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**SHORT COMMUNICATION**

# COMPARATIVE STUDY OF TRACE ELEMENT LEVELS IN SOME LOCAL VEGETABLE VARIETIES AND IRRIGATION WATERS FROM DIFFERENT LOCATIONS IN ILORIN, NIGERIA

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**ABSTRACT.** The level of heavy metals in two varieties of vegetables harvested during the dry and wet seasons from seven different locations in Ilorin, Nigeria, were determined. The correlation between the level of metals in the vegetables and the irrigation water was also studied. Vegetables harvested during the dry season were found to contain higher level of toxic metals. Low water quality, accumulation of particulate after rainless period and nearness of some vegetable gardens to major and well travelled roads appeared to be the major contributory factors. *Amaranthus hybridus* seemed to have higher metal accumulation capacity compared to *Corchorus olitorius mannii*.

**KEY WORDS:** Trace elements, Heavy metals, Vegetables, Irrigation water, Water quality, Metal accumulation capacity, *Amaranthus hybridus*, *Corchorus olitorius mannii*

## INTRODUCTION

Vegetables and fruits contain a number of nutrients, which include ascorbic acid (vitamin C), citric acid, mineral elements, flavonoids and phenolic compounds [1, 2]. The average daily Western diet contains approximately 1 g of mixed flavonoids [1]. Ascorbic acid, flavonoids and other phenolic compounds exhibit antioxidant properties, which have been found useful in maintenance of health and prevention of diseases [3]. The extended conjugation across the flavonoid structure and the number of hydroxyl groups enhances these antioxidant properties by reacting as reducing agents, hydrogen or electron donating agents or single oxygen scavengers [4-6]. Dietary antioxidants offer effective protection from peroxidative damage in living systems and also play an important role in the prevention of carcinogenesis thereby extending the life span of animals [7-9]. Also a recently discovered flavonoid, vitamin P, exhibits beneficial effects on capillary permeability and fragility [10, 11].

Toxic heavy metals arising from human activities accumulate in the soil which have the tendency to absorb physiologically toxic metals and these ultimately get to human when plants grown on such soil are consumed [12]. Some of the human activities which can lead to soil contamination include discharge of industrial and domestic waste water, mining, smelting operations, and vehicular emission [12].

Vegetables mature for consumption within two or three months of planting under conducive environmental conditions including adequate rainfall and sunlight. Vegetable gardens need to be irrigated during dry season for suitable production throughout the year. During the period of low rainfall especially in the dry season, most farmers usually depend on the use of river or stream water for irrigation of vegetable beds.

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The objectives of this study include: (i) to determine the level of heavy (trace) metals such as Zn, Mn, Ni, Cd, Fe and Pb in *Amaranthus hybridus* and *Corchorus olitorius mannii* and to evaluate their suitability for human consumption and (ii) to determine, if any correlation exists between the levels of these metals in both the irrigation water quality and the vegetable varieties. *Amaranthus hybridus* and *Corchorus olitorius mannii* are the two common vegetables consumed in Western part of Nigeria.

## EXPERIMENTAL

Seven gardens located in different parts of Ilorin and its environs are selected for this study (Figure 1). Samples were collected once in a week for a period of two months in 2000 for each season, *i.e.* January and February for dry season and July and August for rainy season. The corresponding irrigation water samples were also collected from all the locations in clean and well-labelled 2-litre plastic containers. Rain water sample was also collected for analysis. The irrigation waters were digested following standard procedure [13]. The vegetable samples collected were washed, firstly with tap water and then with distilled water. After which the leaves were taken, air dried in the laboratory and finally oven dried at a temperature of about 60$^{o}$C. These leaves were then ground into powder with a clean and sterilized blender.

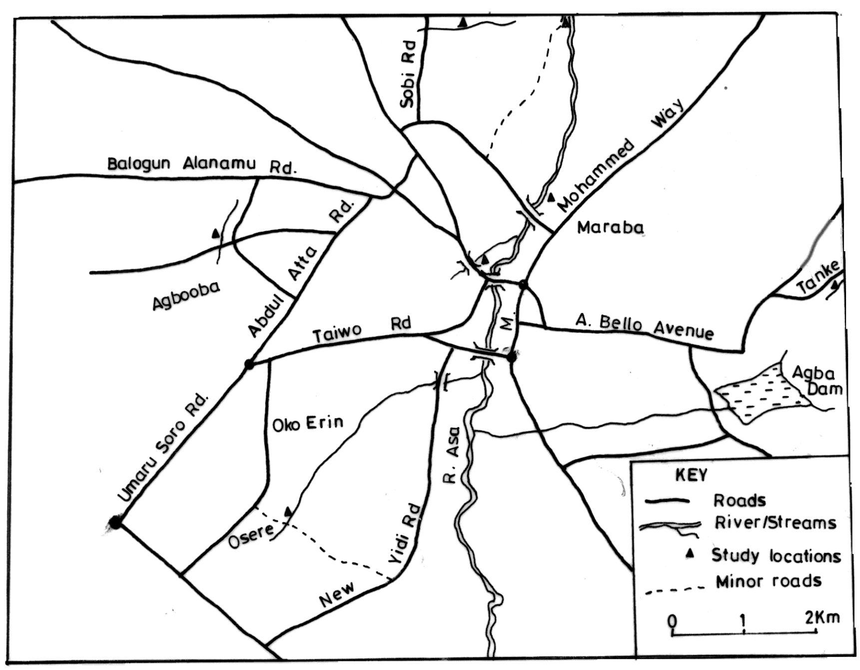


Figure 1. Ilorin Township showing study locations.

About 1 g of each of the powdered samples was digested using a combination of perchloric acid (2 cm$^3$), nitric acid (10 cm$^3$) and sulfuric acid (2 cm$^3$) [14]. The digested samples were then filtered (Whatman No. 42) and washed with distilled water into a 50 cm$^3$ volumetric flask. The filtrate was made to the mark. All samples were then kept in the refrigerator pending analysis.

Double-distilled water and analytical grade reagent were used throughout for all preparations. Stock solutions of Zn, Mn, Cd, Pb and Fe were prepared from either their soluble salts or their metals. Appropriate standards for calibrations were prepared by dilution of stock solutions. A Pye-Unicam SP9 series, atomic absorption spectrophotometer was used for metal concentration determination. All the results of vegetable analysis were reported in mg/kg of dry vegetable, while those of water reported in mg/L. All the analyses were carried out in triplicate. Standard deviation was calculated for each series in order to evaluate the precision of the analysis. The statistical analysis was carried out using SAS statistical package.

## RESULTS AND DISCUSSION

The results of metal concentration during both the dry reason and wet seasons are summarized in Tables 1 and 2, respectively. In *Amaranthus hybridus*, the concentration of nickel ranged from 0.44 to 1.40 mg/kg for dry season and 0.08 to 0.37 mg/kg for wet season. The concentration of manganese ranged from 0.77 to 3.27 mg/kg for dry season and 0.72 to 2.60 mg/kg for wet season. The concentration of zinc ranged from 0.42 to 1.06 mg/kg for dry season and 0.41 to 1.09 mg/kg for wet season, while the concentration of cadmium ranged from 0.64 to 1.13 mg/kg for dry season but it was not detected at all in wet season samples. The concentration of iron ranged from 6.72 to 37.45 mg/kg for dry season and 12.79 to 42.98 mg/kg for wet season. The concentration of lead ranged from 0.11 to 0.33 mg/kg for dry season and ranged from 0.02 to 0.60 mg/kg for wet season.

In *Corchorus olitorius manni*, the concentration of nickel ranged from 0.15 to 3.20 mg/kg for dry season and 0.08 to 0.30 mg/kg for wet season. The concentration of manganese ranged from 0.77 to 9.54 mg/kg for dry season and 1.33 to 2.35 mg/kg for wet season, the concentration of zinc ranged from 0.41 to 0.74 mg/kg for dry season and 0.30 to 0.62 mg/kg for wet season, the concentration of cadmium ranged from 0.70 to 1.20 mg/kg for dry season but it was not detected in wet season samples. The concentration of iron ranged from 8.24 to 64.51 mg/kg for dry season and 13.56 to 29.09 mg/kg for wet season, the concentration of lead ranged from 0.18 to 0.32 mg/kg for dry season and 0.21 to 0.60 mg/kg for wet season.

Table 1. Vegetable mean metal concentration (mg/kg of dry vegetable) at all the locations during dry season.

| *Amaranthu hybridus* | Ni | Mn | Zn | Cd | Fe | Pb |
|---|---|---|---|---|---|---|
| Tanke | 0.59±0.02 | 3.27±0.43 | 0.86±0.12 | 0.99±0.06 | 27.18±0.12 | 0.20±0.02 |
| Gada | 1.40±0.01 | 0.92±0.01 | 0.69±0.01 | 1.13±0.32 | 37.45±0.19 | 0.11±0.01 |
| Osere | 0.89±0.02 | 1.12±0.01 | 0.51±0.03 | 0.64±0.08 | 18.87±0.04 | 0.33±0.04 |
| Sobi | 0.59±0.02 | 0.77±0.08 | 0.42±0.07 | 0.84±0.03 | 6.72±0.07 | 0.29±0.03 |
| Kuntu | 0.59±0.04 | 2.86±0.14 | 0.96±0.14 | 0.92±0.10 | 30.02±0.19 | 0.22±0.01 |
| Amilegbe | 0.44±0.02 | 0.87±0.07 | 1.06±0.31 | 0.92±0.21 | 11.66±0.03 | 0.19±0.01 |
| Ojagboro | 0.74±0.07 | 0.82±0.09 | 0.79±0.18 | 0.92±0.07 | 17.93±0.29 | 0.31±0.11 |
| *Corchorus olitorius mannii* | Ni | Mn | Zn | Cd | Fe | Pb |
| Tanke | 0.15±0.01 | 1.43±0.01 | 0.50±0.02 | 1.20±0.10 | 27.55±0.16 | 0.05±0.01 |
| Gada | 3.23±0.45 | 1.43±0.33 | 0.59±0.06 | 0.70±0.08 | 64.51±0.31 | 0.07±0.02 |
| Osere | 0.45±0.02 | 9.54±0.21 | 0.41±0.06 | 0.99±0.06 | 12.29±0.06 | 0.18±0.05 |
| Sobi | -- | -- | -- | -- | -- | -- |
| Kuntu | 1.40±0.07 | 1.27±0.07 | 0.59±0.01 | 1.06±0.07 | 23.38±0.15 | 0.09±0.07 |
| Amilegbe | 0.15±0.01 | 0.77±0.05 | 0.74±0.01 | 0.84±0.12 | 8.24±0.03 | 0.32±0.01 |
| Ojagboro | -- | -- | -- | -- | -- | -- |

Table 2. Vegetables mean metal concentration (mg/kg of dry vegetable) at all the locations during rainy season.

| *Amaranthu hybridus* | Ni | Mn | Zn | Cd | Fe | Pb |
|---|---|---|---|---|---|---|
| Tanke | 0.08±0.01 | 2.60±0.07 | 0.55±0.04 | < LOD | 42.98±0.11 | 0.02±0.01 |
| Gada | 0.30±0.03 | 0.72±0.02 | 0.51±0.01 | < LOD | 25.22±0.03 | 0.20±0.02 |
| Osere | 0.30±0.02 | 0.97±0.07 | 0.73±0.02 | < LOD | 19.96±0.10 | 0.06±0.01 |
| Sobi | 0.30±0.02 | 1.33±0.08 | 0.41±0.01 | < LOD | 12.99±0.06 | 0.19±0.06 |
| Kuntu | 0.37±0.05 | 0.77±0.02 | 0.64±0.07 | < LOD | 19.15±0.06 | 0.27±0.05 |
| Amilegbe | 0.23±0.01 | 2.20±0.22 | 1.09±0.10 | < LOD | 26.07±0.02 | 0.18±0.01 |
| Ojagboro | 0.305±0.02 | 1.99±0.21 | 1.09±0.02 | < LOD | 12.79±0.11 | 0.60±0.01 |
| *Corchoru olitorius mannii* | Ni | Mn | Zn | Cd | Fe | Pb |
| Tanke | 0.08±0.01 | 1.68±0.07 | 0.35±0.09 | < LOD | 15.73±0.04 | 0.50±0.01 |
| Gada | 0.30±0.01 | 1.33±0.05 | 0.45±0.07 | < LOD | 13.70±0.02 | 0.60±0.05 |
| Osere | 0.15±0.00 | 1.37±0.64 | 0.31±0.03 | < LOD | 13.56±0.13 | 0.22±0.01 |
| Sobi | 0.30±0.02 | 2.35±0.83 | 0.62±0.03 | < LOD | 29.09±0.32 | 0.30±0.05 |
| Kuntu | 0.30±0.02 | 1.38±0.071 | 0.30±0.09 | < LOD | 18.72±0.140 | 0.21±0.03 |
| Amilegbe | -- | -- | -- | -- | -- | -- |
| Ojagboro | -- | -- | -- | -- | -- | -- |

< LOD = below limit of detection.

It appears that the dry season vegetables contain far higher mean concentration of metals than those produced during wet season. This could be due partly to the use of low quality irrigation water during the dry season and also to the physiological absorption of metals from the soil. Kilicel [15] has reported that the rates of deposition of suspended particles are generally higher during the dry season. There was however no significant difference between the levels of metals in each vegetable species at the two seasons at 95% probability level.

The two vegetables contain very high concentration of iron; this is not surprising because Ilorin soil and its environs have been found to contain high concentrations of iron [16]. Cadmium was not detected in the vegetables produced during wet season, while the concentration recorded for the dry season is within tolerate level of human beings. All the other metals concentrations are below the permissible limit set by some western countries and the World Health Organization [13]. Different plant species have different absorption capacity for metals from the soil [17]. It appears that *Amaranthus hybridus* has higher accumulation capacity for metals than *Corchorus olitorius manni*, hence the higher metal concentrations recorded for *Amaranthus hybridus* than *Corchorus olitorius mannii*.

The metals concentrations of irrigation waters being used during the dry season are summarised in Table 3. The results of heavy metal content of rain water are also included. Nickel concentration ranged from 0.19 mg/L at Tanke to 10.98 mg/L at Osere, manganese was not detected at Tanke and Gada but has the highest concentration of 1.02 mg/L at Osere. Zinc concentration was below level of detection at Tanke, Gada, Kuntu and Ojagboro but the highest value of 0.39 mg/L was recorded at Sobi. Cadmium ranged from 0.10 mg/L at Tanke to 3.48 mg/L at Osere. Iron and lead were not determined. The concentration of various metals determined in rain water are nickel (0.34 mg/L), manganese (0.07 mg/L), zinc (0.02 mg/L) and cadmium (0.11 mg/L). The results in Table 3 showed that Tanke irrigation water has the lowest level of heavy metals, while Osere irrigation water is therefore the most polluted. Tanke irrigation water is the only irrigation water that can be compared with the rain water. All the other locations use irrigation waters that are of very low quality.

Table 3. Mean metal concentration (mg/L) of the irrigation waters at all the locations and the rain water.

| Dry season | Ni | Mn | Zn | Cd |
|---|---|---|---|---|
| Tanke | 0.19±0.01 | < LOD | < LOD | 0.10±0.01 |
| Gada | 6.23± 0.02 | < LOD | < LOD | 0.34±0.08 |
| Osere | 10.98±0.16 | 1.02±0.06 | 0.16±0.01 | 3.48±0.02 |
| Sobi | 0.12±0.01 | 0.13±0.02 | 0.39±0.04 | 0.11±0.01 |
| Kuntu | 5.86±0.12 | 0.90±0.05 | < LOD | 2.17±0.02 |
| Amilegbe | 6.78±0.14 | 0.77±0.11 | 0.08±0.01 | 2.37±0.04 |
| Ojagboro | 2.78±0.53 | 0.38±0.05 | < LOD | 1.23±0.02 |
| Rain water | 0.34±0.08 | 0.07±0.02 | 0.02±0.01 | 0.11±0.03 |

< LOD = below limit of detection.

The low quality of irrigation waters at Osere, Amilegbe and Gada could possibly explain the high metals concentration, especially nickel recorded for vegetables in these areas. For example *Amaranthus hybridus* and *Corchorus olitorious mannii* for Gada vegetable garden contain 1.40 and 3.23 mg/kg of nickel, respectively. While Tanke garden recorded low nickel concentration, *i.e. Corchorus olitorious mannii* (0.15 mg/kg) and *Amaranthus hybridus* (0.59 mg/kg).

Vegetables that are produced in gardens that are located close to well travelled roads or high ways are found to contain high concentrations of lead and iron. For example, vegetables from Tanke, Gada and Kuntu gardens contain relatively higher iron, lead and cadmium levels. While gardens that are located in the suburb and away from well traveled roads like Sobi and Amilegbe produced vegetables that contain low concentration of iron and vehicular related metals [18].

There is however an explanation found at Osere garden which is located at the suburb but vegetables from this garden still contain high concentration of all metals. The reason is that the garden is located within the most important industrial layout at the lower end of Asa river in Ilorin.

The dry season irrigation water for Sobi garden is a long standing deep well which is protected from human contaminating activities. This is reflected in the low metal concentrations found in the vegetables from that garden. Agirtas *et al.* [19], found that plants that grow close to refuse dump pick up high quantity of metals. Vegetable species from Gada gardens both during dry and raining seasons has the highest metal concentrations of 64.51 and 37.45 mg/kg for iron for *Corchorus olitorious mannii* and *Amaranthus hybridus*, respectively, for dry season and 25.22 and 13.70 mg/kg for the same metal and vegetables during raining season. Also 1.40 mg/kg of nickel in *Amaranthus hybridus* and 3.23 mg/kg in *Corchorus olitorius mannii* during dry season. Gada vegetable garden is located in position that makes way for all the wastes carried by as a river to be deposited on the garden, also an old refuse dump which still serve the densely populated Gada area is located very close to this garden.

Statistical analysis showed that there was significant difference in the mean metals concentrations in the vegetables at 95% probability level. For instance, iron has a mean value of 21.55 mg/kg which was different from the mean of the rest of the metals, *i.e*. Mn is 1.81, Zn is 0.63, Ni is 0.58, Cd is 0.44 and Pb 0.24 mg/kg. There was no significant difference in the different locations of the vegetable at gardens at P value of 0.8595 and $\propto$ of 0.05, *i.e.* the garden location have no influence on the metal concentrations detected in the vegetables.

The results from the present investigations are in agreement with results from a similar study carried out by workers at Institute of Agricultural Research and Training in Ibadan, Nigeria. Their research findings revealed that all the 17 valley bottom sites used for dry season vegetable cultivation in Ibadan contain high and alarming concentrations of heavy metals such as lead, zinc, cadmium, and cobalt [20].

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