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## Physicochemical Studies on Uburu Salt Lake Ebonyi State-Nigeria

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**Abstract:** Physicochemical properties of soil (sediment) and water from Uburu salt lake were evaluated and compared with control soil and surface water from the same community. Results showed significant ( $p < 0.05$ ) higher values for the heavy metals cadmium, chromium, copper, lead and zinc in the lake water relative to the control. The values of these metals in the lake soil (sediments) however, were significantly ( $p < 0.05$ ) lower than the control soil. Similar significant ( $p < 0.05$ ) elevations were observed in the lake water temperature, salinity, pH, calcium, magnesium, sodium, potassium, nitrate, carbonate, sulphate and phosphate levels compared to the control. Significant ( $p < 0.05$ ) changes were also noted in the lake soil's pH, exchangeable acidity, nitrogen, organic carbon, calcium and magnesium levels. Also the soil texture was affected relative to the control. In a number of cases, the values of the studied parameters were higher than the permissible WHO standards. In view of these findings, cautious use of the salt lake soil and water is advocated.

**Key words:** Uburu salt lake, physicochemical characteristics, soil, water

### INTRODUCTION

A lake is a land locked body of water. Salt lakes form when water flowing into lakes containing salts or minerals cannot leave because the lake is terminal. The water on evaporation leaves behind any dissolved salt and therefore increases in salinity.

High heavy metal levels have been reported in several water bodies and sediments/soil. They include great salt lake, Utah, USA, salt lake city Chicago, River Mississippi and Wadi EL Natrum saline lake in Egypt (Taylor *et al.*, 1980; Garbarino *et al.*, 1995; Gardiner *et al.*, 1995; Taher and Soliman, 1999).

Heavy metals are released into water bodies such as streams, lakes, rivers and ground water by either natural processes or anthropogenic sources (Kanu *et al.*, 2006; Sattler, 2004). Ibe and Duruike (2001) noted that soil is depleted of essential nutrients by erosion. Thus, as the soil becomes depleted of minerals, the water bodies become enriched.

There are close relationship between heavy metal ions and sediments, such as suspended particles, bed loads and bottom sediments, in natural water bodies such as lakes and rivers. Elevated salt concentration create increased competition between cations and metals for binding sites. Often, metals will be driven off into the overlying water. Many factors affect the adsorption of metals to soils and particles. The factors include pH and temperature. A lower pH increases competition between metal and hydrogen ion binding site. A decrease in pH

may also dissolve metal carbonate complexes releasing free metal ions into the water column (Zhou and Kot, 1995).

The Uburu salt lake is a rich source of common salt. Indeed, the natives and some salt manufacturing outfits use the lake water for salt making (RMRDC, 2003). The salt water is usually evaporated to dryness to obtain the common salt (UNIDO, 2005).

The present study was therefore, undertaken, to assess the relative safety of the salt water for this purpose by examining the physicochemical characteristics of the lake water and soil (sediment).

### MATERIALS AND METHODS

**Sampling sites:** Uburu salt lake is located in the Northern part of Ohaozara Local government Area of Ebonyi State, Nigeria. The settlers of Uburu are predominantly farmers. However, lead mining activity is active in this local government Area.

For this study, the lake was divided into transects of North, South, East and West from a reference epicentre. Each of the transects cover an area of about 50 m<sup>2</sup>.

Soil from a farm land about 20 m away from the lake and water from surface water (stream) in the community served as control.

**Sample collection and analysis:** This study was carried out between the months of August and September 2006.

Five soil and water samples were randomly collected from each of the transects and pooled to obtain a homogeneous unity sample.

Water samples were collected and kept in 100 mL sterile plastic containers while soil (sediments) samples were collected at a dept of 15 cm using metal auger and kept in plastic bags. Water sample for metal analysis was treated with 1 mL of HCl in 500 mL sample to arrest microbial activities. For non metal analysis, the fresh water samples were refrigerated in cooler packed with ice blocks to avoid microbial action affecting their concentrations.

Temperature was measured at the site of collection of samples by immersing the bulb in the soil or water and noting the reading in degree centigrade. pH was measured using fresh samples at the laboratory of Biochemistry Department, Abia State University, Uturu. Non metal analysis was also carried out in this laboratory. Metal analysis using atomic absorption spectroscopy was done at the analytical laboratory of Aluminum smelting company of Nigeria (ALSCON) Ikot, Abasi, Akwa Ibom State, Nigeria while soil analysis was carried out in the soil science laboratory, National Root Crops Research Institute, Umudike, Abia State, Nigeria.

**Preparation of samples for analysis:** Soil sample solutions for metal analysis was prepared by treating 1 g soil sample with 10 mL of concentrated nitric acid and 5 mL of 60% perchloric acid in 100 mL kjeldahl flask. The mixture is heated with moderate heat using a hot plate for about 15 min until white fumes appear. Allow the digest to cool. Filter (No. 44 Whatman paper) into 50 mL volumetric flask with rinsing using de-ionised water and made up to mark with de-ionised water. A blank digestion was also carried out using the same procedure.

Water for metal analysis was treated in accordance with standard methods for the examination of water and waste water as prescribed by APHA (1985), using mixed acid digestion. To 50 mL of unfiltered water sample in 500 mL Taylor flask, 0.50 mL concentrated sulphuric acid was added. This was boiled down to obtain white fumes, cooled and 1.0 mL 60% HClO<sub>3</sub> and 5.0 mL concentrated HNO<sub>3</sub> added. The resulting mixture was digested until a clear digest was obtained.

This was cooled, filtered (No. 44 Whatman paper) into 500 mL volumetric flask, diluted to volume and mixed. Blank digestion was carried out in a similar way.

**Justification for use of metal auger for soil collection:** Soil samples were first collected wearing plastic gloves at a depth of 15 cm. Soil samples were also collected using metal auger at a depth of 15 cm. Both samples were digested, chromium and iron content analyzed using

atomic absorption spectrophotometer. The results did not show any significant variation between the two samples and hence the use of metal auger for soil collection in the study.

**Analysis of physical and chemical parameters:** pH of water samples were determined with fresh sample using a pH meter. Soil pH was determined according to the method described by Bates (1954) using air-dried soil sample.

Other physical properties of soil such as particle size were determined as described by Ayres *et al.* (1973).

Organic carbon and organic matter were determined according to the method described by Osuji and Adeseyin (2005). In this determination of TOC and TOM contents, each air-dried soil sample (0.5 g) was put into a conical flasks and 1N K<sub>2</sub>C<sub>2</sub>O<sub>7</sub> solution (2.5 mL) was added. The probes were swirled gently to disperse the sample. Then, conc. H<sub>2</sub>SO<sub>4</sub> (5 mL) was added rapidly and the flask was swirled gently, until sample and reagents were mixed and finally swirled vigorously for 1 min. The flask was allowed to stand in a fume cupboard for 30 min. Then, 5-10 drops of diphenylamine indicator was added and the test probes were titrated against 0.5 N FeSO<sub>4</sub> solution to a moroon color. A blank determination was carried out to standardize the dichromate. The TOC and TOM contents (in %) were then calculated as follows:

$$\begin{aligned} \text{TOC (\%)} &= (\text{Meq (K}_2\text{Cr}_2\text{O}_7) - \text{meq (FeSO}_4) \times \\ &\quad \text{meq (C)} \times f \times 100/w \\ \text{TOM (\%)} &= 1.724 \times \text{TOC} \end{aligned}$$

Where f is a correction factor (f = 1.3) meq stands for weight milliequivalent (in g), W being the weight of the sample (in g).

Chemical parameters of soils and water samples determined include phosphate (PO<sub>4</sub><sup>3-</sup>), sulphate (SO<sub>4</sub><sup>2-</sup>), Carbonate (CO<sub>3</sub><sup>2-</sup>) Nitrate (NO<sub>3</sub><sup>-</sup>).

NO<sub>3</sub><sup>-</sup> was determined according to phenol-2,4-disulphonic acid method in which nitrate reacts with phenol-2,4-disulphonic acid to produce a nitro derivative which on conversion to alkaline salt gave a colour which concentration was measured spectrophotometrically at 410 nm (Allen *et al.*, 1964). SO<sub>4</sub><sup>2-</sup> was measured by turbidimetric method of Butters and Chenery (1959). It involves the precipitation of barium sulphate which turbidity was measured at 470 nm as a function of SO<sub>4</sub><sup>2-</sup> concentration. PO<sub>4</sub><sup>3-</sup> was determined following the molybdate the method using stannous chloride as reducing agent and measuring the absorbance at 700nm. CO<sub>3</sub><sup>2-</sup> was determined by the method described in AOAC

(2005). Nitrogen was determined as described by Yeomans and Bremmer (1991). Exchangeable acidity was by the method of Thomas (1982).

Ca<sup>2+</sup> and Mg<sup>2+</sup> levels were determined by titrimetry while Na<sup>+</sup> and K<sup>+</sup> were estimated using flame photometer.

Atomic Absorption Spectrophotometer (AAS) was employed in determining the concentration of the heavy metals (Alloway and Ayres, 1997).

**Data analysis:** Statistical analysis was done using analysis of variance (ANOVA). Means were compared for significance using the Duncan's Multiple Range Test (p<0.05) Sokal and Rholf (1969).

**RESULTS AND DISCUSSION**

Physicochemical properties of Uburu salt lake soil/sediment and water are shown in Table 1 and 2. The lake soil and water values of studied parameters were compared with values obtained from soil from farm land and water from a stream present in the community. The lake soil temperature was non-significantly (p>0.05) lower than that of the control farm land. This may be due to the cooling effect of the overlaying water. The lake water, however, had significantly (p<0.05) higher temperature relative to the control stream. Both the lake soil and water had higher pH values relative to their controls. The alkaline status of the lake environment is clearly due to the salt content. The water pH is slightly above the WHO recommended permissible level for drinking water (WHO, 1983).

Uburu lake content of the metals calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) as well as the non-metals chloride (Cl<sup>-</sup>), Nitrate (NO<sub>3</sub><sup>-</sup>), carbonate (CO<sub>3</sub><sup>2-</sup>), sulphate (SO<sub>4</sub><sup>2-</sup>) and phosphate (PO<sub>4</sub><sup>3-</sup>) were significantly (p<0.05) higher relative to their controls. A common feature of salt lakes and seas is that they have a high concentration of metal ions especially sodium (Na). Indeed, the lake water sodium and calcium content are above the recommended permissible limits of 20 and 75 mg L<sup>-1</sup>, respectively (WHO, 1971). Similarly, Table 3 shows that the heavy metals, Al, Cd, Cr, Cu, Fe, Mn, Pb and Zn occurred in significantly (p<0.05) higher levels in the lake water samples when compared to the controls. Fe and Mn levels exceeded the permissible limit. These heavy metals may originate from both natural processes such as weathering of rocks and erosion and from human activities such as mining and farming. Evidently, mining operation have great potentials for contamination of environment with heavy metals. In Ohaozara local government Area (where Uburu Lake is situated), there is a lead mine. Leaching of mine tailings and drainage from mined areas can introduce substantial amount of metals

Table 1: Temperature, pH and non-metallic ion levels in Uburu salt lake water

Parameters	Lake water	Control
Temperature	33.000±1.0 <sup>a</sup>	28.000±1.7 <sup>b</sup>
pH	8.030±0.02 <sup>a</sup>	6.830±0.02 <sup>b</sup>
<b>Non-metallic ions (mg L<sup>-1</sup>)</b>		
NO <sub>3</sub> <sup>2-</sup>	19.600±0.03 <sup>a</sup>	8.400±0.05 <sup>b</sup>
PO <sub>4</sub> <sup>3-</sup>	0.186±0.002 <sup>a</sup>	0.039±0.002 <sup>b</sup>
CO <sub>3</sub> <sup>2-</sup>	5568.000±0.13 <sup>a</sup>	91.750±0.06 <sup>b</sup>
SO <sub>4</sub> <sup>2-</sup>	24.340±0.05 <sup>a</sup>	1.420±0.03 <sup>b</sup>
Cl <sup>-</sup>	56.240±0.04 <sup>a</sup>	3.160±0.01 <sup>b</sup>

Figures represent mean±SD (n = 3). Values bearing different superscript differ significantly (p<0.05)

Table 2: Metal content of Uburu salt lake soil and water

Heavy metals	Metal (mg L <sup>-1</sup> )		Metal (mg kg <sup>-1</sup> )**	
	Lake water	Control surface water	Lake soil/sediment	Control soil
Al	0.062±0.002 <sup>a</sup>	0.017±0.001 <sup>b</sup>	9.28±0.22 <sup>b</sup>	14.09±1.11 <sup>a</sup>
Cd	0.003±0.000 <sup>a</sup>	0.001±0.000 <sup>b</sup>	1.93±0.07 <sup>b</sup>	2.06±0.02 <sup>b</sup>
Cr	0.050±0.001 <sup>a</sup>	0.036±0.001 <sup>b</sup>	14.75±1.00 <sup>b</sup>	29.83±1.11 <sup>a</sup>
Fe	0.240±0.008 <sup>a</sup>	0.098±0.002 <sup>b</sup>	1428.00±8.00 <sup>b</sup>	1379.00±10.00 <sup>a</sup>
Cu	0.015±0.001 <sup>a</sup>	0.007±0.001 <sup>b</sup>	9.61±0.32 <sup>b</sup>	13.80±0.20 <sup>a</sup>
Mn	1.322±0.010 <sup>a</sup>	0.021±0.001 <sup>b</sup>	101.60±8.20 <sup>b</sup>	182.10±4.10 <sup>a</sup>
Pb	0.025±0.000 <sup>a</sup>	0.003±0.000 <sup>b</sup>	17.45±0.55 <sup>b</sup>	18.65±1.05 <sup>b</sup>
Zn	0.036±0.002 <sup>a</sup>	0.009±0.001 <sup>b</sup>	54.85±1.15 <sup>b</sup>	140.10±8.20 <sup>a</sup>
Mg	15.200±0.200 <sup>a</sup>	0.800±0.002 <sup>b</sup>	3.60±0.20 <sup>a</sup>	3.20±0.12 <sup>a</sup>
Ca	480.960±4.500 <sup>a</sup>	26.050±0.510 <sup>b</sup>	7.20±0.30 <sup>a</sup>	5.60±0.20 <sup>a</sup>
Na	20.800±0.800 <sup>a</sup>	2.500±0.020 <sup>b</sup>	*	*
K	20.800±0.400 <sup>a</sup>	1.600±0.020 <sup>b</sup>	*	*

Figures represent mean±SD (n = 3). Values bearing different superscript vary significantly (p<0.05). \*Implies not determined and \*\*Soil metal concentration is expressed in mg kg<sup>-1</sup> dry weight

Table 3: Physicochemical properties of Uburu salt lake soil (sediment)

Parameters	Salt lake soil	Control
Temperature	34.000±2.0 <sup>a</sup>	38.400±0.23 <sup>b</sup>
pH	6.080±0.01 <sup>a</sup>	5.920±0.04 <sup>a</sup>
EA	0.320±0.02 <sup>b</sup>	0.800±0.06 <sup>b</sup>
Sand (%)	75.000±2.41 <sup>a</sup>	64.600±1.23 <sup>b</sup>
Silt (%)	19.200±1.65 <sup>a</sup>	11.000±0.82 <sup>b</sup>
Clay (%)	5.800±0.44 <sup>a</sup>	24.400±0.11 <sup>b</sup>
N (%)	0.096±0.002 <sup>a</sup>	0.002±0.000 <sup>b</sup>
OC (%)	1.141±0.003 <sup>a</sup>	2.219±0.004 <sup>b</sup>
OM (%)	1.967±0.002 <sup>a</sup>	3.836±0.014 <sup>b</sup>
Texture	Sandy Loam	Loamy Sand

Figures represent mean±SD (n = 4) Values bearing different superscript vary significantly (p<0.05). EA = Exchangeable Acidity; OM = Organic matter; OC = Organic Carbon and N = Nitrogen

into water bodies as observed in Mississippi River (Garbarino *et al.*, 1995). This may account in part for the high lead level observed in the Uburu salt lake. Akubugwo and Agbafor (1997) reported high lead level in different potable water sources in this lead mining community. Another important source of heavy metals in Uburu salt lake is fertilizer. The community settlers have food crop farming as their main occupation. The location of the lake in the valley is such that it acts as a sink for flood water passing through the farms. Spalding and Sackett (1972) observed that the concentration of uranium in Mississippi River is about 20 times that found in the Amazon River and linked it to specific use of phosphate fertilizer.

The lake soil content of the heavy metals Al, Cr, Cu, Mn and Zn are shown in Table 3. The result indicates significant ( $p < 0.05$ ) lower values compared to the control. This contrasts high heavy metal content reported in surficial sediments from Wadi El natrum saline lakes in Egypt (Taher and Solimon, 1999). The soil Fe content was however, slightly higher than the control. Several factors have been shown to affect the adsorption of metal ions to sediments. They include water temperature, pH and carbon content (Zhou and Kot, 1995). An interplay of the prevailing environmental factors in the salt lake seems to have favoured solubilisation of the metal ions and hence their reduced level in the lake soil/sediment.

The health implications of the high heavy metal content of Uburu salt lake deserve a close study. Our laboratory is presently investigating the heavy metal content of the salt produced by evaporating the water which is consumed by the settlers and else where. The trace element content of Uburu salt lake is also receiving attention. It has been observed that Utah's Great lake had amazing great health benefit because of its composition of trace elements.

### CONCLUSION

Evaluation of physicochemical properties of Uburu lake revealed that heavy metal contents of the lake water were significantly elevated when compared to a control surface water source. The lake soil (sediment) contents of most of the studied heavy metals were lower than those of nearby farmlands. The lake water content of Fe, Mn and Cr were higher than the WHO recommended permissible level. Also the lake water calcium content was far above the approved limit while the pH was slightly above the recommended limit. The inorganic ion content of the lake water was within approved WHO limits. Similarly, most of the studied metals were present in acceptable levels. In view of the high content of Fe, Mn and Cr in Uburu salt lake. Urgent efforts must be made to ensure that their levels in the common salt produced from it are within safe limits.

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