Assessment on Effect of Hospital Wastes on Soil Quality in Uyo Metropolis

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DOI: 10.56201/ijgem.vol.11.no6.2025.pg38.51

Abstract
The study examined the effect of hospital wastes on soil quality in Uyo Metropolis, Akwa Ibom State. It aimed at examining the effect of hospital wastes on chemical properties and heavy metal content of the soil; it also examined the variability of soil quality in relation to distance from the dumpsite and depth as well as the inter-relationship among soil properties between the dumpsite soil and the control soil. Fifteen composite soil samples were collected from five designated distance from the dumpsite namely 0 m(PT01), 20 m(PT02), 40 m(PT03), 60 m(PT04) and 200 m(Control) away from dumpsite under three designated depth namely 0 – 10 cm, 10 – 20 cm and 20 – 30 cm. The study was replicated in two hospitals namely University of Uyo Teaching Hospital Dumpsite and St. Luke's Hospital Dumpsite. Samples were collected with soil auger in each dumpsite and transported to the laboratory for analysis. Data obtained from the laboratory analysis were analyzed for means while significant parameters were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability. Results showed that mean pH was in the order Control > PT01 > PT04 > PT03 > PT02 with 7.76, 7.59, 7.56, 7.22 and 6.74. Calcium (Ca) followed the order PT03 > PT01 > PT02 > PT04 > Control with 1.38, 1.36, 0.98, 0.89 and 0.59. Distance variability of pH, Mg, N, and Zn was less than 15 % classified as low; that of Ca, K, Fe and Cu was between 15 – 35 % classified as moderate while Cr and Ni exhibit high variability with CV > 35 %. Depth variability of the parameters was generally low except N and Cr which exhibit moderate variability. Only one significant relationship was obtained in dumpsite soil while seven significant relationships were obtained in the control soil environment. It was concluded that hospital wastes have significant effect on the chemical properties of the soil including the heavy metal. It was therefore recommended among others that hazardous waste items should be eliminated at source through proper waste sorting and segregation before dumping to reduce the level of soil pollution by the hospital wastes.

Keywords: *Hospital Wates, Dumpsite, Concentration, Heavy Metal, Composite Samples*

1.0 INTRODUCTION

Globally, waste generation has continued to increase in relation to socio-economic parameters such as population, urbanization, personal income and consumption patterns (Nurbekov, 2022). Urbanization as one of the factors has produced high quantities of waste which could be detrimental to the environment. Waste is regarded as a substance which is no longer suited for its intended use and is unwanted material that is gotten through anthropogenic activities either from residence, commercial or industrial activities (Usoh *et al.,* 2025). Waste can create significant health problems and a very unpleasant living environment when it is disposed inappropriately.

According to Usoh *et al.* (2023b), food wastes, broken glasses, plastics, metals, papers, radioactive materials and textiles are among the possible generated wastes. Usoh (2023) noted that the composition of waste generated varies greatly and contains dissolved and suspended materials and depends on the type and age of the waste while Udom *et al.* (2023) observed that animal waste contains excessive nutrients that can negatively affect soil and water bodies. According to WHO (2015), hospital/medical wastes are wastes generated by health care activities, ranging from used needles and syringes to body parts, diagnostic samples, medical devices and radioactive materials. Soil contamination through waste disposal sites is a serious problem because soils are regarded as the ultimate sink for heavy metals discharged into the environment (Usoh *et al.,* 2023a). Nta *et al.* (2017) posited that various forms of wastes generated have caused environmental destruction as well as human death. Due to soil toxicity at specific concentrations, some chemical properties like Zinc (Zn) and Lead (Pb) if present in these wastes may have significant ecological relevance; it is known to have a variety of effects on soil and plant, which can decrease the quality of food and in turn affect human health (Isak *et al.,* 2013) but high crop production/good quality food depend mainly on relationship between good quality soil and water (Usoh *et al.,* 2017). Generally, lack of appropriate soil and water conservation measures has led to land degradation (Ahuchaogu *et al.,* 2022) and inappropriate waste disposal at hospital waste dumpsites have major negative consequences in environment (Usoh *et al.,* 2022).

There has been growing concern over the disposal of waste, which may contain some amounts of hazardous substances. Hazardous substances generated in the hospital environment, just like those generated in the domestic and industrial sectors, may pose a threat to reducing soil quality in an environment. Hospital dumpsites often receive variety of medical waste which may contain hazardous substances. As a consequence, these substances can leach into the soil, posing risks to the soil and the environment. Environmental pollution has been a major problem in Akwa Ibom State and other urban areas in Nigeria and other parts of the world due to improper waste management systems (Usoh *et al.,* 2023c). According to Uchacha *et al.* (2024), waste dumpsites have been one of the forms of waste disposal management as they reduce environmental unfriendliness for wastes. Shamshiry *et al*. (2011) observed that waste management in Nigeria is characterized by inefficient collection methods, insufficient coverage of the collection system and improper disposal while Babayemi *et al*. (2018) observed the complete lack of efficient and modern technology for the management of waste. The ecological impacts such as land degradation/soil contamination as well as water and air pollution are related with improper waste management. Many studies in Nigeria have made preliminary assessments on the impact of domestic and formal waste on the environment but no comprehensive study has been made to examine the impact of hospital wastes on the environment. Studies have not clearly articulated the impact of hospital wastes disposal on soil in Akwa Ibom State. Therefore, this study examines the effect of hospital wastes on soil quality in Uyo Metropolis, Akwa Ibom State.

2.0 METHODOLOGY

2.1 Study Area

The study was conducted in Uyo metropolis, Akwa Ibom State, Nigeria. Uyo is the State capital of Akwa Ibom, an oil-producing state in Nigeria. The city became the capital of the State on September 23, 1987 following the creation of Akwa Ibom State from Cross River State. Uyo lies between latitude $4^0$30" and $5^0$30"N and longitudes $7^0$30" and 8^0 30"E. The initial population of Uyo as at 1991 was 205, 790 and later increased to 498,622 in the year 2006 showing 9.49 percentage growth rate (NPC, 2006). Also, the projected population of the area from 2006 to 2021 is 1,199,929 indicating 9.38 percentage growth rate (NPC, 2006). With its location within the tropical rainforest and dense population, Uyo, like other major cities in Nigeria generates enormous municipal solid waste which is not adequately managed. Uyo has different Municipal Solid Waste Dumpsites but the major one is located in Uyo village road. This is used by Environmental Protection and Waste Management Agency for waste disposal. This dumpsite is operated as an open waste dumpsite.

2.2 Experimental Design

The study adopted a complete randomized design (CRD). CRD was employed in studying the effect of hospital wastes on agricultural soil. Two hospital dumpsite soils were chosen for the study within the Uyo Metropolis namely University of Uyo Teaching Hospital Dumpsite and St Luke's Hospital Dumpsite. The triangular research design was adopted for samples collection and were analyzed at different points.

2.3 Sources of Data

The study used both primary and secondary data. Primary data were collected through direct field work. Secondary data were also collected which comprised of information from journals, articles, textbooks and other publications.

2.4 Collection and Analysis of Soil Samples

Composite soil samples were collected from five designated distance from the dumpsite including 0 m(PT01), 20 m(PT02), 40 m(PT03), 60 m(PT04) and 200 m(Control) away from dumpsite. The 0 m is considered as the pollution source which is regarded as area of highest impact while 200 m away from the dumpsite served as control. Samples were collected at three designated depths namely 0 – 10 cm, 10 – 20 cm and 20 – 30 cm respectively. The triangular sampling method was used to collect soil samples at each sampling point and bulked to form a composite sample of three soil samples. The soil samples were collected using soil auger and placed in well labeled polythene bags. A total of fifteen composite samples were collected at each dumpsite giving a total of 30 soil samples from the two dumpsites. The collected samples were air-dried and sieved through a 4 mm sieve and further sieve through a 2mm sieve. Thereafter, these samples were stored in labelled polyethylene bags for physicochemical analysis. Properties that were analyzed include the following: pH, Calcium (C), Potassium (K), Magnesium (Mg), Nitrogen (N), Iron (Fe), Copper (Cu), Zinc (Zn), Chromium (Cr) and Nickel (Ni).

2.5 Statistical Analysis

Mean, Standard Deviation, Two-way Analysis of Variance (ANOVA) and Pearson's Product Moment Correlation were employed for data analysis. Treatment means were compared using Duncan Multiple Range Test (DMRT) while significant difference tested at 0.05 level of probability.

3.0 RESULTS AND DISCUSSION

3.1 Chemical Properties of the Soil

3.1.1 Soil pH

Table 1 shows the chemical properties of the soil with distance while Table 2 presents the distribution of chemical properties of the soil with depth. pH values at the dumpsite (PT01) which was at 0 m ranged from 7.25 – 8.22 with mean of 7.59 ± 0.35 (Table 1); it was between 6.22 and

7.56 with mean of 6.74 ± 0.60 at 20 m away from dumpsite (PT02); it ranged from 6.25 – 8.75 with mean of 7.22 ± 0.95 at PT03 (40 m away from dumpsite); it ranged from 6.43 – 8.93 at PT04 (60 m away from dumpsite) while it was between 7.32 and 8.63 with mean of 7.76 ± 0.55 at the control point (200 m away from dumpsite). Result shows that there was a significant difference in soil pH between the dumpsite, dumpsite surrounding and the control. The control had the highest pH slightly higher than that of the dumpsite environment. This may suggest that hospital wastes may not post serious threat on soil pH but may influence other properties of the soil. Depth effect was not significant ($p>0.05$). Value obtained at 0 – 10 cm depth ranged from 6.22 – 8.75 with mean of 7.29 ± 0.70, it was between 6.25 and 8.93 with mean of 7.42 ±0.92 at 10 – 20 cm while it ranged from 6.43 – 8.25 with mean of 7.41 ± 0.66 at 20 – 30 cm depth. Soil pH is a measure of the concentration of hydrogen ion in the soils. H^+ is the major cause of soil acidity which affects the performance of crops and activities of micro- organisms. Young (2000) reported optimum pH range of the soil as 6.5-8.0. This suggests that pH values of these soils are within the optimum range.

3.1.2 Calcium (Ca)

From Table 1, distribution of Ca at PT01 ranged from 1.10 – 1.56 with mean of 1.36 ± 0.17 cmol/kg; it varied from 0.70 – 1.34 with mean of 0.98 ± 0.25 cmol/kg at PT02; it ranged from 1.24 – 1.63 with mean of 1.38±0.14 cmol/kg at PT03; 0.38 – 1.43 with mean of 0.89± 0.41 at PT04 while it ranged from 0.50 – 0.66 with mean of 0.59 ± 0.06 cmol/kg at the control. The result shows that the highest Ca was obtained at PT03 followed by PT01 while the control had the least and the difference was significant ($p<0.05$). Depth distribution of Ca revealed that values obtained at 0 – 10 cm ranged from 0.56 - 1.43 with mean of 1.16 ± 0.31 cmol/kg; it was between 0.50 and 1.50 with mean of 1.02 ± 0.34 cmol/kg at 10 – 20 cm depth while it varied from 0.38 to 1.63 with mean of 0.94 ± 0.46 cmol/kg at 20 – 30 cm. The results showed that the highest Ca was obtained at 0 – 10 cm followed by 10 – 20 cm while 20 – 30 cm had the least. Exchangeable Ca decreased with depth. However, comparing the ranges with the critical range of 1000-2000 mg/kg reported by Donalue *et al.* (1990) for crop production, these soils are low in available Ca. This implies that these soils may be poor in productivity because the range obtained are all below the critical range suggesting that these soils are all in deficiency of Ca, According to Edem (2007), deficiency of Ca is characterized by malformation and disintegration of the terminal portions of plants. This means that the terminal buds and root tips become stunted and fail to develop normally. It also results in weak slender plants, high soil acidity and poor leaf quality. However, distribution of available Ca in these soils may also be attributed to the hospital wastes and other factors like the geological formation of the soil and land use since there was a significant difference between dumpsite environment and the control.

3.1.3 Potassium (K)

Values of Potassium (K) ranged from 0.01 – 0.03 with mean of 0.02 ± 0.01 cmol/kg at PT01, it ranged from 0.02 – 0.05 with mean of 0.03 ± 0.01 cmol/kg at PT02; it was between 0.01 and 0.04 with mean of 0.02 ± 0.01cmol/kg at PT03; 0.01 – 0.03 with mean of 0.02 ± 0.01 cmol/kg at PT04 while it ranged from 0.01 – 0.03 with mean of 0.02 ±0.01 cmol/kg at the control. The results showed that mean K was almost constantly distributed across the dumpsite and its environ and even in the control except PT02 which had the highest K. Distribution of K with depth showed that it ranged from 0.01 – 0.04 with mean of 0.02 ± 0.01 cmol/kg at 0 – 10 cm, it was between 0.01 and 0.04 with mean of 0.02 ± 0.01 cmol/kg again at 10 – 20 cm while it ranged from 0.01 – 0.05 with mean of 0.02 ± 0.01 cmol/kg at 20 – 30 cm depth. The result showed that K was constantly distributed with depth.

Table 1: Chemical Properties of the Soil with Distance

Treatment	Variable	pH	Ca	K	Mg	N
			Cmol/kg	Cmol/kg	Cmol/kg	%
PT01	Min	7.25	1.10	0.01	3.00	0.09
	Max	8.22	1.56	0.03	3.43	0.18
	Mean	7.59ab	1.36a	0.02b	3.20a	0.13a
	Sd	0.35	0.17	0.01	0.20	0.03
	Cv	4.61	12.18	34.74	6.17	23.85
PT02	Min	6.22	0.70	0.02	2.10	0.10
	Max	7.56	1.34	0.05	4.10	0.22
	Mean	6.74b	0.98b	0.03a	3.22a	0.15a
	Sd	0.60	0.25	0.01	0.68	0.04
	Cv	8.87	24.96	23.90	21.22	27.97
PT03	Min	6.25	1.24	0.01	2.62	0.06
	Max	8.75	1.63	0.04	3.70	0.30
	Mean	7.22ab	1.38a	0.02ab	3.08a	0.13a
	Sd	0.95	0.14	0.01	0.43	0.09
	Cv	13.21	10.24	44.26	13.98	67.62
PT04	Min	6.43	0.38	0.01	2.10	0.08
	Max	8.93	1.43	0.03	4.32	0.21
	Mean	7.56ab	0.89b	0.02b	2.92a	0.14a
	Sd	0.86	0.41	0.01	0.80	0.06
	Cv	11.34	46.14	48.99	27.48	39.28
Control	Min	7.32	0.50	0.01	0.43	0.02
	Max	8.63	0.66	0.03	3.21	0.08
	Mean	7.76a	0.59c	0.02b	1.67b	0.06a
	Sd	0.55	0.06	0.01	0.00	0.02
	Cv	7.10	10.88	53.63	0.00	35.72

PT01 = the dumpsite, PT02, PT03 and PT04 = 20, 40 and 60 m away from dumpsite, Control = 200 m away from dumpsite. Means with the same superscript along the same column are not significantly different (p>0.05)

Table 2: Distribution of Chemical Properties of the Soil with Depth

Depth (cm)	Variable	pH	Ca	K	Mg	N
			Cmol/kg	Cmol/kg	Cmol/kg	%
0-10	Min	6.22	0.56	0.01	2.10	0.02
	Max	8.75	1.43	0.04	3.67	0.21
	Mean	7.29a	1.16a	0.02a	2.94ab	0.13ab
	Sd	0.70	0.31	0.01	0.48	0.06
	Cv	9.60	27.10	39.38	16.23	42.04
10-20	Min	6.25	0.50	0.01	1.00	0.06
	Max	8.93	1.50	0.04	4.32	0.12
	Mean	7.42a	1.02b	0.02a	3.08a	0.09b
	Sd	0.92	0.34	0.01	0.90	0.02
	Cv	12.39	33.42	40.25	29.10	26.45
20 – 30	Min	6.43	0.38	0.01	0.43	0.05
	Max	8.25	1.63	0.05	3.70	0.30
	Mean	7.41a	0.94b	0.02a	2.44b	0.14a
	Sd	0.66	0.46	0.01	1.16	0.08
	Cv	8.89	48.90	61.33	47.46	55.33

Means with the same superscript along the same column are not significantly different (p>0.05)

Comparing the K obtained in this study with WHO (2015) assessment criteria for soil fertility classification, soils at dumpsite environment have very low K content while the control soil has fairly low K level. The overall assessment reveals low K level in the entire soil which is in line with findings of Isak *et al.* (2013) who reported that K deficiencies are rampant in soils of the South Eastern Nigeria and strongly recommended the use of fertilizers containing K to improve crop production. Low Potassium level of these soils is attributed to several factors including high soil acidity of the south eastern soils and not necessarily the hospital wastes as K content of the control soil is also low.

3.1.4 Magnesium (Mg)

Values of Magnesium (Mg) ranged from 3.0 – 3.43 with mean of 3.20 ± 0.20 cmol/kg at PT01, it ranged from 2.10 – 4.10 with mean of 3.22 ± 0.68 cmol/kg at PT02, it varied from 2.62 – 3.70 with mean of 3.08 ± 0.43 cmol/kg at PT03, 2.10 – 4.32 with mean of 2.92 ± 0.80 cmol/kg at PT04 while it was between 0.43 and 3.21 with mean of 1.67 ± 0.0 cmol/kg at the control. The results revealed that PT02 had the highest Mg followed by PT01 while the control had the least but the difference was not significant. Across the three depths, values of Mg obtained ranged from 2.10 – 3.67 with mean of 2.94 ± 0.48 cmol/kg at 0 – 10 cm; it ranged from 1.0 – 4.32 with mean of 3.08 ± 0.90 cmol/kg at 10 – 20 cm while it was between 0.43 and 3.70 with mean of 2.44 ± 1.16 cmol/kg at 20 – 30 cm depth. The highest was obtained at 10 – 20 cm depth followed by 0 – 10 cm depth while 20 – 30 cm depth had the least and difference was significant. The result revealed that hospital waste has increased the Mg content of the soil as shown in higher concentration of Mg at dumpsite environment compared to very low concentration at the control.

3.1.5 Nitrogen (N)

Values of N ranged from 0.09 – 0.18 with mean of 0.13 ± 0.03 % at PT01, it ranged from 0.10 – 0.22 with mean of 0.15 ± 0.04 % at PT02, it varied from 0.06 - 0.30 with mean of 0.13 ± 0.09 % at PT03, 0.08 – 0.21 with mean of 0.14 ± 0.06 % at PT04 while it ranged from 0.02 -0.08 with mean of 0.06 ± 0.02 % at the control. The results showed that the highest N was obtained at PT02 followed by PT04 while the control had the least. Distribution of N with depth showed that values obtained at 0- 10 cm ranged from 0.02 – 0.21 with mean of 0.13 ± 0.06 %, it ranged from 0.06 - 0.12 with mean of 0.09 ± 0.02 % at 10 – 20 cm while it ranged from 0.05 – 0.30 with mean of 0.14 ± 0.08 % at 20 – 30 cm depth. The highest N was obtained at 20 – 30 cm but was not significantly different from mean obtained at 0 – 10 cm implying that N content of the soil did not vary much with depth.

3.1.6 Iron (Fe)

Table 3 shows heavy metal concentration in the soil. Concentration of Fe ranged from 0.42 – 0.64 with mean of 0.58 ± 0.09 mg/kg at PT01, it ranged from 0.60 – 0.98 with mean of 0.70 ± 0.15 mg/kg at PT02; it was between 0.29 and 0.76 with mean of 0.52 ± 0.16 mg/kg at PT03; it ranged from 0.40 – 0.62 with mean of 0.51 ± 0.08 mg/kg at PT04 while it varied from 0.21 to 0.32 with mean of 0.26 ± 0.0 mg/kg at the control and the difference was significant ($p<0.05$). The highest Fe content was obtained at PT02 followed by PT01 while the control had the least. Higher concentration of Fe at the dumpsite environment than control soil suggests that hospital waste has increased the concentration of Fe in the dumpsite soils. Down the profile, results (Table 4) show that Fe content at 0 – 10 cm depth ranged from 0.21 – 0.63 with mean of 0.47 ± 0.17 mg/kg, it ranged from 0.27 – 0.98 with mean of 0.55 ± 0.21 mg/kg at 10- 20 cm while it varied from 0.26- 0.72 with mean of 0.52 ±0.16 mg/kg at 20 – 30 cm depth but the difference was not significant ($p>0.05$). The result showed that concentration of Fe at dumpsite environment was significantly ($p<0.05$) higher than concentration of Fe in the control soils. This implies that hospital wastes may be attributed to increase in concentration of Fe in the soil.

3.1.7 Copper (Cu)

Values of Cu obtained at PT01 ranged from 0.10 – 0.91 with mean of 0.57 ± 0.34; it ranged from 0.34 – 0.82 with mean of 0.60 ± 0.17 mg/kg at PT02; it varied from 0.30 – 0.67 with mean of 0.44 ± 0.13 at PT03; it ranged from 0.30 – 0.61 with mean of 0.40 ± 0.12 mg/kg at PT04 while it was between 0.30 and 0.61 with mean of 0.38 ± 0.0 mg/kg at the control. From the result the highest Cu was obtained at PT01 followed by PT02 while control had the least. This indicates that there may be Cu toxicity at the dumpsite environment due to the effect of hospital wastes dumped in the soil than the control. Hence, hospital wastes have effect on heavy metal contamination in the soil at the study area. Depth distribution of Cu revealed that values of Cu at 0 – 10 cm depth ranged from 0.10 – 0.82 with mean of 0.47 ± 0.23 mg/kg; it was between 0.30 and 0.91 with mean of 0.50 ± 0.20 mg/kg at 10 – 20 cm while it ranged from 0.30 – 0.82 with mean of 0.46 ± 0.19 mg/kg at 20 – 30 cm depth but the difference was not significant ($p>0.05$). The result showed that concentration of Cu at dumpsite environment was significantly ($p<0.05$) higher than concentration of Cu in the control soils. This implies that hospital wastes may be attributed to increase in concentration of Cu in the soil.

3.1.8 Zinc (Zn)

Values of Zn obtained at PT01 ranged from 0.30 – 0.44 with mean of 0.36 ± 0.05; it ranged from 0.26 – 0.40 with mean of 0.34 ± 0.06 mg/kg at PT02; it varied from 0.30 – 0.58 with mean of 0.41 ± 0.10 at PT03; it ranged from 0.30 – 0.63 with mean of 0.41 ± 0.12 mg/kg at PT04 while it was between 0.30 and 0.54 with mean of 0.40 ± 0.0 mg/kg at the control.

Table 3: Heavy Metal Concentration in the Soil with Distance

Treatment	Variable	Fe	Cu	Zn	Cr	Ni
		←		mg/kg		→
PT01	Min	0.42	0.10	0.30	0.01	0.31
	Max	0.64	0.91	0.44	0.24	0.60
	Mean	0.58ab	0.57ab	0.36a	0.09d	0.45a
	Sd	0.09	0.34	0.05	0.10	0.11
	Cv	14.91	59.40	15.09	111.69	25.39
PT02	Min	0.60	0.34	0.26	0.00	0.00
	Max	0.98	0.82	0.40	0.47	0.02
	Mean	0.70a	0.60a	0.34a	0.16c	0.01d
	Sd	0.15	0.17	0.06	0.19	0.01
	Cv	21.00	28.28	18.55	122.23	77.69
PT03	Min	0.29	0.30	0.30	0.03	0.06
	Max	0.76	0.67	0.58	0.56	0.32
	Mean	0.52bc	0.44bc	0.41a	0.28b	0.15c
	Sd	0.16	0.13	0.10	0.21	0.12
	Cv	29.86	30.27	23.92	73.06	75.36
PT04	Min	0.40	0.30	0.30	0.03	0.24
	Max	0.62	0.61	0.63	0.76	0.47
	Mean	0.51c	0.40c	0.41a	0.36a	0.38b
	Sd	0.08	0.12	0.12	0.30	0.09
	Cv	15.04	29.34	29.90	83.63	23.20
Control	Min	0.21	0.30	0.30	0.00	0.02
	Max	0.32	0.61	0.54	0.66	0.43
	Mean	0.26c	0.38c	0.40a	0.35a	0.16c
	Sd	0.00	0.00	0.00	0.13	0.05
	Cv	0.00	0.00	0.00	37.14	31.25

PT01 = the dumpsite, PT02, PT03 and PT04 = 20 m, 40 m and 60 m away from dumpsite, Control = 200 m away from dumpsite. Means with the same superscript along the same column are not significantly different (p>0.05)

Table 4: Depth Distribution of Heavy Metal in the Soil

Depth (cm)	Variable	Fe	Cu	Zn	Cr	Ni
		←		mg/kg	→	
0-10	Min	0.21	0.10	0.26	0.00	0.01
	Max	0.63	0.82	0.54	0.43	0.43
	Mean	0.47a	0.47a	0.36a	0.19c	0.25a
	Sd	0.17	0.23	0.09	0.16	0.18
	Cv	36.61	48.61	23.65	84.97	71.02
10-20	Min	0.27	0.30	0.27	0.00	0.00
	Max	0.98	0.91	0.63	0.76	0.53
	Mean	0.55a	0.50a	0.38a	0.24b	0.20a
	Sd	0.21	0.20	0.11	0.29	0.22
	Cv	37.78	40.37	27.82	121.41	106.13
20 – 30	Min	0.26	0.30	0.34	0.01	0.02
	Max	0.72	0.82	0.58	0.66	0.60
	Mean	0.52a	0.46a	0.41a	0.32a	0.23a
	Sd	0.16	0.19	0.07	0.26	0.21
	Cv	30.04	41.85	16.90	80.22	89.71

Means with the same superscript along the same column are not significantly different ($p>0.05$)

From the result the highest Zn was obtained at PT03 and followed by PT04 and then the control while PT02 had the least. Depth distribution of Zn revealed that values of Zn at 0 – 10 cm depth ranged from 0.26 – 0.54 with mean of 0.36 ± 0.09 mg/kg; it was between 0.27 and 0.63 with mean of 0.38 ± 0.11 mg/kg at 10 – 20 cm while it ranged from 0.34 – 0.58 with mean of 0.41 ± 0.07 mg/kg at 20 – 30 cm depth but the difference was not significant ($p>0.05$).

3.1.9 Chromium (Cr)

Values of Cr obtained at PT01 ranged from 0.01 – 0.24 with mean of 0.09 ± 0.10 mg/kg; it ranged from 0.0 – 0.47 with mean of 0.16 ± 0.19 mg/kg at PT02; it varied from 0.03 – 0.56 with mean of 0.28 ± 0.21mg/kg at PT03; it ranged from 0.03 – 0.76 with mean of 0.36 ± 0.30 mg/kg at PT04 while it was between 0.0 and 0.66 with mean of 0.35 ± 12.0 mg/kg at the control. From the result the highest Cr was obtained at PT04 followed by the control while PT01 had the least. Depth distribution of Cr revealed that values of Cr at 0 – 10 cm depth ranged from 0.0 – 0.43 with mean of 0.19 ± 0.16 mg/kg; it was between 0.0 and 0.76 with mean of 0.24 ± 0.29 mg/kg at 10 – 20 cm while it ranged from 0.01 – 0.66 with mean of 0.32 ± 0.26 mg/kg at 20 – 30 cm depth and the difference was significant ($p<0.05$).

3.1.10 Nickel (Ni)

Concentration of Ni at PT01 ranged from 0.31 – 0.60 with mean of 0.45 ± 0.11 mg/kg; it ranged from 0.0 – 0.02 with mean of 0.01 ± 0.01 mg/kg at PT02; it varied from 0.06 – 0.32 with mean of

0.15 ± 0.12 mg/kg at PT03; the values were between 0.24 and 0.47 with mean of 0.38 ± 0.09 mg/kg at PT04 while it ranged from 0.02 – 0.43 with mean of 0.16 ± 0.05 mg/kg at the control plot. Depth effect showed that concentration of Ni at 0 – 10 cm ranged from 0.01 – 0.43 with mean of 0.25 ± 0.18 mg/kg, it was between 0.0 and 0.53 with mean of 0.20 ± 0.22 mg/kg at 10 – 20 cm while it varied from 0.02 – 0.60 with mean of 0.23 ± 0.21 mg/kg at 20 – 30 cm depth but the difference was not significant ($p>0.05$). The result showed that concentration of Ni at dumpsite environment was significantly ($p<0.05$) higher than concentration of Ni at the control soils. This implies that hospital wastes may be attributed to increase in concentration of Ni in the soil.

3.2 Variability of Soil Quality in Relation to Distance and Depth from the Dumpsite

3.2.1 Variability in Relation to Soil Distance

The variability of soil quality parameters in relation to distance from the dumpsite is shown in Table 5. Based on Cv classification by Showemimo (2002), CV < 15 % is low, 15 – 35 % is moderate and CV >35% is high. Comparing this with values of CV obtained for respective soil quality parameters, the results show that distance variability of pH, Mg, N, and Zn is low; that of Ca, K, Fe and Cu is moderate while Cr and Ni exhibit high variability. The low and moderate variability implies that what was obtained at the dumpsite (0 m) is not much different from what was obtained from other locations indicating that effect of hospital wastes is not confined to dumpsite only, rather it moves away from the point of deposition to other location within the dumpsite environment. This is possible due to the leachate discharged from the dumpsite. Implication of this is that leachate from the waste can pollute the soil environment up to 60 m from the dumpsite as shown by the low and moderate variability of the soil quality parameters. Hence, effect of wastes on soil does not stop at the point of deposition of the wastes but has the ability to extend to some distance away from the dumpsite.

3.2.2 Variability in Relation to Soil Depth

Depth variability in the dumpsite environment shows that the 0 – 30 cm depth of the soil had almost the same soil quality (Table 6). Variability of the parameters was generally low except N and Cr which exhibit moderate variability. The Low variability implies that whatever happens at 0 – 10 cm of the soil is likely to extend to 30 cm of the soil. So, pollution at the top soil is almost at the same level in the sub soil layer. This may be due to the fact that this dumpsite soil is not compacted. This is why the dumpsite soil should be compacted to check the leaching of material down to soil with the possibility of contaminating the water table.

Table 5: Distance Variability of Soil Quality Parameters from the Dumpsite

Treatment	pH	Ca	K	Mg	N	Fe	Cu	Zn	Cr	Ni
PT01	7.59	1.36	0.02	3.2	0.13	0.58	0.57	0.36	0.09	0.45
PT02	6.7	0.98	0.03	3.22	0.15	0.7	0.6	0.34	0.16	0.01
PT03	7.22	1.38	0.02	3.08	0.13	0.52	0.44	0.41	0.28	0.15
PT04	7.56	0.89	0.02	2.92	0.14	0.51	0.4	0.41	0.36	0.38
Mean	7.27	1.15	0.02	3.11	0.14	0.58	0.50	0.38	0.22	0.25
Sd	0.41	0.25	0.00	0.14	0.01	0.09	0.10	0.04	0.12	0.20
CV (%)	5.69	22.03	22.22	4.44	6.96	15.12	19.39	9.37	54.23	82.30
CV Class	I	II	II	I	I	II	II	I	III	III

I = CV < 15%, II = CV of 15 – 35 %, III = CV > 35 %

Table 6: Variability of Soil Quality in Relation to Soil Depth

Depth (cm)	pH	Ca	K	Mg	N	Fe	Cu	Zn	Cr	Ni
0-10	7.29	1.16	0.02	2.94	0.13	0.47	0.47	0.36	0.19	0.25
10 – 20	7.42	1.02	0.02	3.08	0.09	0.55	0.5	0.38	0.24	0.2
20 – 30	7.41	0.94	0.02	2.44	0.14	0.52	0.46	0.41	0.32	0.23
Mean	7.37	1.04	0.02	2.82	0.12	0.51	0.48	0.38	0.25	0.23
Sd	0.07	0.11	0.00	0.34	0.03	0.04	0.02	0.03	0.07	0.03
CV (%)	0.98	10.71	0.00	11.93	22.05	7.87	4.37	6.57	26.23	11.10
CV Class	I	I	I	I	II	I	I	I	II	I

I = CV < 15%, II = CV of 15 – 35 %, III = CV > 35 %

3.3 Inter-relationship among Soil Properties

Table 7 shows inter relationship among soil quality parameters in the dumpsite environment. Only one significant relationship was obtained and was between Ca and Mg. This implies low level of nutrient interaction in the dumpsite soils. This may be attributed to the effect of the diverse elements that are introduced into the soil environment from the accumulated wastes. It may be inferred that hospital wastes do not support effective nutrient interaction in the soil. The soil may contain toxic elements that might not have been dictated in the analysis. Apart from significant interaction, the sign of the correlation is also important. pH had negative correlation with almost all the parameters suggesting inverse relationship. Similarly, Table 8 shows the correlation analysis among soil quality parameters in the control environment. Seven significant interactions were obtained in the control environment. These include soil pH with K having r = - 0.675 as well as Ni having r = - 0.607. Also, K correlated significantly with Cu having r = 0.820 while N had a very high correlation with Fe (r = 0.903). Furthermore, Mg interacted significantly with Zn (r = 0.763) as well as Ni having r = 0.835 while Zn correlated significantly with Ni having r = 0.607. The high number of significant correlated parameters in control soil suggests that nutrient interaction in control soil is high and this is a normal soil that is devoid of waste pollution. It is clear from the result that hospital dumpsite soil and normal soil are not the same even in nutrient interaction for this is vital for plant growth.

Table 7: Inter-relationship among Soil Properties in Dumpsite Soil

	pH	Ca	K	N	Mg	Fe	Cu	Zn	Cr	Ni
pH	1									
Ca	-.122	1								
K	-.311	-.102	1							
N	-.190	-.040	.385	1						
Mg	.003	.617*	-.034	-.058	1					
Fe	-.306	.328	.568	.320	.051	1				
Cu	-.052	.249	.301	-.007	-.077	.446	1			
Zn	-.283	-.220	.362	.227	-.205	.535	.521	1		
Cr	.484	-.490	-.065	-.310	.172	-.327	-.473	-.049	1	
Ni	.505	.267	-.563	-.183	.417	-.189	-.053	-.361	.037	1

**. Correlation is significant at 0.05 level (2-tailed).*

Table 8: Inter-relationship among Soil Properties in Control Soil

	pH	Ca	K	N	Mg	Fe	Cu	Zn	Cr	Ni
pH	1									
Ca	-.305	1								
K	-.675*	.310	1							
N	-.509	.499	.052	1						
Mg	-.527	.391	.461	.188	1					
Fe	-.531	.484	.039	.903**	.414	1				
Cu	-.478	.573	.820**	.190	.437	.138	1			
Zn	-.471	.348	.442	-.017	.763**	.318	.214	1		
Cr	-.057	-.041	-.274	-.271	.028	-.010	-.486	.501	1	
Ni	-.607*	.461	.389	.304	.835**	.367	.276	.607*	.100	1

**. Correlation is significant at 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).*

CONCLUTION

The study examined the effect of hospital wastes on soil quality in Uyo Metropolis, Akwa Ibom State. It aimed at examining the effect of hospital wastes on chemical properties and heavy metal content of the soil; it also examined the variability of soil quality in relation to distance from the dumpsite and depth as well as the inter-relationship among soil properties between the dumpsite soil and the control. Fifteen composite soil samples were collected from five designated distance from the dumpsite namely 0 m, 20 m, 40 m, 60 m and 200 m away from dumpsite under three designated depth namely 0 – 10 cm, 10 – 20 cm and 20 – 30 cm. The study was replicated in two hospitals namely University of Uyo Teaching Hospital Dumpsite and St Luke's Hospital Dumpsite. Soil samples were collected using soil auger in each dumpsite and transported to the laboratory for analysis. Data obtained from the laboratory analysis were analyzed for means while significant parameters were compared using DMRT at 5% level of probability.

From the findings, it can be inferred that hospital wastes have significant effect on the chemical properties of the soil including the heavy metal concentration. Most of these properties are higher at the dumpsite environment than the control soil environment. Distance variability of pH, Mg, N, and Zn was low; that of Ca, K, Fe and Cu was moderate while Cr and Ni exhibited high variability. Also, variability of hospital dumpsite soil quality with depth is generally low except N and Cr which exhibited moderate variability. Only one significant relationship was obtained and was between Ca and Mg. This implies low level of nutrient interaction in the dumpsite soils. Seven significant interactions were obtained in the control environment hence, indicating that nutrient interaction in waste polluted soil and normal soil is not the same.

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