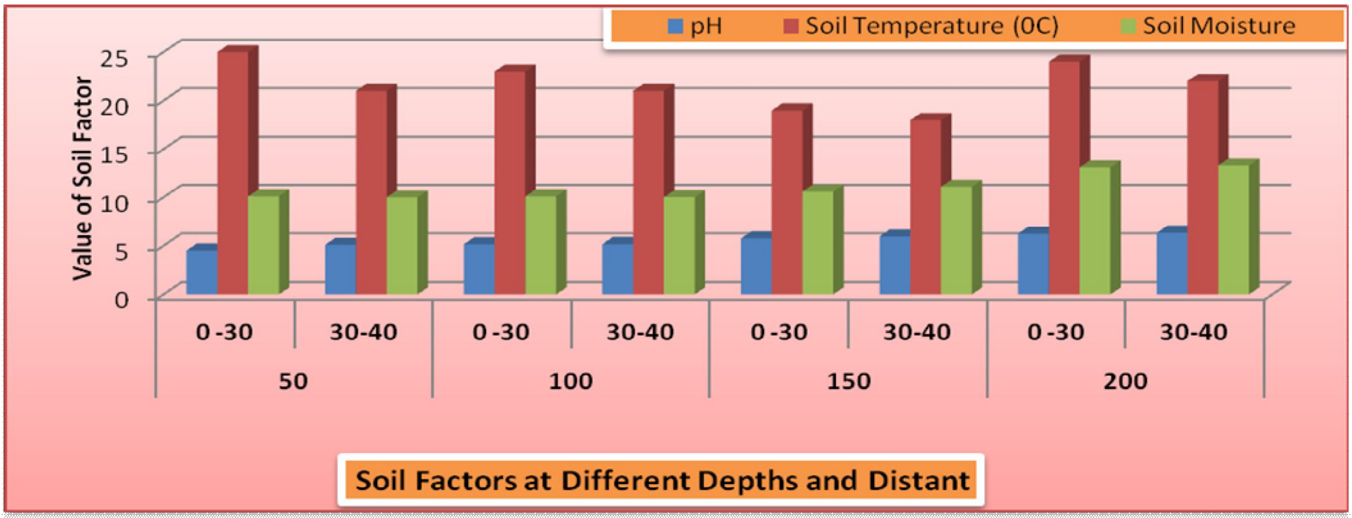

Fig. 1. Variation of soil factors at different depths and distant

from the main road that moves toward alkalinity, and the top soil at the depth of 0-30cm was also more acidic than soil depth of 30 – 45 cm (Fig. 1). At the same depths, the top soil had an increase in temperature than the sub-soil and the surface temperature decreases with distant. The same trend is found in soil moisture which is influenced by heat intensity from ambient temperature.

From Table. 2, the result shows that the heavy metal concentrations in the soil at graded distances

Table. 3: Soil bacteria at graded distance

Soil Bacterial		Unit	50m	100m	150m	200m
			0-30cm	0-30cm	0 -30cm	0-30cm
1	Thermophillus Bacilli (TB)	Cfu/g	1.9 $x10^3$	1.6x 10^7	1.5 x 10^3	1.3 x 10^4
2	Streptococcus Cremoris	Cfu/g	1.4 x 10^7	-	-	-
3	Streptococcus Spp	Cfu/g	1.6 x 10^5	-	-	-
4	Streptococcus Cremoris	Cfu/g	1.4 x 10^3	-	1.4 x 10^2	1.3 x 10^1
5	Bacillus Spp	Cfu/g	1.3x10^7	-	-	-
6	Nitrosococus nitrosus	Cfu/g	-	8 x10^4	-	-
7	Clos tridilum Spp	Cfu/g	-	1.2 x 10^3	-	-
8	Microecus Varians	Cfu/g	-	1.2 x 10^3	-	-
9	Pseudomonas Spp	Cfu/g	-	1.0 x 10	1.4 x 102	1.5 x 10^3
10	Spirillium Spp	Cfu/g	-	1.5 x 10	12.2 x10^6	13 x 10^4
11	Agrobacter Spp	Cfu/g	-	-	1.6 x 10^6	1.9 x 10^6
12	Bacillius Thermoplilus	Cfu/g	-	-	1.7 x10^6	11x10^5
13	Nitrosomonas eunpae	Cfu/g	-	-	-	-

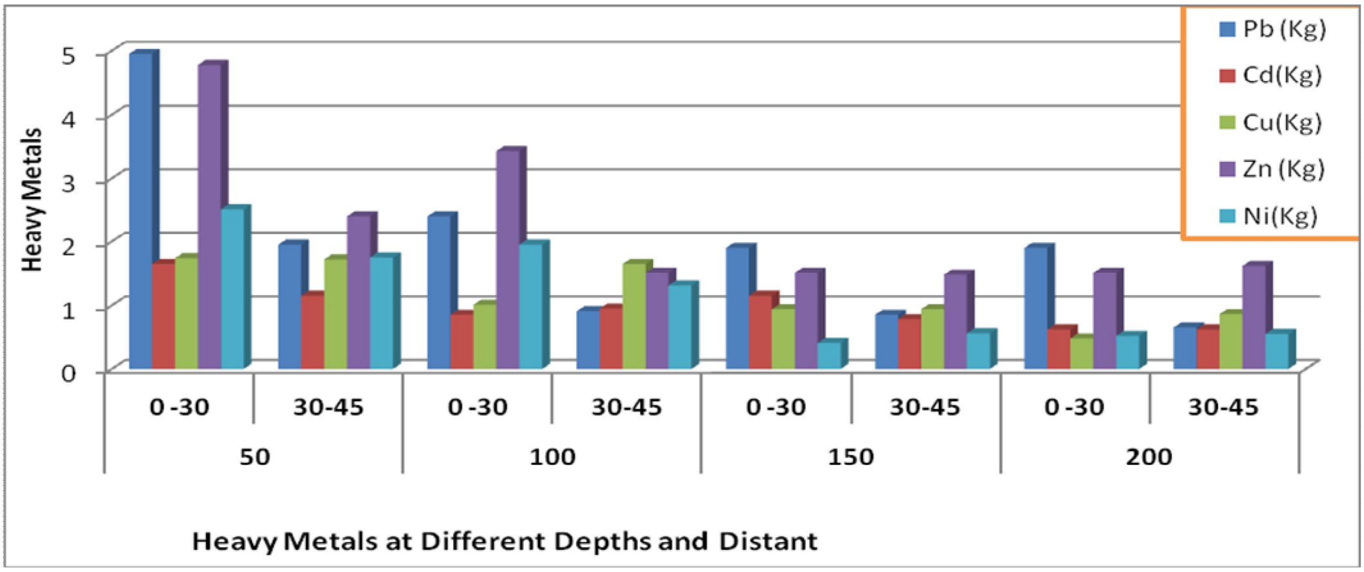

Fig.2. Variation of heavy metal concentrations in the soil at graded distance

varied from one point to the other. For instant at 50 -200m with the soil depth of 30 cm, lead ranged between 1.90 - 4.95 kg, 30-45 0.65 -1.95 kg , cadmium 0.62 – 1.65 kg and 0.62 – 1.15kg, copper 0.48 – 1.74kg and 0.86 -1.72 kg, zinc 1.51 – 4 78kg and 1.62 – 2.40kg, nickel 0.41 – 2.51 kg and 0.55 – 1.75kg respectively. Above all, lead concentration in the soil was found to have 15 51 with mean of 1.94, standard deviation of 10.16 with coefficient of 84.7%. Cadmium had a total of 7.74 with mean of 0.94, standard deviation of 11.0 with coefficient of 91.7% and cadmium comes mostly from diesel fuel (Dierkes & Geiger, 1999). Copper had a total of 9.34 kg with mean of 1.17, standard deviation of 10.8 with coefficient of 90.1%. Zinc had a total 18.24kg with mean of 2.28, standard deviation of 9.78 with coefficient of 81.6% and zinc concentration in the roadside has been confirmed to be tires wear of vehicles Krzysztofiak (1984) and nickel had a total concentration of 9.10kg with mean of 1.14, standard deviation of 10.9 and coefficient of 90.9% respectively. And according to Parry *et al* (1981), Joshi *et al* (1991), metals concentration in the roadsides like lead is caused by leaded gasoline, tire wear, lubricating oil, grease and bearing; zinc is caused by tire wear, motor oil, engine parts, brake emission, copper, cadmium and nickel are caused by bearing wears,

Table 4: Soil Fungi isolated at graded distance

	Soil fungi isolated	Unit	50m	100m	150m	200m
			0-30cm	0-30cm	0.30cm	0.30cm
1	*Aspergillus fumigatus*	Cfu/g	$2x^5$	$2x^6$	-	x^8
2	*Rhizopus Strolnifer*	Cfu/g	x^2	x^6	-	x^9
3	*Mucor hiemalis*	Cfu/g	x^3	x^5	x^6	x^{10}
4	*Mucor miehei*	Cfu/g	x^3	x^5	x^7	x^4
5	*Penicillium spp*	Cfu/g	x^4	x^5	x^7	x^9
6	*Ailernaria tennis*	Cfu/g	x^2	-	-	x^1
7	*Themonye*	Cfu/g	x^3	x^2	-	
8	*Sporotrichum*	Cfu/g	-	x^7	-	
9	*Thermophillium*	Cfu/g	-	x^2	x^3	
10	*Asperallus niger*	Cfu/g	-	-	x^4	-
11	*Hernicola grisea*	Cfu/g	-	-	x^5	x^6
12	*Emericella indulcna*	Cfu/g	-	-	x^8	x^{12}
13	*Fursarium Spp*	Cfu/g	-	-	x^2	x^3
14	*Aspergillus Flerns*	Cfu/g	-	-	x^4	
15	*Alternaira spp*	Cfu/g	-	-	-	
16	*Ascomyces spp*	Cfu/g	-	-	-	

fuel burning, batteries and lubricating oil. From the results, it is further observed that the heavy metal concentrations were higher in the top soils at the depth of 0-30cm and the concentrations decreased with distance from the road side (Fig. 2). And these, indicated that the soil is being polluted by heavy vehicular flows. The results are further explained by authors like Ihenyen (1992), Weckwerth (2001), who attributed high degree of heavy metal contamination in the soil due to motor vehicles. Dierkes & Geiger (1999) viewed that among the larger number of heavy metals; lead, cadmium and zinc are the most common metals that accumulate in the roadsides soils (Williamson, 1973). But, the overall results indicated that cadmium had the highest percentage of concentration in the soil followed by nickel and third copper.

From Table.4, fungi population densities are higher in 200m, 150 and 100m away from the roadside, while there is decrease in the fungi population at 50m along the roadside. The decrease in number of soil microbes can be attributed to the effects of vehicular flows that emit heavy metals and the wearing of tire along the road side. The result is consistent with the finding of (Acea and Carballa, 1985; Nwaugo *et al.*, 2005).The results also indicated that greater number of microbes such *Aspergillus fumigatus* , *Rhizopus Strolnifer* , *Mucor hiemalis*, *Mucor miehei*, *Penicillium spp*, *Ailernaria tenniss*, and *Themonye* were isolated at 50m (Brookes, *et al.*, 1986; Chessbrough, 1987) stated that good spore formers can survive within harsh environmental conditions like in the 50m soil samples.

Summary and Conclusion

From the results, it was observed that the soil pH was lower at 50m from the roadside indicating acidity in the soil which affect productivity of the soil, it reflected the stunted plant growth near the roadside. Soil temperature was also identified along the roadside with decreased soil moisture at decreased distant. Also heavy metals were found close to the main road. Similarly greater number of bacteria and fungal were found in greater population at a distance away from the soil samples close to the roadside. This has affected the activities of microorganisms that would have helped in the decomposition process for mineralization and mobilization of soil nutrients. It is then concluded that since there is little or no human activity along the roadside, heavy traffic has caused the declined in the microbial population in the study area. It is the recommended that, for sustainable soil quality management for food production:

(1) Affected soil with low pH should be limed
(2) Ring - roads should be constructed to divert traffic in Owerri west
(3) Maintenance of vehicles should be monitored by vehicles inspection officers (VIO) to make sure that vehicles are not smoked unnecessarily.
(4) Exotic trees should be planted linearly for gaseous exchange for air quality
(5) The soil that is heavily contaminated with lead should not be used for growing of food crops but for ornamentals trees.
(6) Farmers working on the contaminated soil should wear gloves and shoes to avoid self contamination
(7) Moreover, farmers should remove gloves and shoes at the doorway to avoid tracking soils indoors where children play on the floor.

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