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# Studies on the effects of Burnt Naira Ash on soil properties

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**ABSTRACT:**

Studies on the effects of burnt naira ash on soil properties was carried out using samples collected from the Central Bank of Nigeria dump site and the adjoining environment. The samples were subjected to microbial, physical and chemical analyses. Concentrations of heavy metals (Ni, As, Cd, and Hg) were also determined using Atomic Absorption Spectrophotometer (AAS). Microbial counts ranged from 60 CFU/g to 205 CFU/g with the isolation of the following bacteria species: *Acetobacter* sp, *Epulopiscium* sp, *Shigella* sp, *Staphylococcus* sp and *Fusobacterium* sp. The fungal isolates were *Penicillium* sp, *Rhizopus* sp and *Aspergillus* sp. The soil physical and chemical parameters analyzed, showed relative increase in comparison with the sample from the adjoining environment. While the pH of the control sample tended to be acidic, the samples from the dump site tended to be basic. The Chi-Square value of $\alpha = 0.05$ for total microbial count was significant. Also, at $\alpha = 0.05$, the heavy metal concentration values showed significant difference while chemical and physical properties of the samples were however insignificant at $\alpha = 0.05$. Burnt Naira ash affected the microbial, some physical and chemical properties of the polluted soil.

**Keywords:**
Heavy metals, concentration, soil, naira ash, environment.

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## INTRODUCTION

The Central Bank of Nigeria (CBN) among other usual banking activities controls the minting and printing of Nigeria currency (Naira). It is incharge for withdrawal and subsequent destruction of mutilated Naira notes.

Paper Naira notes are composed of 75% cotton and 25% linen (Gadsbay, 1998). Coloured seals and inscriptions on the Naira notes are done using inks composed of heavy metals such as Mercury (Hg) and other chemical substances (Friedberg, 1995; Steinnes, 1990).

Pathogenic and non-pathogenic microorganisms have been isolated from mutilated Naira notes. These mutilated Naira notes are shredded and briquetted at various CBN branches across the country and finally destroyed by burning at various dump sites. The resulting ash (Naira ash) is left at the open dump site, which is a possible pollutant of the environment (Soil) which invariably will affect the soil fertility.

Soil is fertile when it is capable of supplying minerals to plants (McGraw Hill Concise Encyclopedia of Environmental Science, 2005). When the soil properties change, its fertility will be subsequently affected. Soil properties such as physical, chemical and microbial compositions are affected when it is polluted (Taylor *et al.*, 1997). Soil pollution is defined as the build-up in soil of toxic substances, chemicals, salts, radioactive materials or disease-causing agents, which have adverse effects on plant growth and animal health. Three factors are known to determine the severity of any soil pollutant. These include: the chemical nature, the concentration, and the persistence of the pollutant. Some soil pollutants are biodegradable while others are recalcitrants (non-biodegradable) (Singh, 2005).

Indiscriminate dumping of refuse, toxic wastes, etc have been associated with soil pollution worldwide (Onweremadu, 2007; Chander and Brookes, 1991). However, high level of enviromental degradation resulting from poor waste management, is more pronounced in the underdeveloped countries. Some of these poorly-managed wastes are highly loaded with heavy metals and other toxic substances that are persistent in the soil. Various sources of heavy metals in soil are known which include among others the following: metal smelting, waste disposal (e.g municipal solid waste, hazardous wastes, special wastes such as naira ash, etc), corroded metals, agricultural wastes, etc. It has been established that microbial biomass decreases with increase in heavy metals concentrations in the soil (Khan and Scullion, 2002), and high heavy metal concentrations have been implicated on crops/vegetables grown on heavy metal- polluted soils.

The effect of soil pollution reflects invariably on agriculture and agricultural products as well as human health. Many polluted soils do not support the growth of plants. In many cases, plants/crops grown on polluted soils absorb and accumulate the toxic pollutants which pose health risks on man and animals. Surface and underground waters are also affected (Okereke *et al.*, 2011; Okechi *et al.*, 2013). In Owerri, the capital city of Imo State and its environs, cattles which serve as source of meat supplied and sold to the populace, graze on grasses that grow on polluted soils without restrictions. Considering the above, the research on the effects of burnt Naira ash at CBN dump site, Avu Owerri, on the properties of the soil was carried out to ascertain the possible environmental and health implications.

## METHODOLOGY

### Sample Collection and Preparation

Samples were collected using sterilized hand trowel and put in sterile black polythene bags from Central Bank of Nigeria, Owerri branch dump site along Owerri-Port Harcourt Road, Avu Junction, Owerri North.

Totally, four samples were collected and named as Samples A, B, C and D. Sample A was collected from the top of the dump (mainly Naira ash), Sample B was collected from the dump base (mixture of ash and soil);

Sample C, 15-30 cm deep from the soil surface (mainly soil); Sample D (Control Sample), from soil in the adjourning environment about 100 m away from the dump site.

Some quantity (10 g) of each sample for routine soil analysis and determination of heavy metals concentrations were air-dried in the laboratory at room temperature and sieved with a 2 mm sieve.

**Laboratory Investigations**

Microbial analysis, routine soil analysis and determination of heavy metal (Hg, Cd, As and Ni) concentrations were carried out on the samples.

**Microbial Analysis**

Serial dilutions were carried out on all the samples by weighing 10 g of each sample into respective labeled conical flasks containing 90ml of sterile water. After proper agitation, the mixtures were allowed to settle and 1ml of each sample was transferred to 9ml of sterile water in labeled test tubes. The dilution was done till the $10^{-5}$ dilution was obtained for all the samples.

To already-prepared and labeled plates of Nutrient and SDA agar, 0.1ml of samples from $10^{-2}$ and $10^{-3}$ dilutions were transferred and streaked. Nutrient agar plates and SDA plates were incubated at 37°C and 30°C for 24 hrs and 72 hrs respectively.

Identification and characterization of bacteria isolates were based on microscopy, gram reactions and biochemical tests, while fungi identification was based on Morphology.

**Soil Analysis**

Physical and chemical properties of the samples were determined. Particles size and pH of the samples were the physical parameters determined, while soil organic carbon, organic matter, total nitrogen, available phosphorus, exchangeable acidity, total exchangeable base and heavy metal concentrations were the chemical properties determined.

Soil sample size (Sand, Silt and Clay) distribution was determined by hydrometer method according to Gee and Baucler (1986) with Calgon solution (5 %) serving as dispersant.

Soil pH was determined using pH-Meter (Maclean 198 Model). Organic carbon was determined by Walkley and Black wet oxidation method, modified by Nelson and Sommers (1982). The equation below was used to determine the percentage organic carbon present in the sample.

$$\text{Organic Carbon (\%)} = \frac{MeK_2G_2O_7 - MeFeSo_4 \times 0.003 \times 100 \times F}{\text{air-dried soil sample (gram)}}$$

F=Correlation factor = 1.33

Total Nitrogen was determined by Macwkjelchahl digestion method and modified by Bremner and Malvaney (1992).

Titrimetric method using EDTA (with calcium and magnesium indicators) on 5ml of supernatants resulting from dissolution of 5 g of each soil sample in 50 ml of Ammonium acetate, 5 ml of supernatants mixed with 50 ml of distilled water and 4 ml of Ammonium chloride, was adopted to determine exchangeable bases.

Exchangeable acid was determined by extraction of exchangeable $H^+$ and $Al^{+3}$ with 1 ml KCl and titrated according to Mclaren *et al.*, (1994). Bray II method in Olsen and Sommers, (1995), was adopted to determine available phosphorus.

Atomic Absorption Spectrophotometer (AAS) technique was used to determine the concentrations of heavy metals. This involved the use of filtrates resulting from digestion 1 g of each sample with 5 ml of HCl and $HNO_3$, heated to dry and made up to 50 ml mark with deionized water and filtered.

**Data Analysis**

Results of total heterotrophic bacterial counts were subjected to Chi-square statistical analysis; ANOVA was used for the results of routine soil analysis.

## RESULTS

As shown in table 1, total heterotrophic counts was high (205 CFU/g) in sample A (Naira ash only), 204

**Table 1: Total microbial count in soil samples**

| Soil Sample | THBC (CFU/g) | TCC (CFU/g) | TFC (CFU/g) | TSSC (CFU/g) | Total |
|---|---|---|---|---|---|
| A | 65 | 86 | 18 | 36 | 205 |
| B | 71 | 75 | 34 | 24 | 204 |
| C | 38 | 29 | 21 | 31 | 119 |
| D | 26 | 14 | 16 | 4 | 60 |

CFU/g, in sample B (mixture of Naira ash and soil). It was 119 CFU/g in top soil (sample C) and 60 CFU/g in control sample from the adjourning environment (Sample D). Bacterial isolates were *Acetobacter* sp, *Shigella* sp; *Epulopiscium* sp, *Fusobacterium* sp, *Bacillus* sp, and *Staphylococcus* sp. *Penicilium* sp, *Rhizopus* sp and *Aspergillus* sp were commonly isolated fungi (Table 2).

The physical and chemical properties of the soil samples are shown in Table 3. The Naira ash had no sand, clay and silt while in other samples, they ranged between 85.12% - 89.12%; 4.6% - 11.6% and 3.28% - 6.28% respectively. Other parameters analysed recorded range of values. Basic pH values were recorded in the test samples A, B and C (8.72, 8.80 and 8.47 respectively), but acidic in the control soil sample D (5.02).

The concentration of the heavy metals: Nickel, Mercury, Arsenic and Cadmium were within the range of 0.1764mg/kg – 0.6082mg/kg, 0.0077mg/kg – 0.5455mg/kg, 0.0247mg/kg – 0.4316mg/kg and 0.0563mg/kg – 1.0904mg/kg, respectively. The control soil sample recorded the least value of heavy metals except Nickel which recorded value of 0.5410mg/kg (Table 4).

**Statistical Analysis**

The Chi-Square ($X^2$) value of total microbial count in soil samples showed great significance at 99.95% confidence interval and degree of freedom, 9 ($X^2$ Cal = 40.294, $X^2$.05,9 = 3.325). In the same way, there was significant difference in heavy metal concentrations in soil samples at $\alpha$= 0.05 (since $F_{cal}$ = 4.1442 > $F_{tab}$ = 3.490). However, there was no significant difference in the chemical and some physical properties of the soil samples at $\alpha$ = 0.05.

## DISCUSSION

The number of microbial colonies from ash and ash in direct contact with soil surface were relatively high compared to polluted top soil and that from adjourning environment (control). This could be as a result of the decomposition of the Naira ash, which serves as a substrate for the organisms to grow and multiply rapidly. Different species of bacteria and fungi were isolated; this has to do with the soils, which have large number of microorganisms and highly suitable habitat for them.

pH was basic in the test samples and acidic in the control, this could be as a result of the pollutant (naira ash) with the activities of microorganisms actively contributing to the decomposition of the waste, resulting

**Table 2: Microbial Isolates from Soil Samples**

| | A | B | C | D |
|---|---|---|---|---|
| **BACTERIA** | *Acetobacter* sp | *Acetobacter* sp | *Epulopiscium* sp | *Fusobacterium* sp |
| | *Epulopiscium* sp | *Staphylococcus* sp | *Fusobacterium* sp | *Bacillus* sp |
| | *Shigella* sp | *Shigella* sp | *Bacillus* sp | *Staphylococcus* sp |
| | | | *Shigella* sp | *Acetobacter* sp |
| | | | | *Shigella* sp |
| **FUNGI** | *Penicillium* sp | *Aspergillus* sp | *Rhizopus* sp | *Aspergillus* sp |
| | *Rhizopus* sp | *Penicillium* sp | | *Penicillium* sp |

**Table 3. Physical and Chemical Properties of soil samples**

| | SOIL SAMPLE | | | |
|---|---|---|---|---|
| **Soil Parameter** | **A** | **B** | **C** | **D** |
| Sand (%) | Nil | 89.1200 | 85.1200 | 85.1200 |
| Clay (%) | Nil | 04.6000 | 11.6000 | 09.6000 |
| Silt (%) | Nil | 06.2800 | 03.2800 | 05.2800 |
| Na (mg/100g) | 0.1391 | 0.0570 | 0.0739 | 0.0113 |
| K (mg/100g) | 0.0841 | 0.0821 | 0.1128 | 0.0108 |
| Ca (mg/100g) | 201.10 | 06.5000 | 6.9000 | 0.0400 |
| Mg (mg/100g) | 029.00 | 02.9000 | 0.8300 | 0.0170 |
| Al+H (mg/100g) | Trace | 0.05000 | 0.0500 | 0.1750 |
| Al (mg/100g) | Trace | Trace | Trace | 0.1250 |
| N (%) | 0.082 | 0.02000 | 0.0290 | 0.0360 |
| OC (%) | 02.046 | 0.45340 | 0.5920 | 0.9390 |
| OM (%) | 03.528 | 0.78200 | 1.0210 | 1.6190 |
| AP (ppm) | 20.460 | 7.50000 | 5.5000 | 2.8000 |
| pH | 08.720 | 8.80000 | 8.4700 | 5.0200 |

in the production of $CO_2$. Organic Carbon was higher in the naira ash; this could be attributed to the high decomposition of the naira ash. High concentration of heavy metals could lead to high carbon content since soil heavy metals are found in the lattices of secondary minerals in the form of carbonates (Berti *and* Jacobs, 1996). Organic matter showed variable difference in distribution. It was high at the surface (3.5289) followed by that of the control (1.619) compared to the sub-surfaces. This implies that high rate of degradation and decomposition of materials take place at the surface of the soil as these release organic matter. Decomposition and degradation of waste product release organic and inorganic materials (Onweremadu, 2007) some of which are beneficial to the soil.

Exchangeable acidity was high in the unpolluted soil compared to that of the polluted which were comparatively low. Available phosphorus was found to be higher in the surface soil of the polluted soil and reduced down the profile. The low phosphorus level in

**Table 4: Concentration of Heavy Metals (mg/kg) in soil samples**

| | Soil sample | | | |
|---|---|---|---|---|
| **Heavy Metal** | **A** | **B** | **C** | **D** |
| Nickel (Ni) | 0.49025 | 0.6082 | 0.1764 | 0.5410 |
| Mercury (Hg) | 0.3561 | 0.5455 | 0.1039 | 0. 0077 |
| Arsenic (As) | 0.2971 | 0.4316 | 0.0907 | 0.0247 |
| Cadmium (Cd) | 0.8340 | 1.0904 | 0.4181 | 0.0563 |

the control sample may be attributed to the acidic nature of the soil as higher acidity of a soil result in the fixation of soil phosphorus (Nnaji *et al.*, 2002). The higher available phosphorus at the surface could be due to the decomposition process, which releases nutrient down the soil profile. Total Nitrogen was higher at the polluted area; the ash had the highest value of 0.0082% compared to the rest, reducing with depth. The high value on the polluted soil implies high decomposition of organic matter as soil nitrogen normally originates from organic materials. Exchangeable base (Ca and Mg) were high in the polluted soil but reduced down the gradient; sample from the ash and ash in contact with soil had values of 201.10mg/kg and 29.00mg/kg respectively. Sodium and Potassium also decreased down the soil gradient, all of which may be as a result of the waste deposit and burning. Percentage of sand and silt were higher in ash mixed with soil, but had low percentage of clay. All these parameters did not show any significant difference with control, the major difference in some of the parameters is as a result of microbial activities which were higher at the dump site.

Nickel in the test samples and control was below the permissible limit of World Health Organization. Mercury was higher in ash in direct contact "with the soil surface (0.5455mg/kg) than others when compared to WHO's standard of 0.020mg/kg. Arsenic was also higher than its permissible limit in some of the samples though not significant. Cadmium was the highest in ash in direct contact with soil surface (1.0904mg/kg) and ash

(0.8340mg/kg) compared with WHO's standard of 0.1mg/kg.

Generally the heavy metal concentration was high in all the test samples, this could be as a result of the ink component of the Naira notes. The higher value in the polluted soil is attributable to the degradation and decomposition processes of the waste materials, releasing inorganic substances e.g. heavy metals that are deleterious to the ecosystem (Onweremadu, 2007; Okechi *et al.*, 2013). The continuous deposition of the naira ash will become harmful since heavy metals are not biodegradable and bioaccumulate in plant which when grazed on by animals are taken up in the food chain. When man eats such animals or even Agricultural produce from the contaminated or polluted soil; it can bioaccumulate thereby affecting important organs of the body e.g the kidney, liver etc.

## CONCLUSION

There was a positive relationship between soil organic carbon levels and microbial biomass, as the microorganisms decompose the naira ash. There was significant difference between the polluted soil and the control with respect to total heterotrophic count. The physical and chemical parameters did not show significant difference in the contaminated and control samples although there was little variation in some of the parameters tested.

The concentration of heavy metals tested (Hg, Cd, Ni, and As) showed little variation from the standard concentration (permissible limit in soil). The effect of the heavy metals at this time may not have been significant. However with the continuous deposition of the naira ash, there would be an increase in concentration since heavy metals are not biodegradable. Some of the microorganisms may have died as a result of the toxic effects of the heavy metals. Plants around the site will also take up these elements and it goes up the food chain to man and other animals causing diseases and other health and environmental hazards.

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