

# HEAVY METALS AND MINERAL ELEMENTS OF *Vernonia ambigua*, *Vernonia ocephala* AND *Vernonia pupurea* USED IN NORTHERN NIGERIAN TRADITIONAL MEDICINE

METALES PESADOS Y ELEMENTOS MINERALES DE *Vernonia ambigua*, *Vernonia ocephala* Y *Vernonia pupurea* USADOS EN LA MEDICINA TRADICIONAL DEL NORTE DE NIGERIA

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## ABSTRACT

**Background:** *Vernonia* species are widely consumed as vegetables or medicinal herbs for the treatment of various human diseases in Nigeria. Nevertheless, there exists a growing concern for consumption safety of those herbal plants, due to increasing environmental pollution. This is because plants can accumulate some heavy metals that constitute a potential risk to human health. Nonetheless, also essential elements may be accumulated in plants, which provide nutrients for combating diseases and maintaining human health. **Objectives:** The purpose of the study was to analyze some heavy metals and mineral elements on *Vernonia ambigua*, *V. ocephala* and *V. pupurea* commonly used in Northern Nigerian traditional medicine. **Methods:** Atomic absorption spectrometry (AAS) was used to determine the major elements (calcium and magnesium), trace elements (iron and manganese) and heavy metals (copper, cobalt, chromium, cadmium, lead and zinc). **Results:** We found a high Ca and Fe content in *V. ambigua*, Mg and Co in *V. ocephala*, and Cu and Cr in *V. pupurea*; in contrast, the last specie, showed low accumulation of Pb and Cd among all studied species. **Conclusion:** This study revealed that toxic elements concentrations are lower than the allowed dietary intake (ADI) in all the three *Vernonia* species. The quantitative estimation of these elements is important to understanding the pharmacological and/or toxicological actions of medicinal plants for safe use.

**Keywords:** *Vernonia* species, heavy metals, mineral elements, AAS, Northern Nigeria

## RESUMEN

**Antecedentes:** Las especies de *Vernonia* son ampliamente consumidas como verduras o hierbas medicinales, para el tratamiento de diversas enfermedades humanas en Nigeria. Sin embargo, existe una creciente preocupación por la seguridad en el consumo de dichas plantas, debido al incremento en la contaminación. Esto es debido a que las plantas pueden acumular algunos metales pesados que constituyen un riesgo potencial para la salud humana. Sin embargo, algunos elementos esenciales también pueden acumularse en las plantas proporcionando nutrientes para combatir las enfermedades y mantener una buena salud. **Objetivos:** El objetivo del estudio fue analizar algunos metales pesados y minerales en

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*Vernonia ambigua*, *V. ocephala* y *V. Pupurea*, comúnmente utilizadas en la medicina tradicional del norte de Nigeria. **Métodos:** La espectrofotometría de absorción atómica (AAS) se utilizó para determinar elementos mayores (calcio y magnesio), elementos trazas (hierro, manganeso) y elementos pesados (cobre, cobalto, cromo, cadmio, plomo y zinc). **Resultados:** se encontraron altos contenidos de Ca y Fe en *V. ambigua*, y de Mg y Co en *V. ocephala*. La cantidad de Cu y Cr fueron altas en *V. Pupurea*; en contraste, esta última reportó las cantidades más bajas de Pb (0.01200 mg/100g) y Cd (0.00670 mg / 100g) entre las tres especies de *Vernonia* estudiadas. **Conclusión:** Este estudio demostró que las concentraciones de elementos tóxicos como Pb, Cd y Co detectadas, son inferiores a la ingesta dietética permitido (ADI) en las tres especies de *Vernonia*. Las estimaciones cuantitativas de elementos pesados, son importantes para la comprensión de las acciones farmacológicas y/o toxicológicas de plantas medicinales para su uso seguro.

**Palabras clave:** Especies de *Vernonia*, elementos pesados, elementos minerales, AAS, Norte de Nigeria

## INTRODUCTION

Plants are continually being utilized as therapeutic agents in traditional medicine across Nigeria and other parts of Africa. About 80% of people living in rural Africa rely on traditional medicine for their primary health care needs (1). This involves the use of fresh plants, prepared formulations or as dried commodity being sold in the markets. There is a growing concern on the safety of the herbal plants being consumed in our communities in Northern Nigeria. This is due to increasing environmental pollution rendering plants vulnerable to contamination by metals accumulation (2). The World Health Organization emphasized the need to ensure the quality control of plant products by using modern techniques and applying suitable standards (3). It is therefore of major interest to investigate the concentration of some mineral elements in herbal plants. This is important to our understanding of the potential risk or benefit of the continued use of these herbs as medicines. Plants of the genus *Vernonia* are widely used as medicinal herbs or vegetable foods across Africa. *Vernonia amygdalina* for instance is one of the most widely used medicinal herbs across Nigeria with tremendous therapeutic properties against gastrointestinal disorders, fever, dysentery, malaria, diabetics and constipation. (4-7). *Vernonia ambigua*, *Vernonia ocephala* and *Vernonia pupurea* are among the commonly used herbal recipe in traditional medicine for the treatment of various human ailments including malaria, cough and fever across Northern Nigeria (8-9).

Chemical investigation on most *Vernonia* species around the world has led to isolation and characterization of numerous bioactive organic secondary metabolites (10). However, very little information is available on the inorganic elements constituents of

*Vernonia* species and their implications to traditional medicine is rarely known or established. Some trace elements are essential and may have both curative and preventive roles in combating diseases, as they promote good human health. On the other hand, heavy metals such as lead and cadmium are non-essential and at elevated levels can be dangerous or toxic to the human system (11-12). This study was designed to evaluate the heavy metals and mineral elements on the leaves of *V. ambigua*, *V. ocephala* and *V. pupurea* with a view to assess their therapeutic potentials or safety in relation to their uses.

## MATERIALS AND METHODS

### Plant materials

Fresh plant samples of *V. ambigua*, *V. ocephala* and *V. pupurea* were purchased from medicinal plants market at Zaria city, Kaduna state, in February, 2012. The samples were identified by Umar Shehu Gallah of the Herbarium Unit, Department of Biological Sciences, Ahmadu Bello University, Zaria, and voucher specimens numbers (870, 1334 and 1556 respectively) were deposited.

### Sample Preparation

The leaves of the fresh plants were washed with double deionized water and were air-dried in the laboratory for two weeks. The samples were pulverized with mortar and pestle and made to pass through 1.0 mm mesh sieve size, and finally stored in airtight bottles.

### Chemical analysis

The major elements comprising calcium and magnesium; trace elements (iron, manganese) and heavy metals (copper, cobalt, chromium, cadmium,

lead and zinc) were determined according to previous method with slight modification (13). The ground samples were sieved with a 2 mm rubber sieve and 2 g of each of the plant samples were subjected to dry ashing in a well-cleaned porcelain crucible at 550°C in a muffle furnace. The resultant ash was dissolved in 5 ml of HNO<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> (1:1) and heated gently on hot plate until brown fumes disappeared. To the remaining material in each crucible, 5 ml of deionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 ml volumetric flask by filtration through a whatman filter paper and the volume was made to mark with deionized water. This solution was used for elemental analysis by atomic absorption spectrometry (Spectrophotometer Varian model AA 650 FS). Concentration of each element was calculated on percentage of dry matter.

### Statistical analysis

All determinations were replicated three times and results were reported as mean values  $\pm$  standard deviation. Student's t-test was used for comparison between the two means. A difference was considered statistically significant when  $p < 0.05$ .

## RESULTS

The concentrations of major elements such as calcium ranged from 68.7087-89.0474 mg/100g and magnesium from 8.4777-10.0475 mg/100g in the three samples analyzed. The result of trace element such as iron ranged from 19.5397-21.9040 mg/100g. Manganese content detected was only high in *V. ocephala* (8.3826 mg/100g) (Table 1). Zinc content ranged from 0.3451-0.8450 mg/100g. The contents of toxic metals detected were low in all the three plant samples, but *V. pupurea* had the least content of both lead (0.01200 mg/100g) and cadmium (0.00670 mg/100g) (Table 1).

**Table 1.** Heavy metals and mineral elements contents of *Vernonia ambigua*, *Vernonia ocephala* and *Vernonia pupurea* (mg/100g of dry weight)

ELEMENTS	VERNONIA AMBIGUA	VERNONIA OOCEPHALA	VERNONIA PUPUREA
Calcium	89.0474 $\pm$ 0.021	72.5311 $\pm$ 0.01	68.7087 $\pm$ 0.010
Magnesium	8.6813 $\pm$ 0.012	10.0475 $\pm$ 0.11	8.4777 $\pm$ 0.012
Iron	21.9040 $\pm$ 0.014	19.5397 $\pm$ 0.02	19.5767 $\pm$ 0.018
Zinc	0.3538 $\pm$ 0.011	0.8450 $\pm$ 0.013	0.3451 $\pm$ 0.011
Chromium	0.6182 $\pm$ 0.015	0.7232 $\pm$ 0.016	0.9448 $\pm$ 0.016
Manganese	1.9676 $\pm$ 0.022	8.3826 $\pm$ 0.010	1.3054 $\pm$ 0.012
Copper	0.3442 $\pm$ 0.021	0.3403 $\pm$ 0.016	2.6952 $\pm$ 0.014
Cobalt	0.2553 $\pm$ 0.014	0.8218 $\pm$ 0.011	0.4047 $\pm$ 0.010
Cadmium	0.0086 $\pm$ 0.043	0.0100 $\pm$ 0.018	0.00670 $\pm$ 0.015
Lead	0.0530 $\pm$ 0.010	0.0280 $\pm$ 0.012	0.01200 $\pm$ 0.010

N=3 Data are presented $\pm$ Standard Deviation

## DISCUSSION

Major elements such as calcium and magnesium are known to have both structural and functional roles in biological systems. They are required for energy metabolism, nerve functions and muscle contraction (14). The proper balance between Ca<sup>2+</sup> and Mg<sup>2+</sup> ion constituents enhances muscular and nervous tissues (15). The functional roles of macro minerals in enhancing therapeutic efficacy of medicinal herbs have been highlighted (16-17).

The range of calcium (68.7087-89.0474 mg/100g) and magnesium (8.4777-10.0475 mg/100g) contents of the three *Vernonia* species, are comparable to mineral components from ten Nigerian medicinal plants used in the management of arthritis (18). Our study therefore, revealed that Ca and Mg concentrations in the *Vernonia* species might considerably be sufficient to promote medicinal value. However, cellular interactions of these elements with other electrolytes are likely to occur for positive or negative balance (19-20). Trace elements nutrition is

essential component of human dietary requirement for good health. Because they are required in trace amounts; Fe, Cr, Cu, Mn and Zn have numerous cellular functions. The formation of hemoglobin is associated to dietary iron for disease prevention (21). In this study, Fe content (21.9040 mg/100g) was higher in *Vernonia ambigua* (Figure 1) with no significant difference from other species analyzed ( $P < 0.05$ ). But previous reports showed lower Fe content in *Vernonia amygdalina* as 277.30 mg/Kg and 0.260 mg/g respectively (17, 22). However, *Vernonia blumeoides* (0.760 mg/100g) was observed to have higher iron content (23). But the tolerable upper intake level (UL) of iron based on gastrointestinal iron supplementation is 45 mg iron/day, and a reference daily iron intake (RDIs) of 18 mg/day, has been set by the US Food and Drug Administration (19-20). This suggests that although the *Vernonia* species have accumulated more iron probably due to preference for iron absorption, the bioaccessible amount of iron at physiological level might be hindered by complex ion formation. The absorption, transport and metabolism of trace elements in plant drug or extracts could be hindered by interactions with phytic acid or phytate, Zn, Fe, Ca through complexation; in addition, some free ions may also bind with ligands such as amino acids, phosphates and organic acids, making them unavailable for absorption (24).

Chromium is important to insulin performance and regulation in the body where as copper is a component of enzymes crucial to oxygen mediated reaction of Fe metabolism (25-26). The concentration of these elements indicates their phytoavailability in the three *Vernonia* species. The higher concentration of Cr ( $0.9448 \pm 0.016$  mg/100g) in *V. pupurea* (Figure 2) and Cu ( $0.3442 \pm 0.021$  mg/100g) in *V. ambigua* (Table 1) interestingly show no significant difference amongst the three *Vernonia* species analyzed ( $P < 0.05$ ) This however may imply the functional roles of the *Vernonia* species in traditional medicine. The average MPL for Cr (60  $\mu$ g/day) and Cu (12, 000  $\mu$ g/day) are indications that the plants are safe for human therapeutic uses or consumption (19-20).

Manganese and Zinc are useful micronutrients modulating cellular functions; Mn activates enzymes that are involved in fatty acid metabolism and synthesis (27), while Zn is useful to various Zn-metalloenzymes crucial in human metabolic pathways (28). The capacity of Zn to improve tas-

te, vision and wound healing might be important indication to restoring good health (25). The higher content of zinc ( $0.8450 \pm 0.013$  mg/100g) and manganese ( $8.3826 \pm 0.010$  mg/100g) in *V. ocephala* (Figure 3) may strongly support the use of the plants in traditional medicine. The recommended dietary allowance (RDA) (29-30) for Zn (15 mg/day) and Mn (10 mg/day) are higher than the detectable amounts in the plants suggesting the safety for therapeutic purposes.

On the other hand however, the heavy or toxic metals such as Pb was higher in *V. ambigua* ( $0.0530 \pm 0.010$  mg/100g), while Cd ( $0.01 \pm 0.018$  mg/100g) and Co ( $0.8218 \pm 0.011$  mg/100g) content were higher in *V. ocephala*, but the permissible limit for medicinal plants based on the acceptable daily intake (ADI) for lead is 10 mg/Kg (3) and MPL for cadmium is 0.2 mg/Kg (31). Previous studies on heavy metal accumulation in *Vernonia amygdalina* indicated Pb (0.14 mg/Kg) and Cd (0.06 mg/Kg) contents as reported by Sobukola et al (32), and Cd content of 0.001mg/Kg was also reported (33). Our results agrees with the literature reports implying that the concentration of toxic metals such as Pb, Cd and Co determined in all the three *Vernonia* species are lower than the ADI and indicate the safety with respect to toxicity. Generally, concentrations of metal distribution amongst the three *Vernonia* species did not differ significantly ( $P < 0.05$ ) except for Co, Mn and Zn which are disproportionate to *V. ocephala* and Pb to *V. ambigua*. The pattern or variability of mineral accumulation in herbal plants suggest the preferential absorbability of a particular element than the other, however, the soil composition or climatic conditions are complex forces (34) limiting any tentative generalization. Future studies on bioavailability of these elements in physiological models may be interesting.

## CONCLUSION

The quantitative estimation of major elements such as calcium and magnesium, trace elements (iron, zinc and manganese) and heavy toxic metals (lead, cobalt and cadmium) were carried out on *V. ambigua*, *V. ocephala* and *V. pupurea*. The results have indicated that the plants have accumulated major elements in concentrations that could enhance therapeutic medicinal value. Similarly, variable concentrations of trace metal such as iron were found to be largely accumulated by all the plants. But

manganese and zinc were only higher in *V. ocephala* than the other plants. In addition, the heavy toxic metals such as lead, cobalt and cadmium were found below the permissible limit for human consumption in all the three plants analyzed. It showed that the plants hold tremendous promise in providing the variable mineral supply that could enhance the curative process of ill health. These findings revealed the distribution heavy and some mineral elements amongst the three *Vernonia* species. This is important to understanding the pharmacological and/or toxicological actions of medicinal plants for safe use.

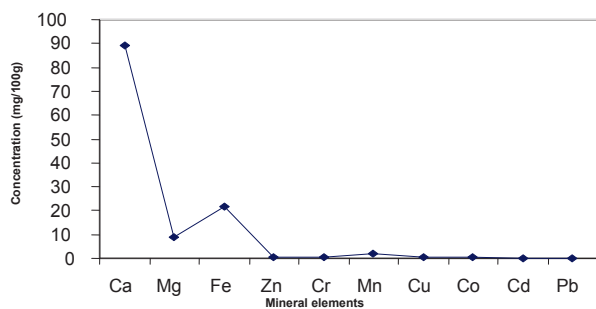


Figure 1. Mineral element concentration of *V. ambigua*

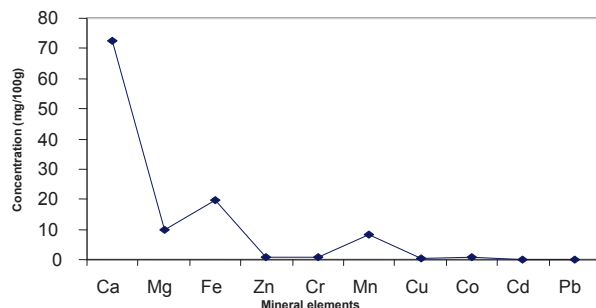


Figure 2. Mineral element concentration of *V. ocephala*

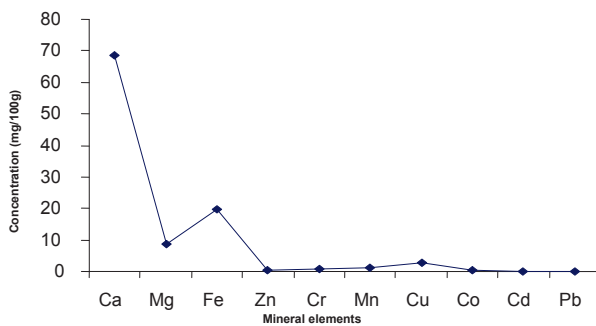


Figure 3: Mineral element concentration of *V. pupurea*

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## CONFLICT OF INTERESTS

Authors have declared no conflict of interests.

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