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# Effects of Piggery and Poultry Bioslurry on the Safe Consumption of *Amaranthus hybridus* and *Corchorus olitorius*

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## Abstract

Several health and environmental hazards had been associated with the use of synthetic fertilizers. It is, therefore, appropriate to look into possible alternatives which can assure safety. Hence this study aims to investigate and compare the effect of bioslurry on the heavy metals and anion contents of vegetables planted on bioslurries amended soils, inorganic fertilizers amended soils and soil with no amendments. Two vegetables *Amaranthus hybridus* (A) and *Corchorus olitorius* (C) as well as five treatments; piggery bio-slurry (V), poultry bio-slurry (W), piggery+poultry bio-slurry (X), inorganic fertilizer (Y) and the control (Z) were employed in the experiments. Nine samples of each vegetable type were harvested from each of the treatments for heavy metals and anion contents analysis from the plant leaves based on IITA (2001) standards. The highest $Ca^{2+}$, $Mg^{2+}$, K+, $Mn^{2+}$, $Fe^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $NO^{3-}$, and $PO_4^{3-}$ contents of the plant type A are 551, 363, 1820, 4.11, 49.50, 0.92, 4.62, 28.40 and 16.30 mg/kg for treatments X, X, V, W, W, W, X, X and V respectively. The highest $Ca^{2+}$, $Mg^{2+}$, K+, $Mn^{2+}$, $Fe^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Pb^{2+}$, $NO^{3-}$, and $PO_4^{3-}$ contents for the plant type C is 233, 162, 1170, 5.20, 39.1, 2.53, 4.00, 15.30 and 7.18 mg/kg for the treatments X, X, Z, Z, Z, Z, Z, W and W respectively. The heavy metal and anion contents of both plant types are below recommended adequate daily intake (ADI) for all the treatments with the exception of $Fe^{2+}$ in the plant type A for the treatment W and $Pb^{2+}$ in the plant type C for the treatments Y and Z. Generally, the vegetables planted with bio-slurry are safe for consumption.

**Keywords:** Bio slurries; Vegetables; *Corchorous olitorius*; *Amanranthus hybridus*

## Introduction

Bio-slurries are the less toxic waste left behind after the production of biogas from anaerobic digestion of fresh biodegradable wastes.

Bio-slurries are rich in nutrients which are needed for plant growth. They can, therefore, be used to support plant growth. Bio-slurry sometimes referred to as the digest ate is an anaerobic digested organic material left behind as a by-product after biogas production in digesters [1]. It contains majorly organic materials from cow dung, poultry litter and other easily decomposable materials such as kitchen refuses, farm wastes, water hyacinth, and crop residues [1,2]. About 25% to 30% of organic matter in the undigested slurry is converted into biogas during the anaerobic fermentation process, while the rest can be used as manure (bio-slurry) [2,3].

The ratio of Nitrogen, Phosphorus and Potassium content of slurry on a wet basis are reported as 0.25, 0.13 and 0.12 and 3.6, 1.8 and 3.6 respectively on a dry basis [4]. Elements such as nitrogen, phosphorus, and potassium as well as zinc, iron, manganese, and copper can also be found in bioslurries [2]. The organic nitrogen in the digested slurry is mainly amino acids [5]. They also contain minerals in abundance, and low molecular weight bioactive substances (hormones such as humic acids and vitamins, so they could be used as organic fertilizer in seedlings [5].

Monnet [6] explained that mineralized nutrients are made readily more available in bio slurries for plant uptake because anaerobic digestion draws carbon, hydrogen, and oxygen from the feedstock and thus mineralizes nutrients which are more available for plant uptake than when the undigested manure is used for soil amendment. Bio-slurry can, therefore, be used in place of chemical fertilizers to build healthy and fertile soil for crop Production [2,7]. Properly prepared and applied bio-slurry can improve the physical, chemical and biological properties of the soils [1]. Bio-slurry could have liming effects on soils and this can be harnessed to reduce the harmful effects of aluminum in acid soils [1]. Bio-slurry, when used as organic fertilizer, could prevent adverse and unfriendly environmental impacts of waste disposal [5].

Seeds treated with bio-slurry in the past had reported better germination rates and the crops which respond best to bio-slurry and bio-slurry compost are vegetables, root crops, potatoes, fruit trees, maize, and rice [2]. Bio-slurry can increase cereal crop productions by 10% to 30% compared to ordinary manure [2,8]. The nutrients from the organic sources are more efficient than those from chemical origins adding that bio-slurries are 100% organic fertilizers which are most suitable for organic farming of some high-value vegetables and ornamental crops [2]. The application of digested bio-slurry could rapidly increase the crop yield and quality of vegetables [5].

Bio-slurry could drastically reduce the dependence on mineral fertilizers as it serves as a serious alternative since vegetables grown with bio-slurry are reported to have better quality yield than those produced with chemical fertilizers [9,10].

However, despite the highlighted several advantages and benefits of bio-slurry; soil amended with bio-slurry is prone to high ammonia concentration in the soil as a result of high pH value of bio-slurry compared to undigested waste.

This may lead to environmental pollution such as acidification and eutrophication in the soil [2,11]. It is therefore important to investigate

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the safety of vegetables planted on bio-slurry amended soils for human consumption. Heavy metals and anion contents of such vegetables were therefore compared with WHO/FAO established (Adequate Daily Intake (ADI)) standards for respective metals.

## Materials and Methods

Freshly voided poultry and piggery solid wastes (in pasty or slurry states) which had undergone little or no deterioration was collected from the University of Ibadan teaching and research farm. The wastes were thereafter loaded into the bio-digesters for anaerobic digestion.

### Laboratory analysis of vegetables

The chemical analysis of the plants were carried after three (3) stands of vegetables were harvested at random from each of the six (6) plots which made up a treatment in replicates; that is nine (9) samples of each vegetable type were collected per treatment in order to make basic comparison between the nutritional values and safe consumption margin of the vegetables produced from each of the treatments. Basic essential components which include Nitrate, Phosphate, Potassium, Calcium, Magnesium, Iron, Lead, zinc, Manganese and Copper were investigated from the edible vegetable leaves according to IITA [12] procedures for the chemical analysis of the vegetables and the soil samples.

## Results and Discussions

### Nutrient uptake by plant A and C (*Amarantus hybridus* and *Corchorus olitorious*)

The Tables 1 and 2 show the results of the soil and bio-slurry analysis. The Tables 3 and 4 show the results of the chemical analysis of each of the plant types from the experimental plots of each treatment V, W, X, Y, and Z respectively. The Tables further show the calcium, magnesium, potassium, manganese, iron, copper, zinc, lead, nitrate and phosphate contents of both plant types A and C. The Figures 1 and 2 explains the comparison between the values of heavy metals and anion contents in each of the plant types based on the applied treatments.

Calcium is an important essential constituent of food meant for human consumption. Calcium helps to build strong bone, teeth, and skeletal system. Calcium is an essential component of the human skeletal system; it helps in skeletal rigidity and integrity. European Food Safety Authority [13] reported that an excessive accumulation of calcium in blood or tissue caused by excessive calcium consumption should not occur in the absence of diseases such as bone cancer, hyperthyroidism, and hyperparathyroidism or in the absence of excessive vitamin D intake.

Adverse effects which have been reported due to high calcium intakes include the so-called milk-alkali syndrome, the formation of kidney stones in persons with a propensity for nephrolithiasis, hypercalciuria and for hyperabsorption of calcium, and interference with the absorption of other minerals [13].

The plant type A (Table 3) from the treatment X has the highest calcium content of 551 mg/kg. This also applies for the plant type C (Table 4) with X having the highest calcium content of 233 mg/kg. These might be due to the high calcium content of the poultry and piggery bio-slurry (this could be as a result of high calcium content in the feed intake of the animals) which were combined in the treatment X. The lowest calcium content for the plant type A and C are 266 mg/

| Parameters | | V | | | W | | | X | | | Y | | | Z | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ẋ | R | SD | ẋ | R | SD | ẋ | R | SD | ẋ | R | SD | ẋ | R | SD |
| pH | 6.38 | 0.03 | 0.01 | 6.39 | 0.06 | 0.03 | 6.34 | 0.04 | 0.02 | 6.29 | 0.15 | 0.075 | 6.42 | 0.11 | 0.055 |
| OM (mg/l) | 9.51 | 4.79 | 2.40 | 8.91 | 3.59 | 1.80 | 10.16 | 6.09 | 3.05 | 6.60 | 1.02 | 0.51 | 7.27 | 0.31 | 0.03 |
| OC mg/l | 5.50 | 2.77 | 1.38 | 5.15 | 2.07 | 1.04 | 6.13 | 3.52 | 1.50 | 2.54 | 0.59 | 1.56 | 4.15 | 0.08 | 0.04 |
| $K^+$ (mg/l) | 77.35 | 123.3 | 61.65 | 85.85 | 140.3 | 70.15 | 141.3 | 87.35 | 15.70 | 29.65 | 27.9 | 13.95 | 96.85 | 162.3 | 81.15 |
| $PO_4^{3-}$ (mg/l) | 66.90 | 110.2 | 55.10 | 95.90 | 36.20 | 18.10 | 114.3 | 73.2 | 36.6 | 69.4 | 16.4 | 8.20 | 83.5 | 11.4 | 5.70 |
| $Mg^{2+}$ (mg/l) | 15.90 | 7.00 | 3.60 | 14.40 | 3.90 | 1.95 | 12.95 | 1.10 | 0.55 | 13.35 | 1.90 | 0.05 | 14.85 | 4.90 | 2.45 |
| $Ca^{2+}$ (mg/l) | 26.00 | 15.30 | 7.70 | 23.35 | 10.10 | 5.05 | 31.30 | 26.00 | 13.00 | 19.65 | 2.70 | 1.35 | 26.4 | 16.20 | 8.10 |
| $NO_3^-$ (mg/l) | 175.2 | 183.4 | 91.80 | 159.7 | 152.6 | 75.30 | 188.7 | 210.6 | 105.3 | 87.30 | 7.80 | 3.90 | 108.7 | 50.6 | 25.3 |
| Sand (%) | 66.70 | 5.00 | 2.50 | 67.90 | 7.40 | 3.70 | 67.90 | 7.40 | 3.70 | 68.30 | 8.20 | 4.10 | 65.90 | 3.40 | 1.30 |
| Silt (%) | 19.90 | 2.60 | 1.30 | 19.05 | 4.30 | 2.15 | 19.40 | 4.00 | 2.00 | 19.35 | 3.70 | 1.85 | 19.05 | 4.30 | 2.15 |
| Clay (%) | 13.40 | 2.40 | 7/80 | 13.05 | 3.10 | 1.55 | 12.90 | 3.40 | 1.70 | 12.35 | 4.50 | 2.25 | 15.05 | 0.90 | 0.45 |
| OM: Organic Matter; OC: Organic Carbon; ẋ: Mean; R: Range; SD: Standard deviation | | | | | | | | | | | | | | | |

**Table 1:** Statistical comparison of soil samples before and after soil amendment and planting.

| Parameters | Mean | Poultry Range | SD | Mean | Piggery Range | SD |
|---|---|---|---|---|---|---|
| pH | 5.99 | 0.88 | 0.44 | 6.19 | 0.08 | 0.04 |
| Carbon: Nitrogen | 14.91 | 8.14 | 4.07 | 10.90 | 2.81 | 8.08 |
| Organic Carbon (mg/l) | 7.78 | 1.90 | 0.95 | 8.82 | 3.77 | 1.88 |
| Total Nitrogen (mg/l) | 0.55 | 0.17 | 0.09 | 1.60 | 0.17 | 0.73 |
| $K^+$ (mg/l) | 0.91 | 0.55 | 0.02 | 0.67 | 0.20 | 0.10 |
| $PO_4^{3-}$ (mg/l) | 0.40 | 0.51 | 0.23 | 0.46 | 0.22 | 0.11 |
| $Mg^{2+}$ (mg/l) | 0.14 | 0.15 | 0.07 | 0.09 | 0.16 | 0.09 |
| $Ca^{2+}$ (mg/l) | 0.78 | 1.55 | 0.77 | 0.66 | 1.31 | 1.98 |
| $NO_3^-$ (mg/l | 4.20 | 4.20 | 0.00 | 7.94 | 7.94 | 0.00 |
| Organic Matter (mg/l) | 13.42 | 3.30 | 1.65 | 15.25 | 6.50 | 3.25 |
| BOD (mg/l) | 790.00 | 357.00 | 178.00 | 1124.50 | 495.0 | 247.5 |
| Conductivity | 353.00 | 270.00 | 135.00 | 369.50 | 191.00 | 95.50 |

**Table 2:** Statistical comparison of chemical analysis of undigested and digested wastes.

| Treatments | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+}$ | $Mn^{2+}$ | $Fe^{2+}$ | $Cu^{2+}$ | $Zn^{2+}$ | $Pb^{2+}$ | $NO^{3-}$ | $PO_4^{3-}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| V | 395 | 306 | 1820 | 2.21 | 11.30 | 0.54 | 2.73 | - | 22.10 | 15.40 |
| W | 234 | 156 | 1077 | 4.11 | 49.50 | 0.92 | 2.84 | - | 25.40 | 16.30 |
| X | 551 | 363 | 1201 | 3.22 | 10.20 | 0.54 | 4.62 | - | 28.40 | 11.80 |
| Y | 333 | 296 | 1430 | 3.12 | 7.44 | 0.42 | 3.42 | - | 10.30 | 7.49 |
| Z | 266 | 206 | 1060 | 1.21 | 8.22 | 0.43 | 1.84 | - | 15.40 | 8.1 |
| ADI | 1300[a] | 350[a] | 3510[b] | 10.00[c] | 30.00[c] | 3.00[c] | 25.0[c] | 0.30[d] | 222[e] | 900[e] |

α: WHO/FAO (2001); b: WHO (2012); c: EFSA (2006); d: FAO/ WHO (2011); e: Muramoto (1999); ADI: Acceptable Daily Intake (mg/day)

**Table 3:** Heavy metals and anion contents of leaves of plant type A (*Amarantus hybridus*).

| Treatments | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+}$ | $Mn^{2+}$ | $Fe^{2+}$ | $Cu^{2+}$ | $Zn^{2+}$ | $Pb^{2+}$ | $NO^{3-}$ | $PO_4^{3-}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| V | 159 | 95.60 | 598 | 3.20 | 8.23 | 0.14 | 0.92 | - | 13.9 | 5.49 |
| W | 171 | 106 | 625 | 1.42 | 6.14 | 0.13 | 0.76 | - | 15.30 | 7.18 |
| X | 233 | 162 | 428 | 1.55 | 7.42 | - | 0.44 | - | 10.70 | 6.18 |
| Y | 179 | 86.30 | 884 | 1.26 | 35.40 | 0.53 | 1.87 | 3.11 | 8.22 | 3.19 |
| Z | 73.7 | 136 | 1170 | 5.20 | 39.10 | 0.92 | 2.53 | 4.00 | 14.80 | 4.77 |
| ADI | 1300[a] | 350[a] | 3510[b] | 10.00[c] | 30.00[c] | 3.00[c] | 25.0[c] | 0.30[d] | 222[e] | 900[e] |

Concentrations in mg/kg
a: WHO/ FAO (2001); b: WHO (2012); c:EFSA (2006); d: FAO/ WHO (2011); e:Muramoto (1999); ADI: Acceptable Daily Intake (mg/day)

**Table 4:** Heavy metals and anion contents of leaves of plant type C (*Corchorus olitorious*).

kg and 73.7 mg/kg respectively from the treatment Z. This is evidently due to the low calcium content of the soil and little or no calcium content of inorganic fertilizers as shown from the results of the soil analysis. The calcium content of the plant type A can be arranged in the following increasing order W<Z<Y<V<X and that of the plant type in the decreasing order X>Y>W>V>Z. The calcium content of each of the plants type A and C from the five treatments are lower than the WHO/ FAO [14] recommended intake limit for adults and adolescents given as 1300 mg/day.

Magnesium in the body help in calcium metabolism in the bone and about 50% to 60% of the body magnesium is found in the bone [14]. Magnesium is said to be the fourth most abundant action in the body and the second most abundant cation in intracellular fluid [15].

Low magnesium levels are associated with endothelial dysfunction, increased vascular reactions, elevated circulating levels of C-reactive protein (a pro-inflammatory marker that is a risk factor for coronary heart disease), decreased insulin sensitivity, hypertension, type 2 diabetes mellitus and metabolic syndrome [15].

The plant type A (Table 3) from the treatment X had the highest magnesium content of 363 mg/kg and the lowest magnesium content of 156 mg/kg for the treatment W. The plant type C (Table 4) on the other hand had the highest magnesium content of 162 mg/kg from the same treatment X, but the lowest magnesium level of 86.3 mg/kg was found in the treatment Y. The magnesium levels in each of the treatments and each of the plant types A and C are lower than the upper limit intake recommended per day by WHO/FAO [14] as 350 mg/day.

The magnesium content of the plant type C can be arranged in the following decreasing order X>Z>W>V>Y and the magnesium content for the plant type A in the following increasing order W<Z<Y<V<X.

EFSA [13] reported the following fact on the levels, usefulness and excessive intake of potassium in the body system: "Potassium is essentially involved in fluid, acid and electrolyte balance and is required for normal cellular function. Potassium deficient diet is so uncommon since potassium occurrence in foods is not unpopular.

Major Evidence suggests that potassium helps in blood pressure modulation and a dietary increase of potassium intake associated with lower blood pressure. Potassium also takes part in acid-base balance in the body system. Potassium is the main intracellular cations and they are mainly found in cells. The major sites of potassium in the body are found in the muscles and the skeleton as well as in the blood, central nervous system, intestine, liver, lung, and skin."

The potassium levels of the vegetable types planted on each of the treatments have values ranging from 428 mg/kg to 1820 mg/kg. The vegetable type A on the treatment V had 1820 mg/kg potassium level and 1060 mg/kg potassium level for the treatment Z and these are respectively the highest and the lowest potassium levels for the plant type A (Table 3). The plant type C (Table 4) on the other hand had lower potassium level than plant type A. The treatment Z had the highest potassium level of 1170 mg/kg and X had the lowest potassium level of 428 mg/kg. This potassium levels for all the treatments are lower than the WHO recommendation of 3510 mg/day. The potassium level of the plant type A has the following increasing order based on the treatments Z<W<X<Y<V. The potassium level of the plant type C followed the decreasing order Z>Y>W>V>X.

The European Food and Safety Authority [13] reported that manganese deficient animals are prone to adverse effects such as impaired growth, skeletal abnormalities, reproductive deficits, ataxia of the newborn as well as defective lipids and carbon hydrate metabolism. The acceptable estimated safe and adequate dietary intake of 1 mg/day-10 mg/day manganese was estimated by the scientific committee for food in the European Union.

The manganese level of the vegetable planted for this experiment ranged from 1.21 mg/kg to 5.20 mg/kg for the same treatment Z, but different plant types A and C. The manganese level for the plant type A ranged from 1.21 mg/kg to 4.11 mg/kg from the respective treatments Z and W. The plant type C on the other hand had manganese level which ranged from 1.26 mg/kg to 5.20 mg/kg for the respective treatments Y and Z. The manganese content for the plant type A increased in the following order Z<V<Y<X<W, while the plant type C has its manganese content also increased in the following order Y<W<X<V<Z. Iron should be one of the most essential components of food meant for human consumption.

Iron is an essential constituent of oxygen carriers, such as

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hemoglobin and myoglobin, and the iron contained within haem is essential for the redox reactions of numerous cytochromes [13].

One of the most important effects of iron deficiency is impaired physical performance due to reduced levels of hemoglobin and myoglobin and lower activity of iron-dependent cytochromes, leading to reduced cellular concentrations of ATP [13].

The plant type A had relatively high iron content which ranged from 7.44 mg/kg to 49.5 mg/kg while the plant type C had its iron content ranging from 6.14 mg/kg to 39.1 mg/kg. The plant type A from the treatment W had the highest iron content of 49.5 mg/kg while the treatment Y had the lowest iron content of 7.44 mg/kg (Table 3). On the contrary, the treatment Z had the highest iron content (39.1 mg/kg) for the plant type C while the treatment W had the lowest iron content of 6.14 mg/kg for the plant type C (Table 4). The iron contents of the plant type A did not exceed the recommended upper limit of 30 mg/day given by the European Food and Safety Authority except for the treatment W which exceeded the recommended upper limit. The plant type C, on the other hand, had two (2) of its treatments (Y and Z) exceeding the prescribed upper limit. The iron content of the plant type A followed the increasing order Y<Z<X<V<W while the iron content of the plant type C followed the decreasing order Z>Y>V>X>W.

Copper is an essential substance to human life, but its excessive intake can cause anemia, acne, adrenal hyperactivity and insufficiency, allergies, hair loss, arthritis, autism, cancer, depression, elevated cholesterol, diabetes, dyslexia, failure to thrive, fatigue, fears, fractures of the bones, headaches, heart attacks, hyperactivity, hypertension, infections, inflammation, kidney and liver dysfunction, panic attacks, strokes, tooth decay and vitamin C and other vitamin deficiencies [16,17]. The planted vegetables for this experiment contained some levels of copper but are all less than the upper intake limit of copper given by EFSA [13] as 3.00 mg/day.

The copper content for the plant type A ranged from 0.42 mg/kg to 0.92 mg/kg while it ranges from 0.13 mg/kg to 0.92 mg/kg for the plant type C (Table 4). The treatment W yielded the highest copper content and treatment Y the lowest copper content for the plant type A (Table 3). The treatment Z, on the contrary, produced the highest copper content and W the lowest copper content for the plant type C. There was no trace of copper detected in the plant type C for the treatment X. The plant type A has its copper contents from each treatment following the decreasing order W>X=V>Z>Y while the copper content for the plant type C followed the increasing order W<V<Y<Z.

Zinc is essential for growth and development, testicular maturation, neurological function, wound healing and immunocompetence [13].

The WHO/FAO [14] reported the followings on Zinc stating that "The presence of zinc is in all body tissues and fluids and it is essential component of a large number (>300) of enzymes taking part in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients. Zinc also stabilizes the molecular structure of cellular components and membranes and thus contributes to the maintenance of cells and organs integrity.

Zinc is essential in polynucleotide transcription and thus in the process of genetic expression. Its role is central in the immune system because it affects a number of aspects of cellular and humoral immunity. Zinc deficiency in humans can result in growth retardation delayed sexual and bone maturation, skin lesions, diarrhea, alopecia, impaired appetite, increased susceptibility to infections caused by defects in the immune system, and the appearance of behavioral changes."

The vegetables planted for the purpose of this experiment had relatively low zinc content which ranges from 0.44 mg/kg to 4.62 mg/kg as compared to the recommended Acceptable Daily Intake (ADI) of 25 mg/day given by EFSA [13].

The plant type A had zinc content which ranged from 1.84 mg/kg (Z) to 4.62 mg/kg (X) (Table 3 and Figure 1), while the plant type C had zinc content which ranged from 0.44 mg/kg (X) to 2.53 mg/kg (Z) (Table 4 and Figure 2). The zinc content of the plant type A followed the increasing order Z<V<W<Y<X while the plant type C followed the decreasing order Z>Y>V>W>X.

The effect of lead accumulation in the body is poisonous and it can affect every organ and system of the human body. High lead exposure can cause severe damages to the brain, kidneys and eventually result in death [17]. Lokeshappa et al. [17] further stated that a long-term exposure to lead can decrease the performance of the nervous system, weaken the fingers, wrists, and ankles, cause a slight increase in blood pressure and anemia, abdominal pain, arthritis, backache, blindness, cancer, constipation, depression, diabetes, migraine, constipation, and tooth decay.

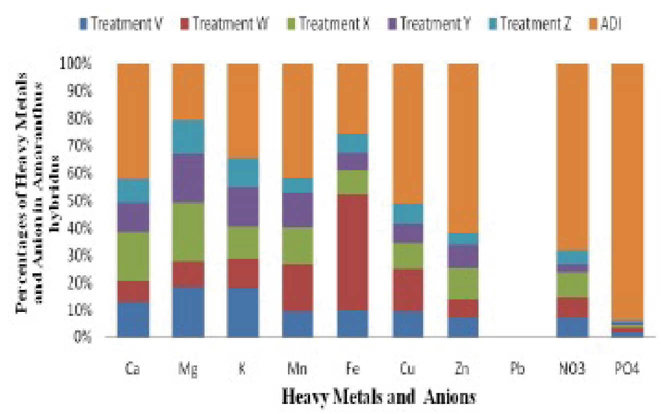


**Figure 1:** Comparison of heavy metal and anion (Contents of *Amaranthus hybridus*).

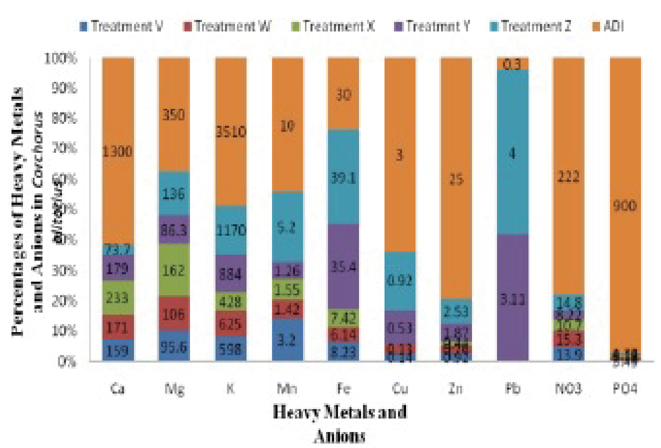


**Figure 2:** Comparison of heavy metals and anion (Contents of the plant type C (*Corchorus Olitorius*).

The lead was not detected in any of the vegetables planted for this experiment except for the plant type C where concentrations of 3.11 mg/kg and 4.00 mg/kg were detected from the respective treatments Y and Z. These exceeded the recommended acceptable daily intake given by FAO/WHO [15]. This might be due to the residual lead in the soil but obviously not as a result of the treatments applied to the soil. These results suggested the importance and possible use of bio-slurry for the treatment of lead-contaminated soils.

Nitrate is one of the simplest forms of nitrogen. Absorbed nitrates from the soil which can be converted them into more complex forms of nitrogen, such as proteins are made use of in plants [18].

Nitrate is described pose serious problem to human health and well-being [19]. Nitrate at a certain level in drinking water causes a severe health condition known as a blue baby syndrome (a blue skin condition) in infants. Nitrate occurs naturally in the nitrogen cycle and in the environment. Nitrate exists in foods such as vegetables and also occurs in drinking water. Brien and price [18] contributed the followings on the effect of Nitrite in vegetables: "Human infants and some animals have bacteria in their digestive systems which convert nitrates to nitrite.

Nitrites bind to the hemoglobin in blood, robbing it of the ability to carry oxygen. Nitrite poisoning may cause shortness of breath and reduced immunity to disease, and in extreme cases, may lead to death from suffocation. This is the cause of 'blue baby syndrome'. However, almost all the documented cases of nitrate poisoning resulted from high nitrate levels in drinking water. Livestock may frequently be poisoned by high nitrate levels in food, possibly due to the lack of variety in their diet. Nitrates also combine with some proteins to make nitrosamines, which may cause cancer. Vitamin C can, however, prevent the nitrosamines from forming."

The nitrate content of the vegetables used for this experiment is minimal as compared to the 222 mg/day ADI recommended by FAO (Table 3 and Figure1)/WHO [20-22]. The nitrate content of the vegetable type A ranged from 10.3 mg/kg to 28.4 mg/kg.

The nitrate content of the plant type C ranged from 8.22 mg/kg to 15.3 mg/kg (Table 4 and Figure 2). The control (Y) treatment recorded the lowest nitrate content for both plant types and this might actually be due to the absence of soil conditional or amendment which further contributed to the nitrate content of the soil which will invariably be transferred to the plant parts. The treatment X had the highest nitrate content for the plant type A, while the treatment W has the highest nitrate content for the plant type C. The treatment Z, however, had a nitrate content which is also relatively high for the plant type C (14.8 mg/kg). These slightly high nitrate contents must have resulted from the high nitrate content of the soil, bio-slurries, and fertilizer added to the soil. The nitrate content for the plant type A is in the following decreasing order X>W>V>Z>Y while the nitrate content of the plant type C is in the following decreasing order Y<X<V<Z<W.

Phosphates are major components of genes, cell structures, and cellular energy cycles, in the bones and in the teeth. Phosphate takes part in the photosynthetic actions of green plants. The bones and teeth in the human body are built of Calcium phosphate ($Ca_3(PO_4)_2$). In poultry, the DCP serves as calcium supplement which enhances a stronger eggshell and bones in the birds.

The phosphate content of the vegetable types used for this experiment is comparatively low based the ADI of 900 mg/day recommended by WHO/FAO [22]. The control treatment (Y) had the lowest phosphate content for both plant types.

The plant type A and C for the treatment Y had 7.49 mg/kg and 3.19 mg/kg phosphate content respectively.

The highest phosphate content for the plant type A was recorded by the treatment was 16.3 mg/kg and the plant type C also had the highest phosphate content of 7.18 mg/kg from the treatment W.

These trends which were noticed in the nitrates and phosphates content of the vegetable obviously resulted from the high nitrate contents of the amendments (bio-slurries and inorganic fertilizer) added to the soil.

The increasing order of the phosphate content for the plant type A can be shown as Y<Z<X<V<W (Table 3) while the decreasing order of the plant type C is shown as W>X>V>Z>Y (Table 4).

Generally, the heavy metal and anion contents of the plant type A are higher than those of the plant type C. It can thus be inferred that the vegetable type A (*Amanranthus hybridus*) has generally better nutrients than the vegetable type C (*Corchorus olitorious*). The mineral compositions of the plant type A were close to those reported in the work of Akubugwo et al. [20] while those of the plant type C were close to those reported by Ndlovu and Afolayan [23].

The chemical analysis of the plant type A revealed some differences between the bio-slurry treatments and the control treatment (Y) as shown in Table 3 and Figure 1. The treatment V had 15.7% higher calcium content than Y and X had 39.6% higher calcium content than Y. V and X had 3.2% and 18.5% higher magnesium content than Y. Only the potassium content of V is higher than Y by 21.4%. The manganese contents of W and X are higher than Y by 24.1% and 3.1% respectively. The iron content of V (34.2%), W (85.0%), X (27.1%) and Z (9.49%) as well as their respective copper content are higher than those of Y treatment by the percentages 22.2%, 54.3%, 22.2% and 2.33% respectively. Only the treatment X had higher zinc content than Y by 26.0%. The nitrate and phosphate content of the treatments V, W, X, and Z are also higher than those of Y by (53.4% and 51.4%), (59.4% and 54.0%), (63.7% and 36.5%) and (33.1% and 7.64%) respectively.

In comparison to the treatment Z, the plant type A had calcium and magnesium contents of V and X higher than those of Z by 32.7% Ca and 32.7% Mg as well as 51.7% Ca and 43.3% Mg respectively. The potassium, manganese, iron, copper, zinc, nitrate and phosphate content of bio-slurry treatments V, W and X are exceeded those of treatment Z by (41.76%, 45.25%, 27.3%. 20.0%, 32.6%, 30.3% and 47.3%), (1.58%, 70.6%, 83.4%, 53.2%, 35.2%, 39.4%, and 50.2%) and (11.4%, 62.45,19.4%, 20.0%, 62,2%, 45.8% and 31.3%) respectively.

Most of the metals in the control (Y) treatment for the plant type C exceeded those of the bio-slurries treatments (Table 4 and Figure 2), except the followings: The calcium content of the treatment X exceeded that of the treatment Y by 23.2%; the magnesium content of the V, W, X, and Z treatments exceeded the control treatment by 9.73%, 18.6%, 46.7%, and 36.5% respectively.

Only the potassium content of the treatment Z exceeded that of the control treatment Y by 24.4% while the manganese content of the V, W, X and Z treatment exceeded that of the control treatment by 60.6%, 11/3%, 18.7%, and 75.8% respectively.

The iron copper, zinc and lead contents of the treatment Z exceeded those of the treatment Y by 42.4%, 42.4%, 26.1%, and 22.5% respectively. The nitrate and phosphate contents of the plant type C for the treatments V, W, X and Z exceeded those of the treatment Y by (40.9% and 41.9%), (46.3% and 55.6%), (23.2% and 48.4%) and (44.5% and 33.1%) respectively.

The metals and anion contents from the bio-slurry treatments of the plant type C are lower when compared to those of the treatment Z but with some few exceptions. The calcium content of the bio-slurry treatment V, W, and X respectively exceeded that of the Z treatment by 53.6%, 56.9%, and 68.4%. The magnesium content of the X treatment exceeded that of the Z treatment by 16.0%. The nitrate content of treatment W exceeded that of Z by 3.3% and the phosphate contents of V, W and X exceeded that of Z by 13.2%, 33.6%, and 22.8%.

## Conclusion

These experiments conducted in 2015, showed *Amaranthus hybridus* (A) and *Corchorus olitorius* on bio-slurry amended soil are safer for human consumption as compared to those grown on inorganic fertilizers amended soil; since the tested heavy metals and anions contents of the vegetables are largely below the safe consumption limits (Acceptable Daily Intake) specified by established standards. The expressed sanitary concerns and side effects of growing vegetables on bio-slurry amended soil had therefore been addressed. This further justifies bioslurries and a cheap, healthy and environmentally friendly source of soil amendments for increased vegetable production and growth which are safe for human consumption.

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