

Research Article

# Soil Enzyme Responses and Crop Productivity Indices Assessment in Agricultural Soil Impacted with Heavy Metals

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## Abstract

The present study assessed the productivity of cultivated garden vegetable among other ecological assessments in soil samples impacted with heavy metals. Assay of soil enzyme responses showed the activity of: catalase, peroxidase, lipase and urease with corresponding OD reading of 0.750, 2.05, 0.22 and 1.704 respectively. There were noticeable increases in the activity of urease and peroxidase while catalase and lipase activity were relatively low in the sampled soil. Out of the 321g of the vegetable seed tested for viability, 45% representing 144.45g was used for the planting and further experiment. After three days of cultivation, germination process was recorded faster in the *T. oleifera* potted ridge while *Amaranthus* and *Solanum* sp seed took 3-4 day for break full dormancy. Determination of total chlorophyll a and b in the selected vegetables showed a correlative increase in chlorophyll a and b in soils contaminated with Zn, Cu and Fe in all the cultivated vegetables: *T. oleifera*, *Amaranthus* and *Solanum* sp, respectively. There are significant increase in total chlorophyll a (0.9mg/g) and b (0.8mg/g) contents from the results when compared with the control experiment as other soil contaminated with heavy metals such as: Pb, and As repressed the selected vegetables cultivated in the soil samples. However total chlorophyll a was seems lightly higher than chlorophyll b in all the selected vegetable cultivated in soil. Analysis on the impact of heavy metals on the shootlength of the cultivated vegetables analysed for thirty-one days showed regressive increase in the shootlength of the cultivated vegetables as the period of harvest increases from 0-31 when compared with the control experiment. However Cd and As had the most estimated impact on the vegetables in all the cultivated soils and its impact progresses as the period of harvest increases. Dry matter weight contents of the cultivated vegetables cultivated in the polluted soils were analysed; also the same index was assessed in the vegetables from the unpolluted soils. There was a significant increase in the dry matter contents of the cultivated vegetables in soil polluted with Cu, Fe and Zn respectively. However, dry matter contents were seen progressively low in vegetables cultivated in soils polluted with Cd, As and Pb. When compared with the control experiment. The results from the present study have shown the vulnerability of agricultural soil and cultivated vegetables to effluent from industrial bias sources used for irrigation and its impact on agricultural productivity.

## Keywords

Heavy Metals, Vegetable, Enzymes, Pollution

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## 1. Introduction

Enormous quantities of noxious pollutants have been released into surrounding over the last few decades. Among these pollutants, heavy metals (HMs), polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH) represent the major pollutants of terrestrial environment [49]. The threat of pollutants not only from natural sources such as seeps but also from anthropogenic activities such as spillages from effluent treatment plants and other emissions, endangers the terrestrial biodiversity [35, 40]. Soil and its inhabitant organisms tend to accumulate different dietary and waterborne contaminants including heavy metals, polycyclic aromatic hydrocarbon and other organic compound such as Anthracene etc from the environment which they live in [66, 19, 21].

Heavy metals otherwise known as the trace metals due to their relativity in abundance and bioavailability are metals with relatively high atomic mass and thus which reflect in their atomic weights examples includes Arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, and selenium [3, 26, 28]. They take part in bio-geochemical reactions and are transported between compartments by natural processes, the rate of which are at times greatly altered by human activities [7, 58, 64]. They persist in nature and can cause damage or death in animals, humans, and plants even at very low concentrations (1 or 2 micrograms in some cases). The metals cannot be metabolized by natural means. Chemical industries are key source of heavy metals (Osuji and Onajeke, 2004). The peculiar ability of heavy metals is to accumulate without being noticed to levels of toxicity [14, 42, 45]. Heavy metals are connected with severe health abnormalities such as nephrotoxicity, neurotoxicity and malignancies of various types (Goyer, 1996). Lead (Pb) interferes with haem biosynthesis [68]. It inhibits the activity of 2-amino laevulinic acid dehydratase which leads to accumulation of protoporphyrin in the red blood cell [29, 37, 54]. Cadmium can expediently substitute zinc in several enzymes consequently changing their configuration and inhibiting catalytic function [60].

With the increasing human population and change in the feeding culture of people, there has been increased need for food supply. This with the need for quality food vitamin has increased the demand for vegetable foods e.g green spinaches and its products [14]. The global consumption of vegetable and derived vegetable products for example has generally increased during recent decades [23]. The cage herbarium sector has grown very rapidly during the past 20 years and is presently undergoing rapid changes in response to pressures from globalization and growing demand for vegetable products in both developing and developed countries [27].

It has been predicted that vegetable consumption in developing countries will increase by 57 percent, from 62.7 million metric tons in 1997 to 98.6 million in 2020 [1].

Vegetables enjoy a good reputation as a nutritious and healthy food. The consumption of vegetables is recommended because it is a good source of antioxidants among other beneficial phytochemical components which has been associated with health benefits due to its cardio-protective effects [4, 10]. Vegetables also contain vitamins, mineral and other trace beneficial elements which play essential role in human health [12, 14, 47]. However, the levels of contaminants in vegetables and its poor management are of particular interest because of the potential risk to humans who consume them. High level of heavy metals bioaccumulation in vegetables to such a degree that it becomes toxic to human when ingested. In Nigeria, data on heavy metals and other potential hazardous compounds in both aquaculture area and open cultured are lacking [38, 62]. The safety and health state of the vegetables consumed are not aware of. Estimation of heavy metals in the environment is important because of the clinical significant of these recalcitrant in foods especially when they passed on to human being through the consumption of vegetables and vegetable products [7, 15, 63]. Agricultural practices and its bountifulness can only improve when the integrity of the surrounding soil is not compromised. The present study provides information on the impact of trace metals on the growth and productivity of vegetables sampled from three farms in Enugu metropolis.

## 2. Materials and Methods

### 2.1. Materials

All the chemicals, reagents and equipments used in the present study were of analytical grade and products of designated companies of BDh, Sigma, May and Baker; the equipments are properly calibrated at each use and stored at regulated condition.

### 2.2. Soil Sample Collection

Soil sample were collected around three different parts within Enugu metropolis (Long.14°N, SE 4) as described by Ezenwelu *et al.* [33] and as contained in ATSDR [2]; the samples were pooled together in a clean container whereas debris were selected off initially. There taken to the laboratory for further analysis.

### 2.3. Contamination of the Soil Samples

Pooled soil samples after 48 hrs acclimatization was impacted with heavy metals of Fe, Pb, Cd, As, Cu, Zn at concentration of 10mg/g optimized at pH 6.5 as described by Valerro [66].

## 2.4. Soil Enzyme Assessment

Soil quality marker enzymes were determined using standard assay protocols, enzyme such as: Lipase, catalase, urease and peroxidase will be assayed.

### 2.4.1. Lipase

Lipase activity in the soil was determined as described by Elshora *et al.* [31].

### 2.4.2. Catalase

Catalase activity in the soil was determined as described by Eze *et al.* [32].

### 2.4.3. Peroxidase

Peroxidase activity in the soil was determined as described by Eze *et al.* [32].

Urease activity in the soil was determined as described by Douglas and Bremner [27].

### 2.4.4. Seed Viability Test

This was carried out as described by Merkl *et al.* [57] using the flotation method.

### 2.4.5. Cultivation of Seeds of *Spinach*, *Water leaf* and *Pumpkin*

Seeds of *Spinach*, *Water leaf* and *Pumpkin* were cultivated as described by Chukwuma and Adams [24].

## 2.5. Determination of the Growth Parameters

### 2.5.1. Plant Shoot Length Measurement

This will be done as described by Merkl *et al.* [57] and records were taken every other four (4) days for the respective plants using a meter rule.

### 2.5.2. Dry Matter Contents

This will be done as described by Merkl *et al.* [57] using the sensitive weighing balance after drying at constant temperature for days.

### 2.5.3. Plant Leaf Area

Mean area of the plant leaves were determined as described by Chukwu and Adams [24] using the formular  $0.5LB$  where  $L$  = length of the leaf in cm,  $B$  = breadth in cm.

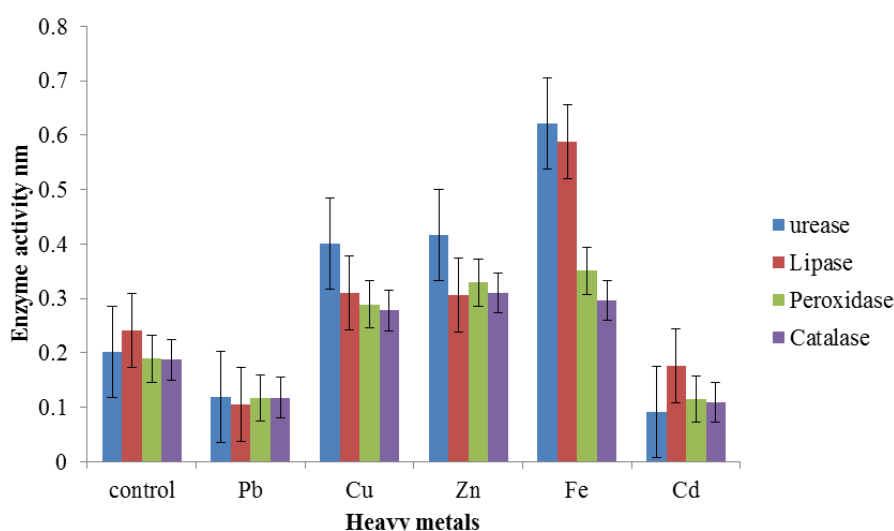
Number of leaves per plant stalk was also extrapolated per each plant.

### 2.5.4. Chlorophyll A and B Determination

This was carried out respectively as described by Merkl *et al.* [57] absorbance were at 623 and 650nm respectively against acetone solution blank.

## 3. Results and Discussion

Soil enzyme responses from the agricultural soil impacted with heavy metals of Fe, Pb, Cd, Cu, Zn at concentration of 10mg/g optimized at pH 6.5. Stress marker enzymes of Lipase, catalase, urease and peroxidase assayed showed differential catalytic activity in the presence of the respective heavy metals as shown in figure 1.



**Figure 1.** Soil enzyme activity in the presence of the heavy metal impacted soil samples.

Analysis of soil enzymes showed the activity of the catalase, peroxidase, lipase and urease, peroxidase and with corresponding OD reading of 0.750, 2.05, 0.22 and 1.704 respectively. There were noticeable increases in the activity of urease and peroxidase while catalase and lipase activity were relatively reduced. Vallero [68] reported the activities of quality marker soil enzymes in the presence of recalcitrant; most constitutive enzymes are said to be mark qualities of soil otherwise House-keeping enzymes whose activities are activated in the presence/influx of recalcitrant to a particular ecological nich(es). Lipases are activated in the presence of

triacylglyceride while peroxidase and catalase activity is stimulated in the presence of peroxide and other superoxides; urease activity is activated in the presence of organic matter urea.

Effect of heavy metals on mean shoot length of *Amaranthus* sp. cultivated in the agricultural soil.

Figures 2, 3 and 4 below shows the differential impact of the heavy metals on development of the cultivated vegetable (*Amaranthus* sp., *Solanum* sp and *T. Oleifera*) in the presence of the heavy metals.

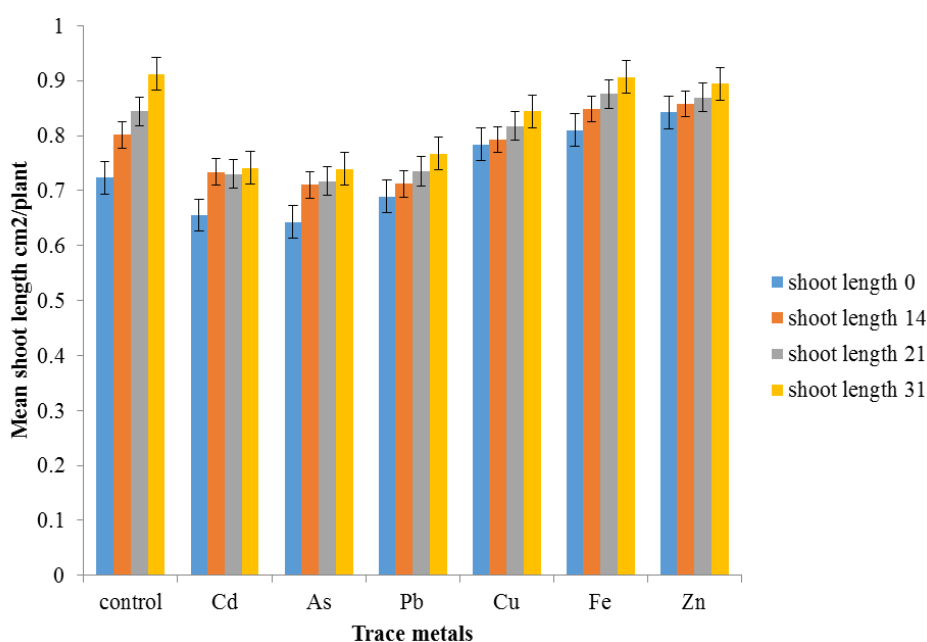


Figure 2. Effect of different trace metals on the mean shoot length of *Amaranthus* cultivated on agricultural soil Enugu state.

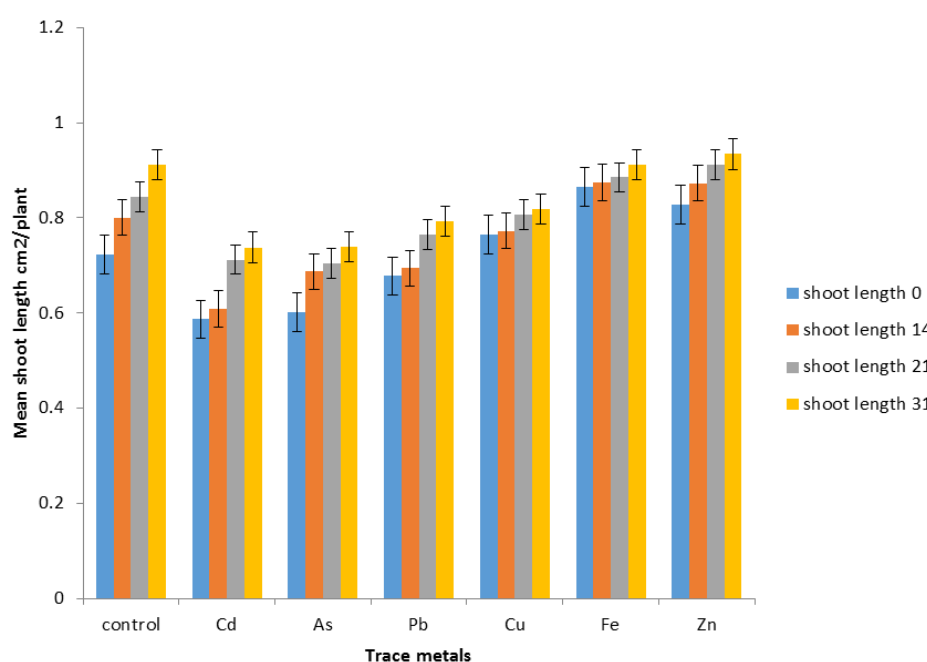
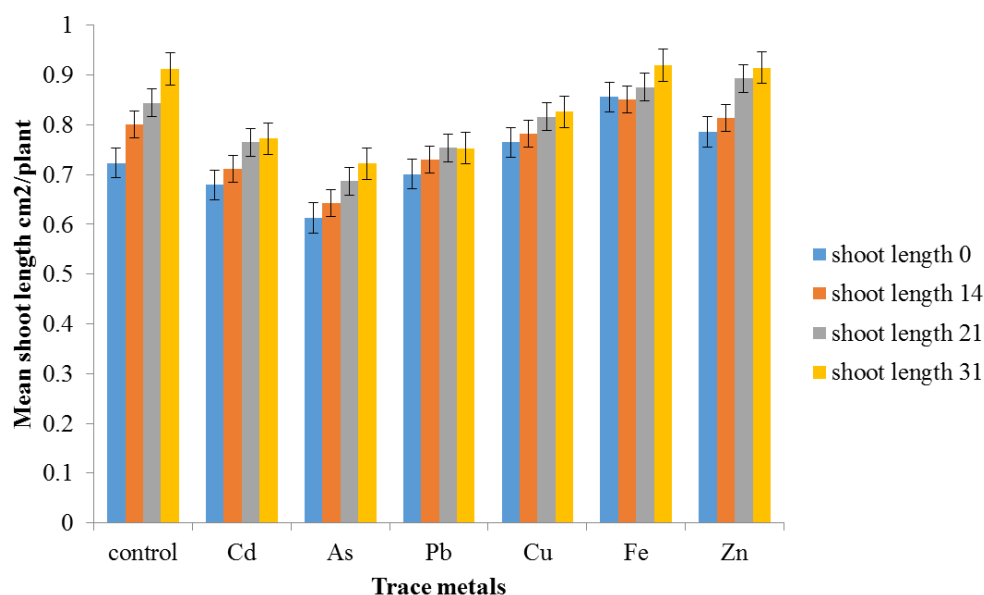


Figure 3. Effect of different trace metals on the mean shoot length of *Solanum* sp. cultivated on agricultural soil from Enugu state.



**Figure 4.** Effect of different trace metals on the mean shoot length of *T. ocellifera* cultivated on agricultural soil from Enugu state.

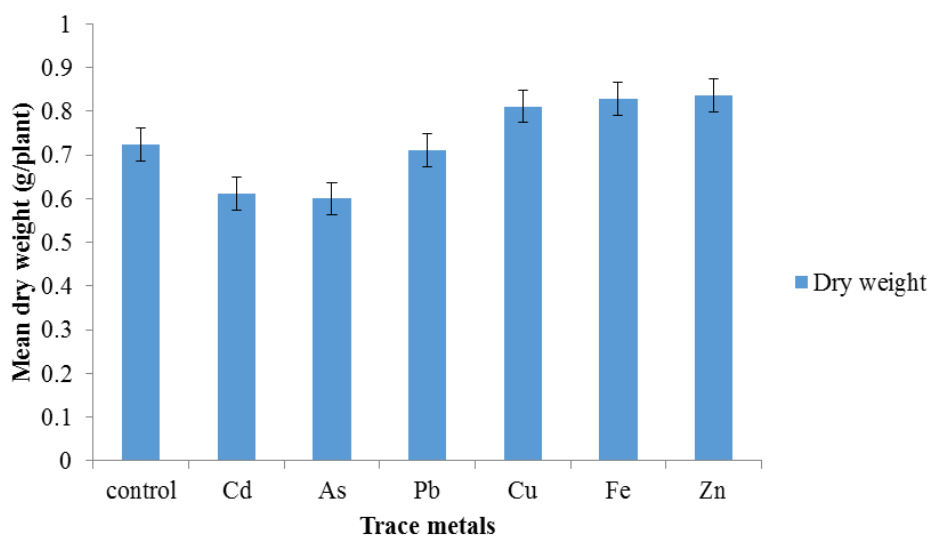
Shoot length as known is the physiology of a plant depicting its growth rate from the soil level. Analysis on the impact of heavy metal pollution on the shoot length of the cultivated vegetables analysed for thirty-one days showed regressive increase in the shoot length of the cultivated vegetables as the period of harvest increases from 0-31 when compared with the control experiment. However Cd and As had the most estimated impact on the vegetables in all the cultivated soils and its impact progresses as the period of harvest increases.

From the results of the respective cultivated vegetables on the soil from Enugu state; there were noticeable non significant difference in soils contaminated with Fe, Cu and Zn and when compared with the control experiment. Mahmood A. and Malik [52] stated that Fe and Cu increases the growth

and seedling of their experimented *Zea-May* and *Phaseolus sp.* in their study while Pb was a poison to the cultivated crops.

### 3.1. Effect of Different Trace Metals on the Mean Dry Matter of *Amaranthus sp.* Cultivated on Agricultural Soil from Enugu State

Figure 5, 6, and 7 below shows the differential impact of the heavy metals on total dry matter contents of the cultivated vegetable (*Amaranthus sp.*, *Solanum sp* and *T. Oleifera*) in the presence of the heavy metals.



**Figure 5.** Effect of different trace metals on the mean dry matter of *Amaranthus sp.* cultivated on agricultural soil from Enugu state.

### 3.2. Effect of Different Trace Metals on the Mean Dry Matter of *Solanum* sp. Cultivated on Agricultural Soil from Enugu State

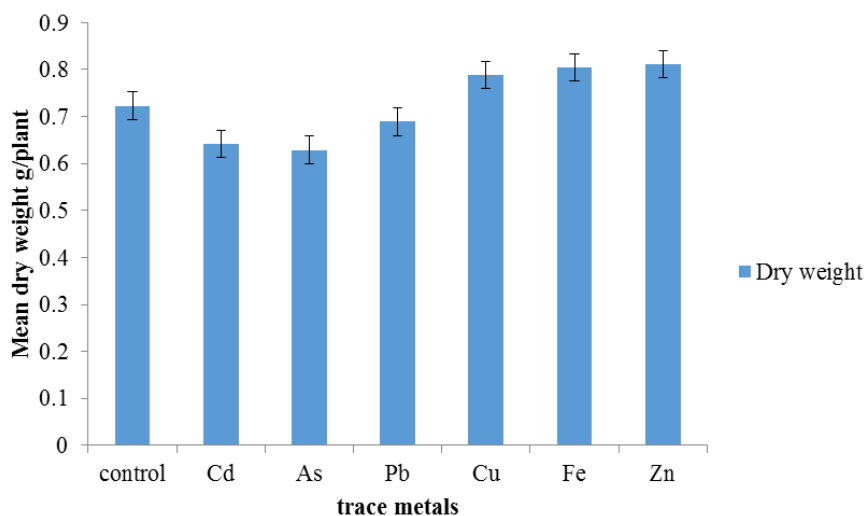


Figure 6. Effect of different trace metals on the mean dry matter of *Solanum* sp. cultivated on agricultural soil from Enugu state.

### 3.3. Effect of Different Trace Metals on the Mean Dry Matter of *Toceifera* Cultivated on Agricultural Soil from Enugu State

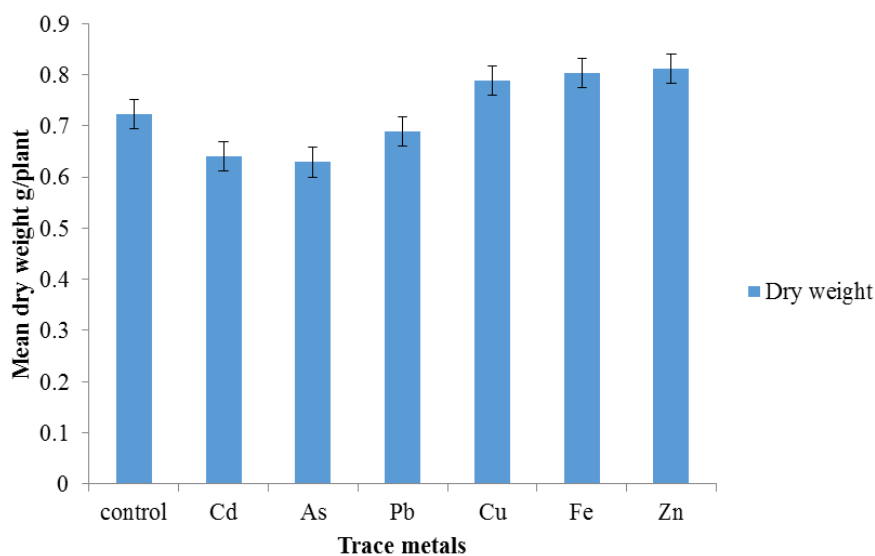


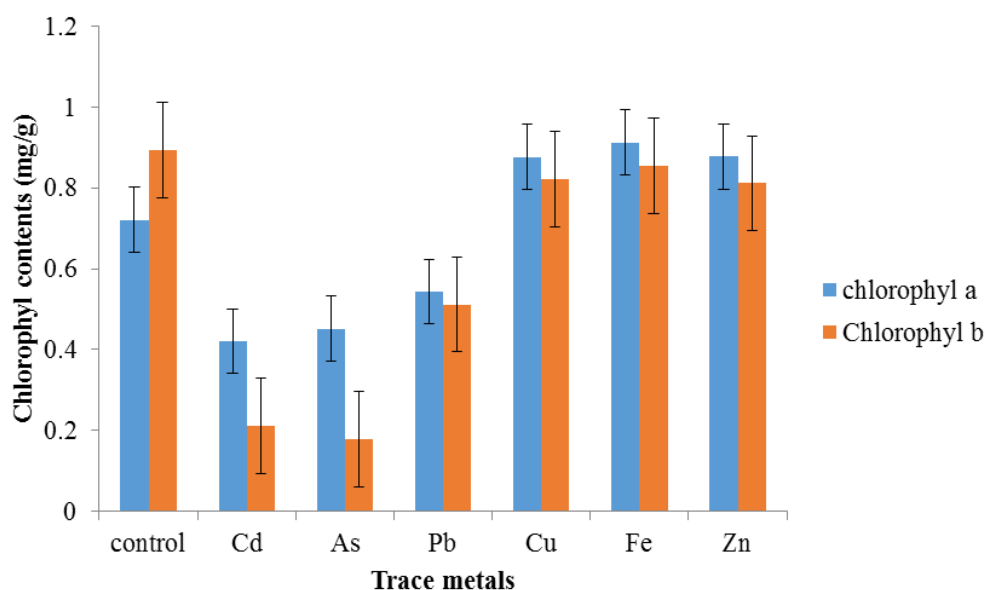
Figure 7. Effect of different trace metals on the mean dry matter of *T. oceifera* cultivated on agricultural soil from Enugu state.

Dry matter weight contents of the cultivated vegetables cultivated in the polluted soils were analysed; also the same index was assessed in the vegetables from the unpolluted soils. Dry matter contents which reflect the weight content of biological entities devoid of available water ( $a_w$ ). From the figures, there was a significant increase in the dry matter contents of the cultivated vegetables in soil polluted with Cu, Fe and Zn respectively. However, dry matter contents were seen

progressively low in vegetables cultivated in soils polluted with Cd, As and Pb. When compared with the control experiment, there is a significant decrease in dry matter contents of the vegetables cultivated in soils polluted with Cd, As and Pb respectively; however, the dry matter contents were seen higher in vegetables cultivated in soils polluted with Fe, Zn and Cu when compared with the control experiment. Thebo *et al.* (2017) in their experiment on the global, spatially-explicit

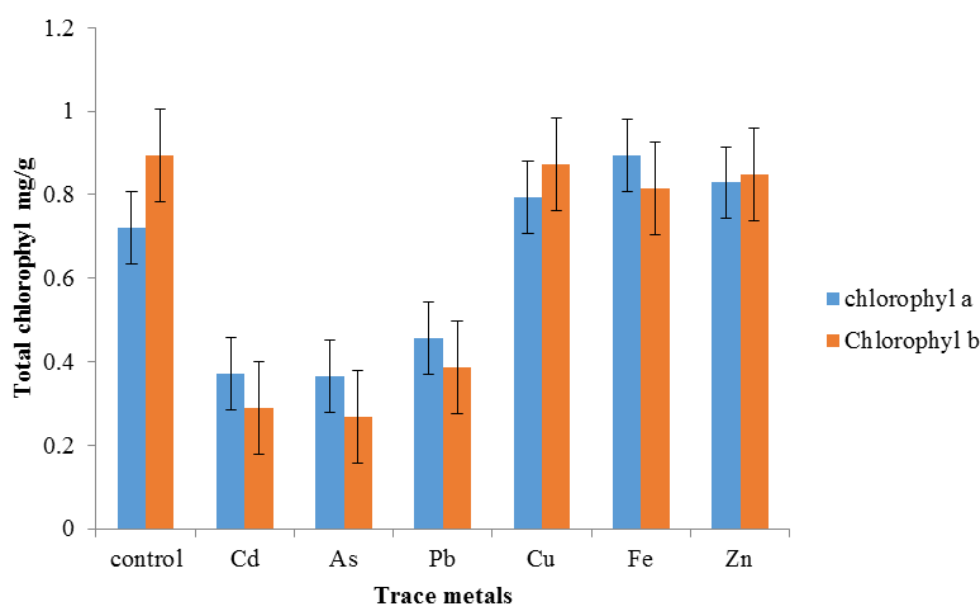
assessment of irrigated croplands influenced by urban wastewater flows showed a significant impact of divalent Fe on the growth and seedling of Water lilies which reflects positively in its dry matter contents. Merkl *et al.* [57] exemplified the significant of some fibrous plants like *Sativum* as phytoremediators in a crude oil impacted soils. They went further to state that there were recorded increase in the growth and productivity of these crops which was aided by bio timely stimulations with minerals like Fe and Zn. Li *et*

*al.*, [48] reported that total dry matter of plants is a quality marker of enriched soil on plant growth as crops cultivated on fertile land grows faster than that of a compromised soil. Chukwu and Adams [24] reported a similar correlation on effect of generator (Exhaust) Fumes on the growth and development of *Lycopersicum esculentus* (Tomato), in their study, the total dry matter of the tomato plant increases as the cultivation day progresses.



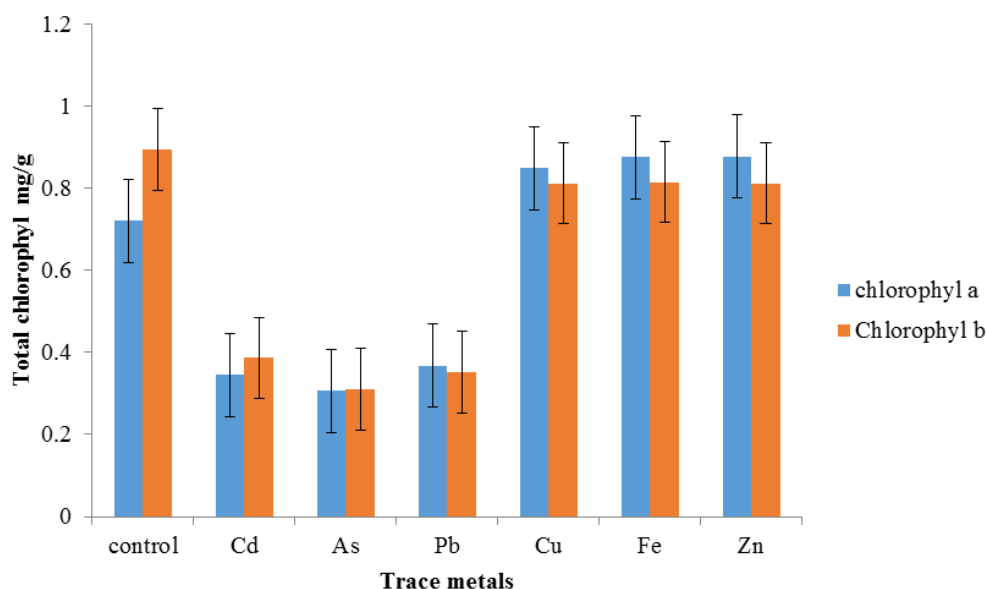
**Figure 8.** Effect of different trace metals on the total chlorophyll contents of *Amaranthus* cultivated on agricultural soil from Enugu state.

Effect of different trace metals on the total chlorophyll contents of *T.oceifera* cultivated on agricultural soil from Enugu state.



**Figure 9.** Effect of different trace metals on the total chlorophyll contents of *T. oceifera* cultivated on agricultural soil from Enugu state.

Effect of different trace metals on the total chlorophyll contents of *Solanum* cultivated on agricultural soil from Enugu state.



**Figure 10.** Effect of different trace metals on the total chlorophyll contents of *Solanum* cultivated on agricultural soil from Enugu state.

Total chlorophyll a and b in the selected vegetables showed a correlative increase in chlorophyll a and b in soils contaminated with Zn, Cu and Fe in all the cultivated vegetables: *T.oleifera*, *Amaranthus* and *Solanum* sp respectively.

Recall as described by Valerro [66] that Heavy metals of Zn, Cu and Fe are important biogeochemical metals (ions) which recycles with the olefiers of soils and aquatic bodies and aid in fostering of other nutrient uptake by cultivated plants. He went further to state that they are important metals for pigmentation in any green or other coloured plant(s). There are significant increase in total cholorphyl a and b contents from the results when compared with the control experiment as other soil contaminated with heavy metals such as: Pb, As, Pb repressed the selected vegetables cultivated in the soils. However total chlorophyll a was seen slightly higher than cholophyl b in all the selected vegetables.

## 4. Conclusion

Agricultural sustainability and revolution stand out as major fulcrum of nations developmental strides. Quest for vegetarian diets is on the increase due to high clinical evidences from animal and other related meal. The statues of these vegetables and alike in the market today remains very obscure. The results from the present study have shown the vulnerability of agricultural soil and cultivated vegetables to effluent from industrial bias sources used for irrigation and its impact on agricultural productivity. These on the long run may endanger the health statues of the peasant farmers who use them for irrigation and the crops cultivated.

## Abbreviations

Pb	Lead
Zn	Zinc
Cu	Copper
Pnpp	Paranitrophenyl Palmitate
BDL	Below Detectable Limit

## Ethics

Authors declared no ethical issues that may arise after the publication of this manuscript.

## Author Contributions

**Uchenna Fredrick Anikwe:** Conceived and designed the experiments, performed the experiment and processed the data, analyzed the data and wrote the manuscript.

**Cyril Onyekachi Edeoga:** Co-supervised the research and revised the manuscript.

**Emeka Henry Oparaji:** Performed the experiment, processed the data and revised the manuscript.

**Godwin Ikechukwu Ameh:** Analyzed the research design and methodology, interpreted the data.

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## Conflicts of Interest

The authors hereby state that there is no conflict of interest from anybody as regards to this research article.

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