

## **Generated Organic Waste Effects on Insitu Soils Properties at Uyo Municipality Animal Park/Market, Nigeria**

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**Abstract**—*Insitu soil polluted by generated organic waste at Uyo municipality animal market/park was investigated for physico-chemical, heavy-metals (HMs) and microbial properties at 5 stations at 2cm, 10cm and 20cm depths using wet acid digestion, and atomic absorption spectrophotometer and McCartney method. The five stations, within grid size of 10m x 60m on the lot, were goat/cattle roasting spot (GCRS), slaughter house vicinity (SHOV), abattoir surrounding (ABTR), goat shed (GTSH) and solid waste dump site (MDPS). Statistical analysis of data, spatial and profile variation and significant differences between stations used SPSS version 17 package. Acidic soil was observed at ABTR and SHOV (pH: 5.6-6.5) but alkaline at MDPS; while pH showed no significant difference with depth Heavy metal pollution (HPI) of insitu soil was significant ( $p < 0.1$ ), high and variable amongst stations with Pb, Zn, Cu, Ni and Mn (or 55% of the observed HMs) being the highest at SHOV. Only Ni, Cr, Cd and those at GCRS were below screening level. Only Pb, Mn and Cr were homogeneously distributed at all stations (CV 1.7% - 15.6%). Generally, Mn, Cd, Cr, Hg and V varied with depth; HPI varied amongst stations following the order GRCS>MDPS>SHOV>ABTR>GTSH. Geometric mean of enrichment factors (EF) followed the order Pb>Cd>Cr>Cu>Mn>Ni; Pb with EF>6 (2039.4 – 8576.9 mgkg<sup>-1</sup>) showed toxicity problem, potentials for co-absorption of metals and bio-accumulation in plants downslope. Bacterial and fungal contamination varied amongst stations, with the animal roasting site recording the highest. Screening and monitoring of Pb, Cd at GRCS and Cu particularly is required. Surface drainage and treatment plant for waste and wastewater at downslope area are required to protect borehole and stream from pollution.*

**Keywords**—*generated organic wastes, heavy metal toxicity, microbial contamination, enrichment factor, insitu soil contaminant, NPS drainage, waste treatment, animal market/park*

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### **I. INTRODUCTION**

Siting of animal market/park with abattoir in Uyo municipality, Akwa Ibom State, Nigeria is necessary as proper management of nomadic animals droppings have not been recognized before now that urban renewal and development have taken place. This was a necessary measure to reduce the spread of generated droppings by nomadic cattle in the urban, and liters of waste animal feeds, stale straws, grubbed hays and animal droppings accompanying the itinerary of trucks of animal transportation and marketing. Arising from this, an area of about 3000m<sup>2</sup> was allotted and traders and sourjourners found shelter in the market halls and resided in huts in the precincts of the market/park carrying out their transactions. The animal market/park received a loading of thirty six herds of cattle in 3-6 long trucks weekly depending on orders. These arrived the facility every Monday and constituted a total of 108-216 cows per week. Also 500 goats were offloaded from about 4-6 No. 911 high-axle lorries weekly depending on orders, and those constituted about 8,000-12,000 goats every week.

The release of pollutants from active or open animal market/park can be a major source of contaminant to groundwater, surface water and soils [1]. As rainfall, runoff and waste water contact and percolate through the liters of animal droppings and organic wastes, it sets up chemical reaction so that chemical compounds are leached from the organic wastes into the infiltrating water constituting point source and nonpoint sources pollution. This leachate migrates vertically and laterally into the environment by direct or indirect discharge into any adjacent water body and insitu soil and to down slope areas in and around the municipality animal (cattle and goat) market/park.

It has a tendency to increase the water content of the waste and soil until excess saturation condition occurs, then the water will slowly move through the waste, absorb the soluble materials present in the solid waste [2] and seep through the ground. This will contaminate the insitu soil directly since there is no control of infiltration and no designed drainage system on the bare ground of the open market. Thus, the insitu soil samples represent excellent media to monitor heavy metal pollution in the lot due to the anthropogenic activity because the heavy metals are usually deposited in the topsoil [3], [4], [5]. Thus, the soil and water resources are under stress from urbanization, industrial development and population growth. Where international trade, urbanization and the environment coincide, as in this facility, it becomes vital and imperative to reliably monitor the quality of the micro-environment so that necessary actions may be addressed to controlling the leaks of pollution to the larger downstream catchment as it is said “little drops of water make the ocean”.

The waste from the facility includes animals droppings on daily basis, liters of used and stale animal feeds and straws; spilled, dripping or spent oil; abattoir waste water overspill, and strewn-about solid waste from traders and squatters. Abattoir waste water is known to contain a variety of metals while other organic waste has large microbial population and biodegrades under the humid environment, leaching out various chemical and microbial pollutants to the immediate environment. These are then transported by microorganisms and NPS runoff to adjacent land and streams especially down slope of the facility. Heavy metal pollution load was observed in the down slope bush-fallow with bio-accumulation in

vegetables planted there [6]. Currently, also there are no waste treatment plants for the market/park; and regulation activity for the protection of water sources is not established or organized as a policy.

Thus, this investigation will provide current data on the extent of environmental resources pollution by animal droppings and generated organic wastes in the animal market/park as a combined and sustained point source (PS) and nonpoint source (NPS) pollution, which may compel the design of necessary control measures.

## II. MATERIALS AND METHODS

### A. Location of Study Site

The study site of about 3000m<sup>2</sup> is located in Iba Oku Village micro-catchment in Uyo Local Government Area of Akwa Ibom State, Nigeria. Uyo has a population of 304000 in an area of 95 km<sup>2</sup> within longitudes 5° 30' and 7° 56' E and latitudes 4° 30' and 5° 30' N on an altitude of 6.5m [7], [8]. The area is in the tropical zone of equatorial rainforest belt which houses vegetations of green foliage of trees, shrubs and oil palm trees with good supply of grass for cattle and goat feeds.

### B. Sample Collection and Preparation

Debris, rock pieces, and physical solid waste contaminants were removed from the soil surface at the locations of measurement. Samples of soil polluted by organic wastes on the lot were collected at five different locations within approximate grid size of 10m x 60m on the market/park ground, namely: at GCRS being the location for goat/cattle roasting, ABTR for abattoir surroundings; SHOV for slaughter house vicinity, GTSH for goat shed, and MDPS for market/park solid waste dump site. The soil samples were taken within grid size, at depths of 2, 10 and 20cm using stainless steel soil auger and removed with plastic spatula into well labeled 10mm diameter plastic covered cans. The samples were transferred to the Soil Science Laboratory, University of Uyo for physical, chemical and microbial analysis. The soil samples, at the laboratory, were spread on old newspapers to air-dry and then mixed thoroughly to obtain representative samples for each depth. After drying, debris were hand-picked out and the samples for each location and depth were crushed of aggregates or lumps in a porcelain pestle and mortar, taking care not to break the actual soil particles. Soil samples were then sieved through a 1mm sieve to collect the silt/clay fractions and stored in labeled nylon bags for analysis.

### C. Chemical Analysis

For heavy metals and other elements, wet acid digestion was used to obtain acidified filtered samples [9]. One gram of each sample was weighed into digestion flask, and then acidified with 20ml nitric acid and 5ml perchloric acid to completely digest the soil over a hot plate (till the mixture turn white). Then 20ml of deionized water was added and the mixture jars shaken for 16 hours with orbital shaker before the mixture was filtered through whatman filter paper (No 42) into acid-washed bottles. Then the digest or solution was made up to 100ml with distilled water and stored for analysis of heavy metal elements by atomic absorption spectrophotometer per standard methods [9], [10], [11].

The raw data obtained during the laboratory analysis were processed to obtain various parameters used for interpretation. Concentrations of Copper (Cu), Lead (Pb), Zinc (Zn), and Manganese (Mn) were determined by direct aspiration of the extract solution into an air acetylene flame. Before doing so, a calibration curve of the metal stock was prepared using aliquot from the standard stock solution of the metal or its salts in preparing the working solution. Extractable phosphorus was obtained by Bray's method; Nitrate-Nitrogen (N-NO<sub>3</sub>) and ammonia (NH<sub>4</sub>) were obtained by Brucine and Nessler's colorimetric methods respectively [9], [10]; Sulphates, DO, BOD, alkalinity, acidity were also determined while electrical conductivity was measured using electrical conductivity meter. Sulphate used turbidimetric methods. Total carbon followed the method in [12]. Particle sizes distribution was determined by hydrometric method and soil pH by glass electrode in distilled water [12], [13].

Microbial colony was counted using McCartney method. Total coliform was determined by total coliform content method. Pour plates were made into MacConky agar medium for heterotrophic bacterial counts while potatoes dextrose agar was the medium used for fungi counts. Macroscopic examination of fungi isolates was made by direct observation on the plate using pigmentation and media textural properties, while microscopic examination was made by wet preparation of colonies. A sterile needle was used to pick the colonies. Characterization and identification of the isolates used gram stain and other tests for identification of medical bacteria and Bargay's determinative bacteriology manual. Oxidase test was used to observe *Escherichia coli*.

### D. Statistical Analysis

Data on metal concentrations were statistically analyzed for descriptive statistics, spatial variability and significant differences by ANOVA using SPSS version 17 package. The distribution of maximum and minimum values of metal concentrations at spatial locations on the market/park soil as well as the distribution and variation in soil profiles to indicate homogeneity or non-homogeneity were also evaluated using covariance (CV), heavy metal pollution index and Enrichment factor. The mean of mean station values was obtained as geometric mean of mean as

$$G \text{ mean} = (Ms_1 \times Ms_2 \times \dots \times Ms_n)^{1/n} \quad (1)$$

where  $Ms_1$  is station mean and  $n$  is number of heavy metals.

Heavy Metal Pollution Index (HPI), showing the cumulative or combined effects of all available metals pollution in the soil at each location, was evaluated using the index [14], [15], [16] given as

$$HPI = (CF_1 \times CF_2 \times CF_3 \times CF_n)^{1/n} \quad (2)$$

where CF is contamination or enrichment factor (EF) given below, and  $n$  is number of elements.

Enrichment factor (EF) is used to assess the variations in heavy metal accumulations in the soil and was calculated by the formula given by [5], [17]. Thus,

$$EF = \frac{\text{value of a given metal concentration found on soil (mg/kg)}}{\text{Normal local background concentration of the metal (mg/kg)}} \quad (3)$$

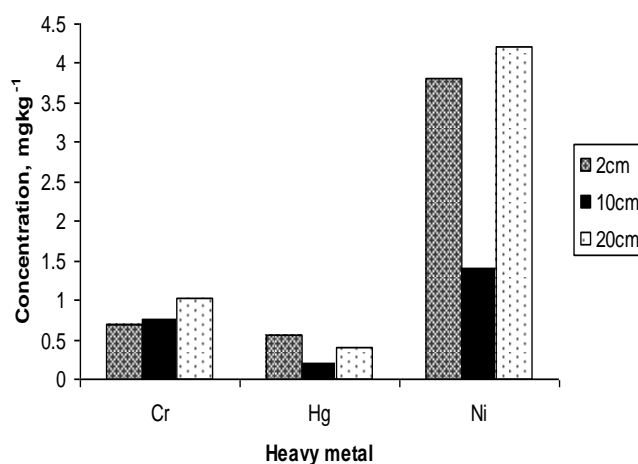
### III. RESULTS

The data from the investigation are given in tables below.

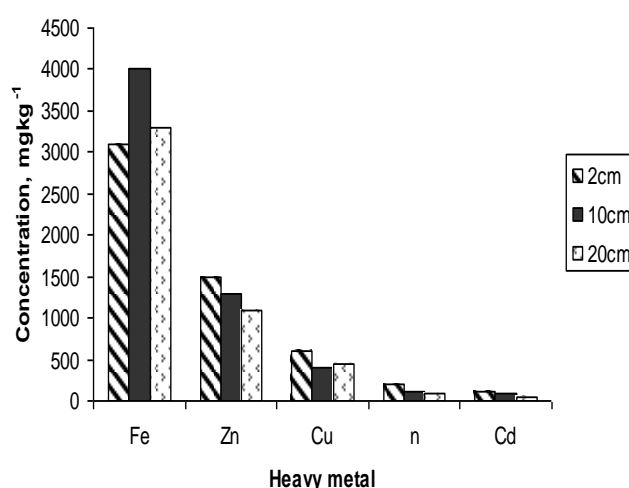
**Table I:** Physico-Chemical Properties of Insitu Soil under Organic Waste Material Pollution at Animal Market/Park, Uyo.

		Range	Mean	Sd	CV%	F- Value
pH	GCRS	7.8 -7.96	7.89	0.08	1	7.735**
	ABTR	3.97 - 6.82	5.64	1.49	26.4	
	SHOV	6.4 - 6.54	6.49	0.08	1.2	
	GTSH	6.23 - 7.28	6.75	0.53	7.9	
	MPDS	8.2 - 8.45	8.35	0.13	1.6	
	Gmean		6.96	0.23	3.3	
EC (m <sub>scm</sub> <sup>-1</sup> )	GCRS	86 - 173.00	126.00	43.92	34.8	6.267**
	ABTR	174 - 418.00	260.33	136.75	52.5	
	SHOV	65 - 670.00	342.67	305.54	89.2	
	GTSH	961 - 3863.00	2422.00	1451.10	59.9	
	MPDS	301 - 488.00	363.67	107.68	29.6	
	Gmean		397.3	195.66	49.2	
TOC (%)	GCRS	2.63 - 5.51	4.23	1.47	34.7	1.282**
	ABTR	2 - 6.11	4.04	2.06	50.9	
	SHOV	3.7 - 6.74	4.73	1.74	36.8	
	GTSH	5.76 - 6.14	6.01	0.22	36.6	
	MPDS	5.15 - 6.36	5.88	0.64	10.9	
	Gmean		4.91	0.94	19.1	
Sand (%)	GCRS	92.36 - 94.36	93.69	1.15	1.2	39.029**
	ABTR	93.1 - 95.10	94.10	1.00	1.1	
	SHOV	83.8 - 85.80	84.80	1.00	1.2	
	GTSH	80.4 - 84.40	82.40	2.00	2.4	
	MPDS	83.4 - 87.40	85.40	2.00	2.3	
	Gmean		87.95	1.36	1.5	
Silt (%)	GCRS	0 - 0.00	0.00	0.00	0.0	1.611
	ABTR	2 - 2.10	2.03	0.06	2.9	
	SHOV	5.2 - 7.20	5.87	1.15	19.6	
	GTSH	3.6 - 7.60	5.27	2.08	39.5	
	MPDS	5.6 - 46.00	19.40	23.04	1.2	
	Gmean		5.90	1.35	23.0	
Clay (%)	GCRS	5.64 - 5.64	5.64	0.00	0.0	1.273
	ABTR	2.8 - 4.90	3.53	1.18	33.4	
	SHOV	8 - 10.00	9.33	1.15	12.3	
	GTSH	12 - 12.00	12.00	0.00	0	
	MPDS	10 - 87.00	35.67	44.46	124.6	
	Gmean		9.55	3.92	41.0	
NO <sub>3</sub> (mgkg <sup>-1</sup> )	GCRS	155 - 225.00	181.67	37.86	20.8	121.408**
	ABTR	345 - 420.00	390.00	39.69	10.2	
	SHOV	102.2 - 110.10	106.23	3.95	3.7	
	GTSH	24.1 - 24.33	24.21	0.12	0.5	
	MPDS	0.9 - 2.10	1.67	0.67	40.1	
	Gmean		49.73	3.43	6.9	
NH <sub>4</sub> (mgkg <sup>-1</sup> )	GCRS	28.2 - 37.40	31.90	4.86	15.2	9.611**
	ABTR	29.26 - 30.04	29.77	0.44	1.5	
	SHOV	30.1 - 36.20	32.43	3.29	10.1	
	GTSH	79.63 - 190.35	132.74	55.50	41.8	
	MPDS	32.6 - 40.60	36.93	4.04	10.9	
	Gmean		43.23	4.36	10.1	
SO <sub>4</sub> (mgkg <sup>-1</sup> )	GCRS	96.25 - 104.50	99.00	4.76	4.8	1.206
	ABTR	50.2 - 99.20	77.50	24.98	32.2	
	SHOV	99.89 - 108.80	103.30	4.81	4.7	
	GTSH	17.38 - 131.01	77.16	57.05	73.9	
	MPDS	113 - 123.00	118.70	5.14	4.3	
	Gmean		50.06	11.09	22.2	

Significant at P<0.05, \*\* Significant at P<0.01, Gmean = geometric mean



A. Distribution of Cr, Hg and Ni with depth



B. Distribution of Fe, Zn, Cu, Ni and Cd with depth

Fig. 1 Distribution of heavy metals with depth in soil at animal market/park, Uyo

#### IV. DISCUSSION

Physico-chemical properties, in table 1, show significant differences at ( $p < 0.01$ ) and variability in properties. Silt and clay did not have significant variability except at MDPS station which showed the highest values and variability (CV = 118.8% and 124.6% respectively). Sand was the highest fraction (87.95%) at all stations and was largely homogenous in distribution (CV = 1.1% – 2.4 % only). Particle size distribution also showed significant spatial variability with sand content of the stations following the decreasing order: ABTR>GCRS>MPDS>SHOV>GTSH. Silt content was low with no significant difference between the stations ( $p < 0.05$ ) (Table I). The low content may be due to the effect of runoff erosion and leaching which remove fine particles with running water. Much of the entrained silt and clay may have been deposited at the edge of the market with fallow-bush, hence the comparatively higher content of silt and clay at waste dump site (MPDS) which is at the downslope border of the bush-fallow with the market/park, receiving sediment eroded from the market/park ground by NPS runoff.

Clay distribution also showed low content with significant difference ( $p < 0.05$ ) between the stations. Constant removal of fine particles caused by high rainfall on the bare soil in the area may explain why sand particles contained the highest percentage at stations. Also, with silt/clay ratio of 15%, these soils are young [18]. The textural class was slightly different: GCRS, ABTR were loamy sand while MPDS was clay loam.

##### A. Distribution with Depths

Sand and clay particles maintained their proportions throughout the depths but silt followed no particular trend with depth. The topsoil depth (0-2cm) had the highest silt content whereas it was almost similar in 10cm and 20cm depths. Heavy metals are absorbed into soil surface hence the high significant ( $p < 0.01$ ) correlation coefficients between silt, which was very high on the surface, and heavy metals: Pb, Zn and Cd ( $r = 0.0875, 0.933$  and  $0.963$ ) respectively. The pH was mildly acidic at all stations except at MPDS (the organic waste dump station) ( $pH = 8.35 \pm 0.13$ ). Obviously, the leaching of organic filtrate affected the soil there.

The acid level, pH, varied significantly amongst the five stations. ABTR had the most acidic soil amongst the stations followed by SHOV. This suggests that the abattoir water and slaughter house blood and other animal wastes deposited high acidity to the soils at their stations. GTSH had the least acid soil. Blood is known to be acidic. Similarly, GCRS had the most alkaline soil from the alkaline composition of the waste involved. This may be largely attributed to the proximate ash waste deposited there from the roasting of the animals and solid wastes which are alkaline in nature. The distribution of soil pH showed no significant difference ( $p < 0.05$ ) with depth, implying that pH varied mainly on the soil surface than in subsoil and the pH values of 2-20cm depths were almost similar (Table I). This is in line with such observations by [18].

Electrical Conductivity was high (mean  $E_c = 397.3$  ms/cm) but varied widely at stations (CV = 29.6%). The difference was very significant ( $p < 0.01$ ). Concentrations of ammonia and nitrate were high and showed significant differences amongst stations ( $p < 0.01$ ) as well as high variability (CV = 1.5% – 41.8% and 0.5% - 40.1% respectively). All together significant differences existed in values of physico-chemical properties as well as spatial variability amongst stations on the animal market/park ground and these were the marked effect of the combined PS and NPS contaminants generated on the facility.

Electricity conductivity (ECe) decreased in the following order: MPDS>SHOV>ABTR>GTSH>GCRS, indicating a significant spatial variation between the stations. The ECe of these soils were high suggesting that the entire micro catchment soil had high potentials for retaining cations on their exchange site. This is beneficial to crops. The higher ECe at MDPS than the other stations may be due to the salinity levels of these soils [19]. ECe varied with depth with the 2cm depth having the highest value, followed by the 10cm before the 20cm depth. The soil of the organic-waste-generating facility was heterogeneous with respect to electrical conductivity at depths. This may be connected with surface decomposition and release of element from organic waste. Comparatively, the soil of the normal soil was observed to have similar ECe values within the surface and subsurface soils (0-20cm and 20-40cm depths).

Total Organic Carbon (TOC) showed the distribution of total organic carbon at the five stations (Table II). The mean value, however, were above 2.0% reported by [20] as the critical level for crop production. Thus, the entire micro watershed facility had enriched the organic carbon content of the soil at stations. This is confirmed by low significant level (5%) indicated by F-value (1.282). Slight variations in TOC amongst the five stations may be caused by the proportion of dissolved carbon than other factors; this indicates that it was easily broken down by micro-organisms in the environment compared to other low organic carbon. Hence the microbial activities were relevant and engendered by the organic waste on the lot. Total Organic Carbon increased with depths. Although organic carbon from organic matter on the soil surface is generally contained within the top layers of the soil profile, the high TOC in the 20cm depth may be due to the dissolved component of organic carbon materials found on the soil and leaching into the soil.

The distribution of nitrate is almost inverse to that of TOC and indicates that it may have been brought about by a combination of organic waste decomposition, atmospheric nitrogen fixation into the soil by electrical discharges during lightning or by fixation by micro-organisms [21]. The highest  $NO_3$  was obtained at 10cm depth.

## **B. Other Chemicals**

Ammonia ( $NH_4$ ) distribution amongst stations followed the order: GTSH > MPDS > SHOV > GCRS > ABTR and was quite similar to those of TOC. This suggests that  $NH_4$  was mineralized from organic material in the soil. There was a significant difference in  $NH_4$  content in the wastes ( $p < 0.05$ ) as confirmed by  $F = 9.611$  (Table I) and attributable to the difference in organic matter content in the soil, which determines the soil content of  $NH_4$  at corresponding station. The  $NH_4$  increased slightly with depth. The depth-wise distribution in 10 and 20 cm depths was almost similar but higher than the amount in 2 cm depth. This may be related to the rate of mineralization and leaching of  $NH_4$ .  $NH_4$  is easily leached by rainfall which is high in the area.

Sulphate ( $SO_4$ ) concentration reduced in the following order: MPDS > SHOV > GCRS > ABTR > GTSH. The mean values were greater than  $0.2$  mg  $kg^{-1}$  which is used for classifying soils as sulphur deficient soils; hence the generated animal and organic wastes had increased  $SO_4$  content in the animal market/park soil.

## **C. Heavy metals, (HM), distribution in polluted insitu soil and screening levels**

Nine heavy metals (HM) were analyzed, namely lead

(Pb), Zinc (Zn), Copper (Cu), Nickel (Ni), Manganese (Mn), Cadmium (Cd), Chromium (Cr), Mercury (Hg), and Vanadium (V) (Table II). Their spatial distribution was very significantly different amongst stations from 0.00% - 157.69% (Table II). While the distribution was largely homogeneous for Pb (CV = 1.66% - 15.6%), Mn (11.39% - 29.28%), Cr (16.68% - 35.19%), and V (0.27% - 38%), it was non homogeneous or very heterogeneous for Zn (5.02% - 93.40%), Cu (7.18% - 50.45%), Ni (16.53% - 157.69%) and Cd (23.93% - 50.00%). However, Pb recorded its highest content ( $8576.97 \pm 1338.27$  mg  $kg^{-1}$ ) at SHOV station, Zn ( $2895.27 \pm 758.40$  mg  $kg^{-1}$ ) at SHOV, Cu at all stations although highest ( $910.88 \pm 65$  mg  $kg^{-1}$ ) at SHOV, Ni ( $4.13 \pm 0.27$  mg  $kg^{-1}$ ) and Mn ( $567.86 \pm 166.30$  mg  $kg^{-1}$ ) at SHOV, Cd ( $642.51 \pm 153.73$  mg  $kg^{-1}$ ), at GCRS, Hg ( $79.09 \pm 16.07$  mg  $kg^{-1}$ ) and V ( $67.54 \pm 18.49$  mg  $kg^{-1}$ ) at GCRS and ABTR respectively.

Generally, HM concentration was highest at SHOV station for Pb, Zn, Cu, Ni, and Mn (i.e. 55% of the nine HM studied) (Table II). Cd and V were only the highest concentration at GCRS, while SHOV also recorded the least HM concentration for Cr. In all, the distribution of HM pollution in insitu soil under organic loads at animal market/park was significantly high ( $p < 0.01$ ) and variable. Gmean of HM concentration followed the reducing order (Table II): Pb>Zn>Cu>Mn>Ni>V>Cr>Cd>Hg. The highest metal pollution from 55% of the observed HM occurred at stations at the vicinity of abattoir/slaughter house (SHOV). Compared with screening levels of 23,600mg $kg^{-1}$ , 1600mg $kg^{-1}$  for Ni, 70mg $kg^{-1}$  for Cd and 230mg $kg^{-1}$  for Cr and Cu [22], only Ni, Cr, Cd (except at GCRS and Zn at ABTR only) were compliant or below the screening levels; the rest were above the screening levels. Compared with critical values of 0.5 and 1.0mg $kg^{-1}$  for Pb and Zn, their concentrations were higher and toxic at the market/park soils.

Lead Pb was homogeneously distributed at all stations ( $C_v = 1.7\%-15.6\%$ ) although its mean contents were very high (Table II). The total concentration of Pb at all stations ( $2039.4 - 8576.97 \text{ mgkg}^{-1}$ ) greatly exceeded the  $400 \text{ mgkg}^{-1}$  USEPA soil screening level for cleanup effort of contaminated soil [22]. Here the soil at the animal market/park lot requires monitoring and cleanup of Pb. The high content of Pb is known to enhance co-absorption of other metal elements, especially in acidic soil [6], [23]. Most of the lead comes from human activities like burning of fossil fuels and waste (when it stays in air before dropping out into soils) and from landfills, paints, water proofing materials, household utensils, and alloys, amongst others [24]. These sources occur in the urban and at the animal market/park and add up to the very high total lead at the lots (Table II). However, Pb sticks to soil particles and does not move from soil to groundwater or drinking water except the water is acidic [24]. Thus, the acidic soil and the percolating low acidic water (Table I) may inform the environment watchers to watch the borehole and stream water for high lead pollution or screen them from high Pb pollution under the sustained generated organic load on the animal market/park ground. The high concentrations of heavy metals and significant spatial distribution especially at the market's border with down slope buffer soil, close to stations MDPS, ABTR and SHOV, suggest the possible transfer of the HM contaminants to adjacent soils and water ecosystem by NPS runoff and acidic lateral flow, as was observed where such anthropogenic activities with industrial and organic waste generation occurred [3], [25], [26]. This confirms the earlier observed high HM pollution of the down slope buffer soil [6]. Hence, it is suggested that the facility's borehole and stream water which indicate low acid levels [6] be monitored for high HM levels or be screened for cleanup effort.

Generally, there was variation in Mn, Cd, Cr, Hg, and V with depth. Concentration of Mn decreased slightly with depth while that of Hg and Ni followed no definite pattern with depth. Perhaps this is due to the susceptibility of the metals to leaching action of rain water on the gently sloping terrain of the facility.

**Table II:** Heavy Metal Content of insitu soil polluted with organic waste materials at animal market/park, Uyo.

Property	Location	Range	( $\text{mgkg}^{-1}$ )	Mean ( $\text{mgkg}^{-1}$ )	Std	Cv%	F-value
Pb	GCRS	2318.09 -	2539.37	2423.40	111.02	4.6	62.43**
	ABTR	1878.20 -	2136.80	2039.49	140.67	6.9	
	SHOV	7282.18 -	9954.84	8576.97	1338.27	15.6	
	GTSH	2884.61 -	2979.26	2925.94	48.45	1.7	
	MPDS	2218.11 -	2446.06	2340.75	114.96	4.9	
	Gmean			3108.71	163.38		
Zn	GCRS	1206.37 -	1329.00	1258.80	63.22	50.2	20.88**
	ABTR	3.07 -	570.52	308.50	286.20	92.8	
	SHOV	2071.48 -	3564.44	2895.27	758.40	26.2	
	GTSH	890.44 -	1163.71	1006.86	141.05	14.0	
	MPDS	651.84 -	911.77	755.81	137.54	18.2	
	Gmean			969.30	192.77		
Cu	GCRS	274.60 -	861.12	583.86	294.57	50.4	5.79**
	ABTR	154.63 -	570.52	296.81	237.10	79.9	
	SHOV	857.12 -	983.75	910.88	65.44	7.2	
	GTSH	490.54 -	566.53	522.98	39.19	7.5	
	MPDS	223.94 -	437.22	315.92	109.62	34.7	
	Gmean			482.24	114.45		
Ni	GCRS	0.12 -	4.40	1.56	2.46	157.7	1.53
	ABTR	0.07 -	3.07	1.10	1.71	155.5	
	SHOV	3.87 -	4.40	4.13	0.27	6.5	
	GTSH	1.60 -	3.73	2.49	1.11	44.6	
	MPDS	0.15 -	3.87	1.42	2.13	1.5	
	Gmean			1.90	1.22		
Mn	GCRS	209.28 -	290.59	246.16	41.18	16.7	9.17**
	ABTR	178.62 -	267.93	216.83	46.03	21.2	
	SHOV	378.57 -	690.49	567.86	166.30	29.3	
	GTSH	198.62 -	286.60	233.46	46.76	20.0	
	MPDS	263.93 -	331.92	299.48	34.10	11.4	
	Gmean			291.90	54.99		
Cd	GCRS	522.54 -	815.80	642.51	153.73	23.9	52.35**
	ABTR	0.05 -	0.11	0.08	0.03	0.3	
	SHOV	0.05 -	0.09	0.07	0.02	28.6	
	GTSH	0.01 -	0.03	0.02	0.01	50.0	
	MPDS	0.53 -	1.60	1.11	0.54	48.6	
	Gmean			0.60	0.22		
Cr	GCRS	0.80 -	1.51	1.08	0.38	35.2	13.40**
	ABTR	1.07 -	1.60	1.29	0.28	21.7	
	SHOV	0.15 -	0.21	0.18	0.03	16.7	
	GTSH	0.31 -	0.51	0.40	0.10	25.0	
	MPDS	1.07 -	1.47	1.20	0.23	19.2	
	Gmean						

	Gmean			0.65	0.15		
Hg	GCRS	0.40 -	0.67	0.53	0.14	26.4	5.31**
	ABTR	0.27 -	0.67	0.45	0.20	44.4	
	SHOV	0.19 -	0.32	0.25	0.07	28.0	
	GTSH	0.03 -	0.15	0.10	0.06	60.0	
	MPDS	0.27 -	0.53	0.40	0.13	32.2	
	Gmean			0.30	0.11		
V	GCRS	63.98 -	95.98	79.09	16.07	20.3	40.63**
	ABTR	51.99 -	87.98	67.54	18.49	27.4	
	SHOV	0.08 -	0.12	0.10	0.02	20.0	
	GTSH	0.01 -	0.01	0.01	0.00	0.0	
	MPDS	0.13 -	0.13	0.13	0.00	0.0	
	Gmean			0.93	1.81		

\* Significant at P<0.05, \*\* Significant at P<0.01, Gmean = geometric mean

**Table III:** Geometric mean of heavy metal concentrations in decreasing order at stations in animal market/park Uyo

Station	GCRS	ABTR	MPDS	SHOV	GTSH
G max	87.27	26.26	16.05	16.2	7.14
G mean	64.71	17.31	13.65	13.67	5.78

G max, G mean = Geometric mean of heavy metal pollution index for maximum and for mean concentration of metal at each station analyzed on the market/park ground

**Table IV:** Enrichment factor (EF) for six metals at stations at the animal market/park, Uyo compared to pristine value at the area

	Pb	Cu	Ni	Mn	Cd	Cr	HPI CF
GCRS	351.2	2.2	0.007	1.14	4015.7	5.68	7.2
ABTR	295.6	1.1	0.005	1.01	0.5	6.79	1.3
SHOV	1243	3.4	0.02	2.64	0.4	0.95	2.1
GTSH	423.9	1.9	0.012	1.08	0.001	2.1	0.5
MPDS	339.1	1.2	0.007	1.39	6.9	6.32	2.4
G <sub>mean</sub>	450.5	1.8	0.009	1.36	3.8	3.42	2.2

N/B: Gmean EF order: Pb>Cd>Cr>Cu>Mn>Ni

#### D. Heavy Metal Pollution Load Index (HPI)

The geometric mean of the HM pollutants was used to express heavy metal pollution load index (HPI), since such a method tends to reduce the data outliers which might bias the report of the cumulative mean of Hm in the soil [27]. The HPI so obtained showed large differences in the index values at stations in the following reducing order or degree of HM contamination (Table III): GCRS > ABTR > SHOV > MPDS > GTSH. Also, using pristine HM values from control station under fallow at an upslope site to the market/park [23], [27], the HPI was calculated as a geometric mean of contaminants factor ratio also called Enrichment factor (EF) given as:

$$HPI = (CF_1 \times CF_2 \times CF_3 \times \dots \times CF_n)^{1/n} \quad (4)$$

CF = EF is given in equation 3 and

EF = CF<sub>n</sub> sample/CF<sub>n</sub> background

where CF is contaminant or enrichment factors, n is number of metals in samples analyzed at each station, CF<sub>n</sub> sample and CF<sub>n</sub> background are for sample and background soils contaminants respectively. CF<sub>n</sub> < 1 depicts low contamination while 1 < CF<sub>n</sub> < 3 depicts moderate contamination, 3 < CF<sub>n</sub> < 6 depicts considerable contamination and CF<sub>n</sub> > 6 is for very high contamination. It could be simplified that CF<sub>n</sub> < 1 is for low contamination and CF<sub>n</sub> > 1 is for high contamination (i.e. low soil resources quality).

The background or pristine HM values for the area were: Pb (6.90±3.25 mg kg<sup>-1</sup>); Cu (268.36±85.55 mg kg<sup>-1</sup>); Ni (206.20±48.21 mg kg<sup>-1</sup>); Mn (215.30±48.86 mg kg<sup>-1</sup>); Cd (0.16±0.09 mg kg<sup>-1</sup>); Cr (0.19±0.05 mg kg<sup>-1</sup>); Boron (0.03±0.03 mg kg<sup>-1</sup>); Fe (105.96±10.25 mg kg<sup>-1</sup>). It was not possible to get the background pristine values for Zn, Hg and V, therefore both CF and HPI were computed using 6 HMs, which Gmean EF varied in the order Pb>Cd>Cr>Cu>Mn>Ni (Table IV).

From Table IV the contaminants enrichment factors showed very large magnitudes above the background values especially for Pb at all stations, and for cadmium at GCRS. These gave CF > 6, indicating extreme Pb contamination of soil at all stations and cadmium at GCRS only on the animal market/park ground. Pb and Cd must be promptly monitored, and seepage controlled by designed drainage from seeping directly into ground and surface water systems. Nickel at all stations had CF < 1, depicting deficiently contaminated soil; hence it is safe. Apart from Cd at ABTR, SHOV and particularly at GTSH (CF = 0.001), the remaining metals (Cu, Mn, Cr) recorded moderate to serious contamination and require monitoring at the site and some waste control measures over the market/park soil to save the ecosystem downstream.

The HPI that was due to contamination factors had its order rearranged from the one based on measured concentrations, but this may be due to the exclusion of 3 metals in HPI calculation. The degree of contamination at stations with six metals followed the order: GCRS > MPDS > SHOV > ABTR > GTSH in Table IV while HPI, based on nine HM, followed the order GCRS>ABTR>MPDS>SHOV>GTSH, with GTSH trailing both lines.

Therefore, in monitoring close source of environmental pollution, where sustained production of animal and organic wastes go on daily, close monitoring or large density of monitoring instruments must least exclude any heavy metal to avoid under assessment of associated risk.

**Table V:** Microbial population in insitu soils polluted with the waste material at animal market, Uyo.

Parameter	Waste Location	Mean (x 10 <sup>2</sup> Cfu/g)	Sd	F- value
Total	GCRS	94.67	90.89	1.328
	ABTR	24.33	19.01	
	SHOV	92.00	13.75	
	GTSH	42.33	20.22	
	MPDS	57.67	9.07	
Fungi	GCRS	4.67	6.43	1.337
	ABTR	0.00	0.00	
	SHOV	3.67	2.08	
	GTSH	3.00	0.00	
	MPDS	5.67	2.52	
Bacteria	GCRS	90.67	84.51	1.730
	ABTR	21.67	15.28	
	SHOV	88.33	11.68	
	GTSH	39.33	20.21	
	MPDS	52.67	8.08	

Decreasing order of total microbes: GCRS>SHOV>MPDS>GTSH>ABTR

Decreasing order of bacteria microbes: GCRS>SHOV>MPDS>GTSH>ABTR

### E. Microbial Population in the soil

Microbial population included the population of bacteria, fungi and total microbial count. The distribution of total microbial population followed the order: GCRS > SHOV > MPDS > GTSH > ABTR with mean values of (94.67±90.89, 92.33±13.75, 57.07±9.07, 42.33±9.00 and 24.33±20.21) x 10<sup>2</sup>cfu g<sup>-1</sup> respectively (Table V). Bacterial population varied amongst stations with the highest at GCRS, followed by SHOV, MPDS, GTSH and ABTR in that order (Table V). GCRS had mean value of 90.67±84.87x10<sup>2</sup> cfu g<sup>-1</sup> while ABTR had the least mean value of 21.67±15.28x10<sup>2</sup> cfu g<sup>-1</sup>. Fungal population followed the order: MPDS > GCRS < SHOV > GTSH > ABTR with mean count of 5.67±2.5x10<sup>2</sup> cfu g<sup>-1</sup> for MPDS and 0.00 cfu g<sup>-1</sup> for ABTR.

The variation may be attributed to component or decomposable material of the waste. Product like Nitrogen-carbon ratio of the waste samples affects microbial population [28]. The more micro-organisms will infest materials with high nitrogen than those with low nitrogen contents. However, in this study, deviations from above norm seemed to play up. For instance, highest aggregate microorganisms were found at GCRS. Thus, it is suggested that other factors affected the microbial count at distribution stations apart from nitrogen content of the waste materials. These may include pH value of the waste. Microorganisms have optimum pH range for survival. Comparison of the five stations waste samples show that GCRS was less acidic and less alkaline (pH = 6.3). This condition may be more conducive for survival of the microorganism. Hence, waste from GCRS may be easily digested or biodegraded by multitude of microorganisms than waste at other stations. This condition generated high microbial load at GRCS.

The very high concentration of Cd (153 mg kg<sup>-1</sup>) at station GRCS and (0.03-0.05 mg kg<sup>-1</sup>) at other stations (Table II) is a critical environmental hazard. Cadmium enters water and soil from waste disposal and spills or leaks at hazardous waste sites. It is possible that the roasting of animal skins, burning of waste white goods, oil contaminated rags from transporters, used or worn tyres at the roasting site released cadmium into the soil and air as Cd binds strongly to soil particles [24]. The site should be monitored for Cd as it would appear it could generate Cd concentration greater than the FDA's 15 ppm limit in food colours or the normal range of 0.05-0.2 mg kg<sup>-1</sup>. In the case of chromium the higher value at GCRS, ABTR and MPDS related it to the sources of chemicals containing chromium. It is known that disposal of manufactured products/chemicals containing chromium such as fossil fuel (from arriving trucks parked near the MPDS and generators) release chromium to the air, soil and water [24].

### F. Correlations

Pb had significant relationship with Zn(r=0.957), pH(r=0.0930) and silt (r = -0.029). The negative correlation coefficient obtained for silt implies that concentration of Pb in the waste sample decreased as silt content of the soil increased, hence the low value of silt in the depths related to low Pb at depths. The pH had a direct relationship with Pb as evidenced in the positive value of r. Thus, pH is a major soil property that influenced the concentration of both chemical and heavy metal content of the soil. Similarly, Zn had significant relationship with Cd (r=0.892), pH (r=0.911), silt (r=-0.933), NO<sub>3</sub> (r=-0.835) and SO<sub>4</sub> (r=0.783). Cu did not show significant relationship with any of the properties, Ni had significant interaction with Mn only (with r=0.819) while Cr and TOC correlated significantly with Mn (r = -0.870 and 0.905 respectively). Furthermore, there was significant negative relationship between Cd and silt as well as Cd and NO<sub>3</sub> (r = -0.963 and -0.945 respectively). Cr and TOC correlated significantly.

## V. CONCLUSION

Insitu soil properties (physico-chemical, heavy metal and microbial population) were investigated at animal market/park ground in Uyo, Nigeria, where animal droppings and organic wastes were generated daily from weekly truck loads of animals (cattle and goats). Wet acid digestion and Atomic Absorption spectrophotometry (AAS) were used for heavy metals and Mckonkay agar and pour plates for microbials characterization and identification. Data were analyzed for descriptive statistics, significant differences, ANOVA and correlations using SPSS version 17. Heavy metal load index (HPI)



and Enrichment factor (EF) were also compared with normal or critical soil levels. The measurement was at five stations at 10m x 60m grid size on the market/park ground and a station for pristine values upslope; and took five months, mostly in the rainy season, to observe the combined point and nonpoint source pollution, wastes decomposition and leaching of elements under rainfall-runoff environment. All properties (physical, chemical, heavy metal and microbial population) showed significant ( $p < 0.01$ ) spatial variability in the micro-catchment. Highest metal concentration (55% of the nine observed) were found at animal roasting station (GCRS). Lead (Pb) recorded values significant above critical levels and correlated highly with Zn, Cd, and Ni but showed inverse variation with silt and depth. HPI and EF were high, and  $EF > 6$  for Pb showed extreme lead contamination of soil. Others were  $CF > 1$  suggesting very high soil contamination at toxic level by HM apart from Cd from organic wastes. Variation with depths was not significant. Prospect of bio-accumulation of Pb at down slope ecosystem existed. Very severe enrichment was observed at GCRS with  $EF > 6$  for Cd and moderate at other stations. Nickel was significantly low and homogenous in distribution.

Nutritional properties like TOC and  $NO_3$  and  $SO_4$  depended on the dissolved component or composition of waste type. Microbial (bacteria, fungi and total microbial counts) were high and elemental content of waste helped microorganism survival and population. However Nitrogen-nitrate concentration depended on combined factors of microorganism population, nitrogen fixation perhaps by lightening discharges. Surface drainage and treatment plant for waste and waste water at down slope are required to protect pollution of borehole and stream water. The waste generated and the effect on soil is enormous and sustained.

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