

## Concentration of Potentially Toxic Elements in the Clinical Waste Dumpsites in Ebonyi State, Southeast Nigeria: Its Evaluation and Policy Dimension

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### Authors' contributions

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### ABSTRACT

**Background:** Clinical wastes are potentially toxic elements (PTE) and harmful microorganisms which can infect health workers and their patients. They comprise both biodegradable and non-biodegradable elements. Clinical waste management (CWM) is the control of all waste generated in the hospitals using professional methods that help to prevent the spread of ailments. This study therefore evaluated the concentration of potentially toxic elements (PTE) in the clinical dumpsites in Ebonyi State.

**Materials and Methods:** The PTE studied were chromium (Cr), lead (Pb), and nickel (Ni). Samples were collected from three major hospitals namely Federal Teaching Hospital Abakaliki (FETHA), Rural Improvement Mission (RIM), and Matar Hospitals in Ebonyi North, Central and South senatorial zones respectively. A total of fifteen samples were collected in addition to control samples. Four samples from each of the hospital dumpsites. The samples were dried, digested, filtered, and analyzed for PTE using Atomic Absorption Spectrophotometer (Shimadzu; AA-7000).

**Results:** At FETHA, the concentration of Cr was 37.00 mg/kg while lead concentration varied from 51.00-19.40 mg/kg and Ni concentration ranged from 9.60-21.74 mg/kg. At R.I.M Hospital, the concentration of Cr varied from 18.50-37.00 mg/kg, the Pb concentration varied from 51.00-207.40

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mg/kg while Ni concentration ranged from 7.20-21.70 mg/kg. The concentration of Cr at Matar hospital was observed to be relatively constant at 18.51 mg/kg while the concentration of Pb varied from 6.48-2832.00 mg/kg, and Ni concentration ranged from 2.40-14.50 mg/kg. The result also showed that in the control samples, Cr concentration ranged from 0.07-0.50 mg/kg, while the concentration of Pb and Ni varied from 0.40-0.96 mg/kg, and from 0.07-0.06 mg/kg respectively. **Conclusion:** The concentration of PTEs in the clinical waste dumpsites of these facilities was high and therefore constituted a potential health risk to man and his environment. Environmental health officers should be charged with more responsibilities to ensure healthy environment and safety.

*Keywords: Concentration; potentially toxic elements; clinical waste dumpsites; evaluation; policy dimension.*

## 1. INTRODUCTION

Clinical waste management (CWM) is the control of all wastes generated in the hospital using professional methods that prevent the spread of diseases and their vectors. In hospital environments, approximately 85% of its waste is classified as general waste (non-hazardous), while the remaining 15% is termed 'hazardous material' which could be radioactive, toxic, or infectious. In areas where clinical waste is incinerated, toxic air pollutants such as furans and dioxins are emitted in to the environment [1-4]. Disposal of clinical waste results to several other problems such as high infection rate. It is advisable to render the waste non-infectious and unrecognizable (human body parts) before disposal. The technical means to render clinical waste absolutely sterile has been in existence for quite a long time. Burning and incineration were indeed the preferred methods for handling clinical waste. Many hospitals chose the option of burning all their clinical wastes on site [2,5,6].

Developed countries generate higher amount of hazardous waste per clinical bed daily than developing countries [1].

Ebonyi State Environmental Protection Agency (EBSEPA) is saddled with the responsibility of municipal waste disposal [3]. Waste accumulated in designated dumping areas are usually carried away in open trucks and transferred to areas not inhabited by people. Dumping continued until dry season when some of the waste became dry and can be burnt. After burning, a caterpillar will be made to level the area before fresh soil is used for final covering [4,6].

However, there was no documentation in the State Ministries of Health and Environment on the concentrations of PTEs on dumpsites of clinical wastes in Ebonyi State. This study therefore evaluated the concentration of

potentially toxic element (PTEs) in the clinical dumpsites in Ebonyi State.

## 2. MATERIALS AND METHODS

This study was carried out selectively in all the 3 senatorial zones of Ebonyi State. A comparative analytical design was employed for the study. The apparatus used were: a 250  $\mu\text{m}$  sieve, petri-dishes and spatulas, 100 ml measuring cylinders, round-bottomed flasks, filter papers, volumetric flasks, and test tubes. The reagents used were  $\text{HNO}_3$  (trioxonitrate V acid), HCL (hydrochloric acid), and deionized water. Equipment used were weighing balance [Contech; CAC-224], a six-chambered-heating; mantle and atomic absorption spectrophotometer (AAS) [Shimadzu; AA-7000] [5,7]. Ethical approval was obtained from Ebonyi State Ministry of Health, Abakaliki.

### 2.1 Sample Collection

Three major hospitals namely; Federal Teaching Hospital Abakaliki (FETHA), Rural Improvement Mission (RIM), and Matar Hospital were selected using representative sampling method.

Prior to sample collection, protective wears (latex hand gloves, nose and mouth mask, and safety leather shoes) were worn appropriately. At each dumpsite, a total of five samples were collected: two ash samples, two soil samples (from a depth of < 10 cm) and one control sample. Therefore, in each of the hospitals, five samples were collected making a total of fifteen samples in all.

The samples were labelled thus:

- a. The initial alphabet indicated the senatorial zones; N for North, C for Central, and S for South.
- b. The middle alphabet indicated the nature of sample; A for ash samples, S for soil, and C for control.

- c. The last numeric showed the sampling points.

The collected samples were placed inside bags and labelled thus: NA1, NA2, NS1, NS2, NCI, CA1, CA2, CS1, CS2, CC1, SA1, SA2, SSI, SS2, and SCI and sealed. They were then transported to the laboratory.

## 2.2 Sample Preparation and Digestion

The ash and soil samples were Sun-dried for 48 hours, the lumps were crushed. Using a 250 mm sieve, the samples were sieved and stored in sealed plastic containers. To digest the sample, 3g of sieved samples were weighed and placed into round-bottomed flasks (capable of withstanding very high temperatures) with 30 ml of *aqua-regia* solution (a mixture of trioxonitrate V acid, HNO<sub>3</sub> and hydrochloric acid, HCL in the ratio of 1:3) resulting to a cloudy mixture. The mixture was heated in a six-chambered-heating mantle to a temperature of 75-80°C until it became clear. It was then allowed to cool, filtered into 100 ml volumetric flask which was then filled up to mark with de-ionize water. The digested samples were analyzed using Atomic Absorption Spectrophotometer (AAS) [5,7].

## 2.3 Calibration of Atomic Absorption Spectrophotometer (AAS)

To ensure accurate reading of the instrument, reagent blanks and prepared standards were used. Reagent blanks checked for contaminations while the prepared standards checked accuracy, repeatability and reproducibility. A total of six calibration standards

ranging from 0-10 µg mL<sup>-1</sup> (mg L<sup>-1</sup>) were prepared from 1000 Mg mL<sup>-1</sup> Cr, Ph, and Ni stock solutions. With this, the instrument was calibrated, the calibration graph and regression coefficient (R<sup>2</sup>) were also plotted. The R<sup>2</sup> value of 0.98 linearity was obtained. Based on the R<sup>2</sup> value obtained, all the samples were analyzed [5,7].

## 3. RESULTS

Tables 1, 2 and 3 showed the total concentrations and corresponding descriptive statistics of the PTE in the samples. In Table 1 below, the concentration of chromium (Cr) was not detected in the ash samples (as shown in bar chart. Fig. 2) but 37.00 mg/kg in its soil samples. The lead (Pb) concentration varied from 32.00-207.00 mg/kg in the ash samples and 32.00-52.00 mg/kg in the soil samples while the concentration of nickel (Ni) ranged from 9.70-21.70 mg/kg in the ash samples but 14.00-19.00 mg/kg in the soil samples.

In Table 2, the concentration of Cr in the ash samples varied from 18.50-37.00 mg/kg but 37.00 mg/kg in its soil samples. In the ash samples, Pb concentration varied from 12.90-19.40 mg/kg but 6.48-12.96 mg/kg in the soil samples while Ni concentration in the ash samples was 7.20-21.70 mg/kg, and remained 12.08 in its soil samples.

Table 3 showed that the concentration of Cr was relatively constant at 18.51 mg/kg in both ash and soil samples while Pb varied from 25.90-2832.00 mg/kg in its ash samples but 6.48-162.00 mg/kg in its soil samples. Ni concentration was 12.08 mg/kg but ranged from 2.40-4.50 mg/kg in its soil samples.

**Table 1. Total concentration and corresponding descriptive statistics of PTEs in clinical dump site at FETHA**

Sample	Concentration (mg/kg)		
	Pb	Cr	Ni
NA1	32.40859	0.00000	9.661188
NA2	207.41000	0.00000	21.73906
NS1	32.40859	37.03641	14.49178
NS2	51.85319	37.03641	19.32515
NC1 (control)	0.40859	0.07559	0.00000
<b>Parameters</b>			
Mean	81.02 ± 84.75	37.03 ± 21.38	16.30 ± 5.35
Median	119.90	18.51	18.11
Minimum	32.40	37.03	9.66
Maximum	207.41	74.07	21.73

**Table 2. Total concentration and corresponding descriptive statistics of PTEs in clinical dump site at R.I.M hospital**

Sample	Concentration (mg/kg)		
	Pb	Cr	Ni
CA1	19.44460	37.03641	21.73906
CA2	12.96399	18.51959	7.24728
CS1	6.480607	0.00000	12.07787
CS2	12.96399	37.03641	12.07787
CC1 (Control)	0.96399	0.51959	0.07787
<b>Parameters</b>			
Mean	81.02 ± 5.29	37.03 ± 17.72	16.30 ± 5.29
Median	9.72	18.51	9.66
Minimum	6.48	18.51	7.24
Maximum	19.44	37.03	21.73

**Table 3. Total concentration and corresponding descriptive statistics of PTEs in clinical dump site at Matar hospital**

Sample	Concentration (mg/kg)		
	Pb	Cr	Ni
SA1	2832.431	0.00000	12.07787
SA2	25.92521	18.51959	0.00000
SS1	162.0374	18.51959	14.49178
SS2	6.480607	18.51959	2.416686
SC1 (Control)	0.480607	0.51959	0.661188
<b>Parameters</b>			
Mean	64.81 ± 84.75	13.88 ± 9.25	7.25 ± 7.11
Median	93.98	18.51	14.49
Minimum	6.48	18.51	2.41
Maximum	2832.43	18.51	14.49

**3.1 Reliability Test**

Data on PTE in clinical waste at Matar hospital showed an odd value of sample, SA1 or lead concentration as 2832.431 mg/kg. For decision on whether value should be rejected or not, it was subjected to statistical test called the *Q-test*.

$$Q = \frac{|questionable\ value - nearest\ value|}{largest\ value - smallest\ value} \dots(i)$$

From Table 3, the corresponding values are applied thus:

$$Q = \frac{|2832.431 - 162.0374|}{2832.431 - 6.480607}$$

$$Q = \frac{|2670.3936|}{2825.9504} = 0.94495\ mg/kg$$

So, the Q calculated (Qcal)= 0.94495 mg/kg

From statistical *Q-test* table,

Q<sub>critical</sub> = 0.831 (for four samples)

Since,

$$Q_{cal} > Q_{critical} \dots(ii)$$

Then, the *questionable value* of 2832.431 mg/kg is rejected.

**4. DISCUSSION**

Generally, the concentrations of PTE in the ash samples were higher than those of the soil samples. This finding may be that burnt clinical substances containing PTEs yielded the ashes which in turn leached into the soils (increasing their concentration) over time.

The concentration of PTE in Ebonyi North zone was much higher compared to other zones in the state. This could be attributed to the volume of human activities, the high level of patronage in the hospitals situated in the zone which resulted to the high amount of PTE per kilogram of clinical waste generated. Obviously, it was not surprising that more grams of clinical waste per hospital

bed was generated from this zone as previous studies reviewed that increased levels of PTEs in the environment was due to anthropogenic activities [2,3]. Among the three PTE studied, Pb had the highest concentration while the least was Ni.

In the control samples (NC1, CC1, SC1), there were no clinical wastes in the sites. The high value of 2832.431 mg/kg shown in Table 3 could

be that the sample was collected from a point where a high amount of lead-containing substances was burnt since the value of such concentration was obtained from an ash sample labeled, SA1. And so, as more of such lead-containing substances were burnt in such open dumpsites, PTE continually leached into the soil, water bodies, and eventually got into the food-chain. When these PTE reach toxic levels, they result in environmental health risk [8-11].

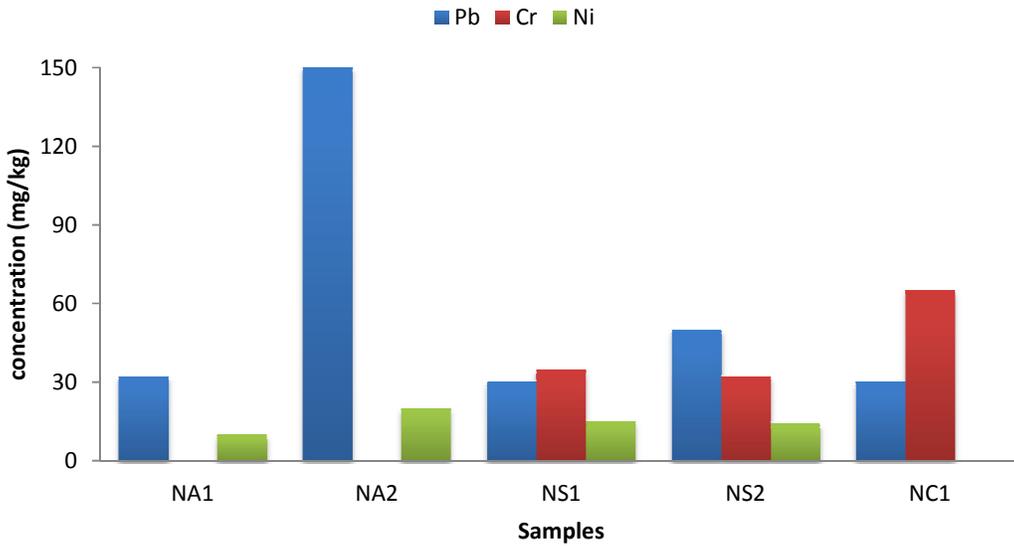


Fig. 1. Bar chart of PTEs concentrations of clinical waste at FETHA

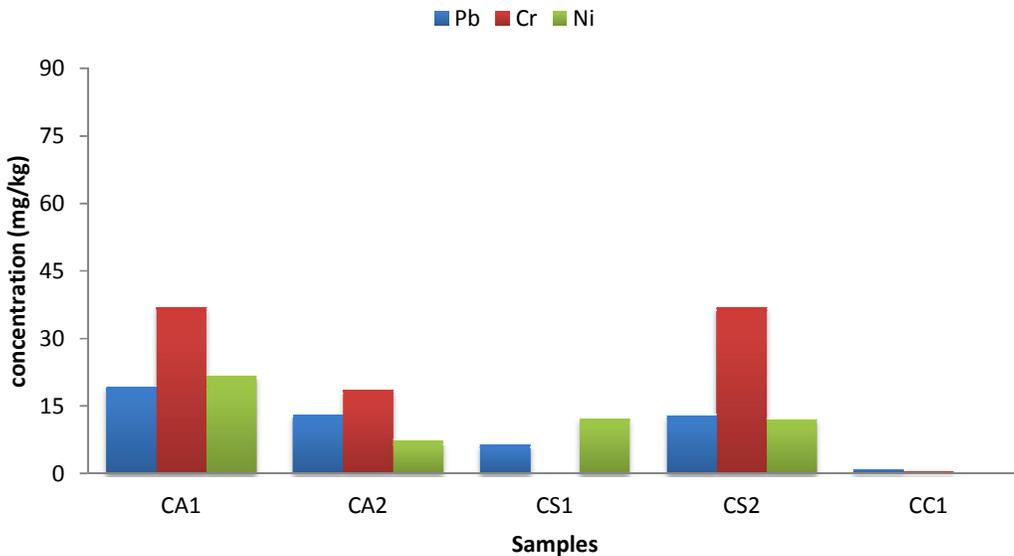
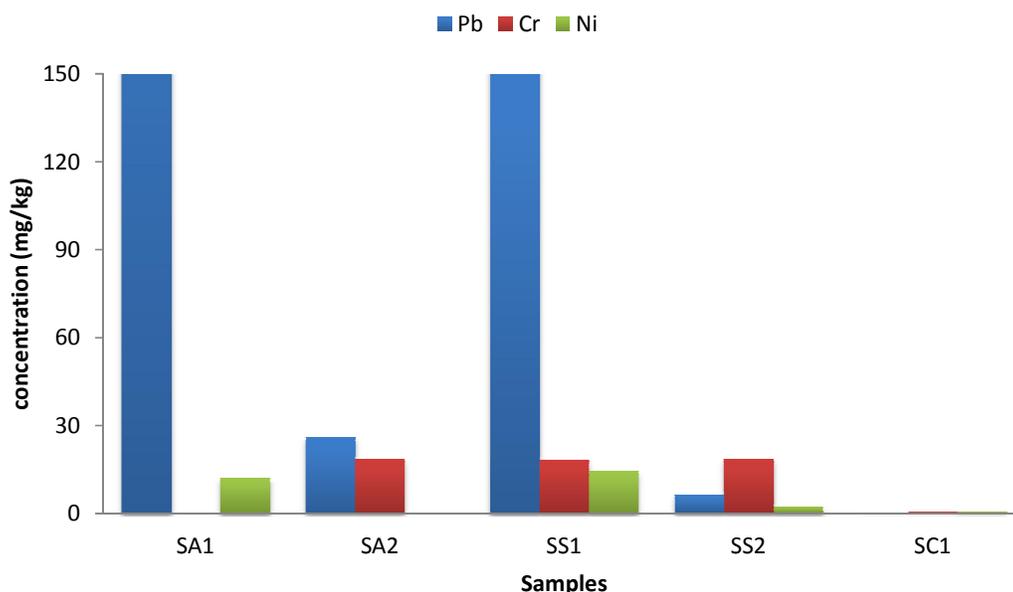


Fig. 2. Bar chart of PTEs concentration of clinical waste at R.I.M Hospital



**Fig. 3. Bar chart of PTEs concentrations of clinical waste at Matar Hospital**

This study showed that inappropriate methods of clinical waste management were used in the study area and so needed to be addressed since clinical wastes were disposed and burnt openly without treatment. There was a strong indication that health workers and the general public were unaware of the health risk posed by potentially toxic elements (PTE) in clinical wastes. Health effects resulting from PTE in dumpsites ranged from depleting the immune system, causing renal failures, cancer, neurological disorders especially among children whose immune systems are still weak to massive deaths. On the circumstances of exposure, the health hazards are immense owing to scavengers (including persons who pick metal scrapes, discarded but recyclable materials for economic reasons), and lack of personal and corporate protective measures or equipment among clinical waste handlers. The management of clinical waste in Nigeria is characterized by poor conduct, obsolete disposal protocols [2], and improper management of the waste at all stages [12-14]. Ebonyi State is not an exception, its clinical waste management should be improved upon as they contain substantial amount of PTE especially lead which poses health risks to the general public.

## 5. CONCLUSIONS

The concentration of PTEs in the clinical waste dumpsites of these health facilities was high and

therefore constituted a potential health risk to man and his environment. Environmental health officers should be charged with more responsibilities to ensure healthy environment and safety.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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