Asian Journal of
Science, Technology, Engineering, and Art

e-ISSN : 3025-4507
p-ISSN : 3025-5287
Index : Harvard, Boston, Sydney University, Dimensions, Lens, Scilit, Semantic, Google, etc

https://doi.org/10.58578/AJSTEA.v2i2.2790

EFFECTS OF GINGER ON GROWTH INDICES AND PB BIOACCUMULATION OF TOMATO FRUITS CULTIVATED IN LEAD AND SPENT ENGINE OIL-CONTAMINATED SOILS

Amoo Abdulhamid Olaniyi[1], Ezeonu Chukwuma Stephen[2], Umaru Isaac John[3]
Federal University Wukari, Taraba State, Nigeria
abdulhamidamoo@yahoo.com

Article Info:

Submitted:	Revised:	Accepted:	Published:
Feb 10, 2024	Feb 27, 2024	Mar 3, 2024	Mar 9, 2024

Abstract

Good soil is needed for public health and this research studies lead concentrations of tomato planted in different soil samples in Wukari, Taraba state, Nigeria (with 50mg/kg simulated and non-simulated contamination) labelled groups A-H. Two weeks-old tomato seedlings were transplanted to triplicates of soils pots labelled A: normal soil, B:Ginger treated (positive control), three negative controls; C:lead contaminated; D Spent Engine Oil (SEO) contaminated, and E:Pb+SEO containing soil, F:Lead contaminated+ginger treatment, G: SEO contaminated+ginger treatment, H:lead+SEO contaminated+ginger treatment. The lengths, circumferences and weights of 36 tomato fruits per plant pot were measured at random. Lead uptake and bioaccumulation were also assessed in tomato fruits derived from each group. Tomato fruits in group E weighed highest (15.41±7.81g) while those in group H had the lowest weight (12.02±6.69g). The longest and the highest average tomato fruit circumference were recorded in group D (5.61±2.66cm and 6.15±2.93cm) respectively. Conversely, group H presented the shortest mean tomato fruits with 4.19±2.45cm and lowest fruit circumference (4.49±2.34cm). Bioaccumulation of lead was highest in tomatoes of group E with 1.79±0.47ppm and the lowest was derived from

AJSTEA Journal is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License

group A:normal soil with 0.68±0.13ppm on average each. The lead concentrations of all groups exceeded permissible limits specified in WHO/FAO Standards (0.01 ppm) as well as the maximum allowable concentration of 0.02 ppm by EU and 0.05 ppm limit set by USEPA suggesting a public health concern.

Keywords: Soil pollution, Food Safety and Security, Reactive Oxygen Species, Heavy metal toxicity, Phytoremediation

INTRODUCTION

In recent years, attention has been focused on the role of biotransformation, bioaccumulation of chemicals in the soil by plants to highly reactive metabolites that initiate cellular toxicity (Ezeonu *et al.*, 2022b). This is so because the side effects of such plants to human health are innumerable. Many compounds, including highly needed synthetic agrochemicals like pesticides, herbicides and fertilizers can cause cellular damage through metabolic activation of plants physiology to highly reactive compounds such as free radicals that start a long cascade of oxidative stress that may finally damage the plants in such soils (Ilahy *et al.,* 2022). There is even likelihood of exponentially dreadful effects on the final consumers of such plants i.e. animals and ultimately humans, in a process called bio-magnification (NIEHS, 2021) as many people have come down with adverse biological effects due to toxicity, carcinogenicity, mutagenicity, and teratogenicity of these organic and inorganic contaminants (Marchand, 2017). This study thus set out to contribute to the body of information by evaluating Pb bioaccumulation and as a result estimating the harmful effects of soil induced contamination with lead (Pb) and spent engine oil (SEO) on tomato fruits growth statistics like fruit weight, circumference and length. Also, the human health risks associated with the consumption of such fruits were forecast by correlating the bioaccumulation figures with the globally acceptable standards of contaminants above which tomato fruits are said not to be fit for consumption.

Taraba State in the north-eastern region of Nigeria is among the states with lowest population densities with the fourth largest land mass, and also among the least industrialised and urbanised states (www.tarabastate.gov.ng, 2022) going by data from 2006 National Population Census. These facts could lead to the conclusion that the level of pollution in the state will be very low which is a false premise considering the grossly

agrarian economy of the state, with most of its revenue from taxes and levies on farmers (www.tarabastate.gov.ng, 2022). With agriculture in modern times comes the use of farm machinery like tractors, ploughs, harvesters and a great deal of agro-chemicals like fertilizers, pesticides and herbicides (Ezeonu *et al.,* 2012).

Lead (Pb) is a ubiquitous heavy metal without any known beneficial physiological role in biological systems, rather than its recorded toxicity (Abu-Dieyeh, 2020). Pb as well as As appear to be the most common heavy metals (HMs) in atmospheric particulate matter, according to Zhang *et al.* (2018), with the potential of causing irreversible health effects. Toxic effects of lead in soil include overproduction of reactive oxygen species (ROS) by plants, inhibition of ATP production, lipid peroxidation, and DNA damage (Molina and Segura, 2021). Lead in excess amounts also decreases seed germination, root elongation, seedling development, plant growth, transpiration, chlorophyll production, and water and protein content, among other things (Ardisana *et al*., 2018; Ilahy *et al.,* 2021). Acute toxicity is related to occupational exposure and is quite uncommon (Rebelo and Caldas, 2016). Occupational exposure to lead is found among workers at smelters or battery recycling plants (Berg, 2009). People near industrial estates, coal combustion, and non-ferrous smelting are also at risk of lead contamination (Hikon *et al.,* 2018). The previous usage of tetra ethyl leaded gasoline, lead arsenate insecticides, and lead paint all contribute to higher lead levels in urban soil (Abu-Deiyeh *et al*., 2018). Chronic toxicity of the metal is more prevalent for people through these sources and it interferes with a number of body functions primarily the central nervous system, hematopoietic, hepatic and renal system producing serious disorders (Kathuria and Ramachandran, 2020). Saha and Zaman (2013) even opined that heavy metals such as lead and cadmium can cause breast cancer and prostate cancer in humans as a result of the reactive oxygen species (ROS) generated. More so, lead can be transmitted from a mother to her child via breast milk (Koyashiki *et al.,* 2010). The fetal brain presents a greater sensitivity to the toxic effects of Pb compared to the mature brain (Schnaas et al., 2006). It is thus more pertinent to avoid even the minutest concentration of lead in children as literature posits that effects of such exposures are not reversible, not even with chelating techniques (Kathuria and Ramachandran, 2020). The debilitating effects of lead in children is so much that in May 2015, at least 28 children under the age of five were killed by drinking stream water contaminated with lead in Niger state, Nigeria (Onuah and Abrak, 2015). While some other heavy metals (HMs), such as nickel (Ni), copper (Cu), and zinc (Zn), can be hazardous in excess quantities per body

mass given that they are necessary cofactors for some human enzymes to function properly (Molina and Segura, 2021, Abu-Deiyeh *et al.*, 2018), lead (Pb) serves no function in the human body and so human exposure should be totally eradicated according to advocacies of public health experts. Pb is poisonous to humans even at quantities as little as 5μg/dL as suggested by CDC (US Centers for Disease Control) and other internationally recognized bodies like WHO/FAO, USEPA (www.astdr.cdc.gov, 2011; www.fao.org, 2011). Several scientists however strongly hold that there is absolutely no safe threshold for lead exposure. The combustion of leaded petrol in automobiles may be responsible for the continued widespread distribution of Pb in Nigeria's environment (Balogun, 2017). Pb is a naturally occurring and industrially produced element that is very toxic to human, especially children (Koyashiki *et al.,* 2010).

According to surveys by Lam *et al.* (2010), Lam *et al.* (2012) and EPA (2016), spent engine oil (SEO) accounts for more than 60% of total waste generated by heavy machinery, with around 200 million tons of SEO produced yearly. Engine Oil pollution might affect soil physical properties. Since Oils are denser than water, they might reduce and restrict soil permeability (Abioye *et al.*, 2012). The widespread need for farm machinery that run on engine oil makes the concern on Spent Engine Oil contamination on soil and the resulting farm products in this case, tomato become more germane and overarching. Spent Engine oil (SEO) has many constituents that have been confirmed to have many deleterious effects in living systems (Ilahy *et al.,* 2022). In a study by Ilahy et al. (2022), SEO reduced the count and quality of leaf and fruit per plant. The research of Ilahy *et al.,* (2022) also recorded an increase in lycopene and β-carotene concentration, which are non-enzymatic antioxidant biomarkers indicating an increased oxidative stress due to SEO contamination in soil. The presence of different types of automobiles and machinery has called for an increase in the use of engine oil whose waste are most times disposed to surroundings like open fields and water ways thus contaminating our natural environment with hydrocarbon (Abioye *et al.,* 2012). Hydrocarbon contamination of the air, soil, and freshwater especially by polyaromatic hydrocarbon (PAHs) attracts public attention because many PAHs are toxic, mutagenic, and carcinogenic. Unfortunately, improper disposal techniques contaminate farmlands. Furthermore, excess spent engine oil, like other hydrocarbons have been implicated in the decrease of soil biomass like earthworm and the exorbitant increase in the activity of soil microbial enzymes like ureases and dehydrogenases (Dendooven *et al.*, 2011; Lipińska *et al.,* 2013).

The production and safety of tomato (*Solanum lycopersicum* L.) as a mainstay in Nigerian and global culinary services (Encyclopedia of Life, 2014), is grossly affected by so many factors - just like other farm products - of which soil contamination is topmost, as a result of farming practices and other anthropogenic factors like urbanization and industrialization (Oladitan and Oluwasemire, 2108). There is a great need to ensure the food safety of tomato from the farm to the vine owing to the numerous benefits of tomato such as its ability to reduce the risk of heart disease and certain cancers (Siddiqui *et al.*, 2018), provision of about 80% of the recommended daily intake of lycopene and 40% of the recommended Daily Value (DV) of ascorbic acid (Oladitan and Oluwasemire, 2018). Also, tomato provides 15% of vitamin A, folic acid, iron, and other nutrients that reduce the risk of cardiovascular diseases (CVDs), diabetes, cancer (Umaru *et al.*, 2019, Pepoyan *et al.*, 2022). The presence of contaminants in soil has been indicated as a major setback to adequate tomato yield. Among those contaminants are Spent Engine Oil and Pb (Marchand, 2017; Ilahy *et al.,* 2022).

Many polluted farms nowadays contain an inestimable array of organic and inorganic substances, including, but not limited to petroleum hydrocarbons (PHC) including engine oil, diesel, kerosene, petrol, pesticides (Marchand, 2017), and heavy metals (HM) comprising lead (Pb), copper (Cu), zinc (Zn), mercury (Hg), and cadmium (Cd).

Ginger (*Zingiber officinale*), has been reported as having antioxidative potentials (www.nccih.com, 2016; Hosea *et al.,* 2018). Ezeonu *et al.* (2022b) also found out ability of ginger to curb the negative effects of heavy metal contamination in maize and thus improve growth and oxidative balance of plants. This research thus aims to evaluate the potential of ginger to improve growth indices of tomato fruits from soils in which there has been induced contamination with Pb and SEO.

METHODS

Sample Collection and Geographical Location

This study took place in the Biochemistry laboratory at the Federal University Wukari in Taraba State, Nigeria between August and December, 2022. Wukari in North-East Nigeria's Southern Guinea Savanna region is home to Federal University Wukari. It has an elevation of 152 m above sea level, latitudes of 7.85 ^{0}N and 9.78^{0} E, an annual rainfall of 1450 mm, an average daily temperature range of 24 to 33 °C during the wet seasons, and an

annual relative humidity of 78% (www.tarabastate.gov 2022). According to the 2006 census, the city had a total population of 241,546 people and a 4.308km^3 area (National Population Commission, 2017).

Preparation of Ginger Extracts

Ginger rhizomes were carefully washed with clean water. The rhizomes were then chopped into smaller pieces and washed with distilled water before being air-dried for 7 days at room temperature. To get a powdered sample of whole ginger, the rhizomes were pulverized and sieved using a mesh size of 2 mm in diameter.

Soil Simulations, Tomato Seeds and Planting Condition

The tomato seeds were purchased at the Wukari market. Planting was done both on the simulated soil and other soil groups as well as raising in nursery beds for possible transplanting. A total of five seedlings per pot was transplanted into 10 L pots containing 3kg of soil microcosm with 5cm spacing between seeds. The pots were then placed in a space field within the university premises, under natural meteorological circumstances with supplemental watering as required by the experimental design. In order to cater for environmental interference of rain, leaching and evapotranspiration, all treatments were repeatedly administered on a weekly basis for a total of ten (10) weeks in each experimental pot. Following the preparation of 8 different soil groups (3 pots /treatment), seed cultivation/ transplanting was carried out using the order of the grouping as follows:

Group A: 1kg of soil microcosm only serves as normal control.

Group B: 1kg of soil microcosm treated with ginger extract as positive control.

Group C: 1kg of soil microcosm contaminated with lead acetate (100mg).

Group D: 1kg of soil microcosm contaminated with SEO (100mg)

Group E: 1kg of soil microcosm contaminated with lead acetate (50mg) + SEO (50mg).

Group F: 1kg of soil microcosm contaminated with lead and treated with ginger extract (100mg).

Group G: 1kg of soil microcosm contaminated with SEO (100mg) and treated ginger extract (100mg).

Group H: 1kg of soil microcosm contaminated with lead acetate (100mg) + SEO (100mg) and treated with ginger extract (100mg).

Physical Properties of the Tomato Fruits

The growth indices of the tomato fruit including length, circumference and weight of 36 tomato fruits per group were measured and documented after harvesting.

Test for Pb^{2+} Bioaccumulation

The method of Adriano (1986) was used in determining the level of lead accumulation in the harvested tomato fruits. A total of three (3) tomato fruit samples were collected randomly per pot from each of the twenty-four (24) pots. The plant samples were mixed to give the representative fraction of each of the plant pots. The harvested tomatoes were then sun dried until stable weights were obtained. It was then grounded in a mortar and sieved with 2 mm mesh size, then stored in labelled polythene container prior to analysis. A total of 1.0 g of the powdered tomato plant samples was digested with 10 cm^3 mixture of analytical grade acids HNO_3: $HCIO_4$ in the ratio 5:1. The digestion was performed at a temperature of about 90 ºC for 30 minutes in a fume cupboard until clear solutions were obtained. Digested samples were allowed to cool, filtered into a 100 cm^3 volumetric flask, and made up to the mark with deionized water. Atomic Absorption Spectrophotometer Model, AA090M046 PG Instruments, at the Sen Bwacha Central Laboratory of the Federal University Wukari, Taraba state, Nigeria was used to determine lead concentration in the samples.

RESULTS

Tomato Fruit Indices

The data obtained from the measurement of tomato fruit weights varied from 15.41±7.81g in group E (Pb + SEO, i.e tomato fruits from soil co-contaminated with lead and SEO) to as low as 12.02±6.69g obtained from fruits of group H. (Pb + SEO + G, i.e tomato fruits from soil co-contaminated with lead and SEO together with ginger treatment). The average tomato fruit circumference variedc as low as 4.49±2.34cm in group H (Pb + SEO + Ginger, i.e tomato fruits from lead and spent engine oil induced soil contamination coupled with ginger treatment) to as high as 6.15 ± 2.93cm for fruits of group D: SEO (i.e. spent engine oil only contaminated soil without treatment). From the results also, the average tomato fruit lengths reached 5.61 ± 2.66cm in group D (SEO, spent engine oil containing soil) and the group with the shortest average fruits was H (Pb

+ SEO + Ginger, i.e tomato fruits from lead and spent engine oil contaminated soil and treated with ginger) containing length 4.19 ± 2.45cm. Table 1 below summarizes the results of average height, weight and circumferences of the tomato fruits.

Table 1: Tomato Weight, Circumference and Length

GROUP	WEIGHT (g)	CIRCUMFERENCE (cm)	LENGTH (cm)
A: Normal	13.71 ± 6.70^{ab}	5.63 ± 2.78^{ab}	5.20 ± 2.40^{bc}
B: G +ve control 1	12.02 ± 6.69^{a}	4.79 ± 2.83^{ab}	4.59 ± 2.70^{ab}
C: Pb	13.83 ± 6.39^{ab}	5.24 ± 2.61^{ab}	5.07 ± 2.71^{bc}
D: SEO	13.40 ± 4.87^{ab}	6.15 ± 2.93^{b}	5.61 ± 2.66^{c}
E: Pb+SEO	15.41 ± 7.81^{b}	5.26 ± 2.58^{ab}	4.92 ± 2.51^{bc}
F: Pb + G	15.39 ± 6.85^{b}	5.35 ± 2.48^{ab}	4.82 ± 2.22^{bc}
G: SEO+G	13.00 ± 5.78^{ab}	4.54 ± 2.23^{a}	4.33 ± 2.19^{ab}
H: Pb+SEO+G	12.89 ± 5.93^{ab}	4.49 ± 2.34^{a}	4.19 ± 2.45^{a}

Results are expressed in mean ± standard deviation of triplicate determination. Values with the same superscript have no significant difference between groups, while values with different superscripts significantly differs between groups within the same column at P< 0.05. Group A: Normal control (i.e., soil without prior contamination nor treatment), B= Positive control (uncontaminated soil treated with ginger), C:,Pb (negative control 1) (tomato planted in lead contaminated soil), D:SEO (negative control 2) (Spent Engine Oil contaminated soil), E:Pb + SEO (tomato planted in lead and SEO contaminated soil combined), F:Pb+Ginger (tomato planted in lead contaminated soil with ginger extract treatment), G:SEO+Ginger (tomato cultured in SEO contaminated soil with ginger extract treatment), H:Pb+SEO+Ginger (tomato cultured in soil contaminated with both lead and SEO and along with ginger extract treatment), AVE ± STDDEV= Average± Standard Deviation.

Lead Metal Accumulation of Tomato Fruits

The unit pot lead metal concentration is of 0.53 ppm to 2.212 ppm is the average mg/kg Pb bioaccumulation of experimental plants from the results of this study. Considering average ± standard deviation, the group with the highest tomato fruit lead buildup was group E (Pb+SEO only; i.e. lead and spent engine oil contaminated soil) presenting with 1.79±0.47 ppm Pb bioaccumulation while the normal soil (Group A) produced the lowest

tomato fruit lead with an average Pb concentration 0.68±0.13 ppm. The full picture of the tomato fruit lead metal contamination is given in table 2 below.

Table 2: Lead Metal Accumulation of Tomato Fruits

GROUP	POT A (ppm)	POT B (ppm)	POT C (ppm)	AVE ± STD DEV (ppm)
A: Normal	0.78	0.53	0.73	0.68 ± 0.13^{a}
B: G +ve control 1	0.71	0.82	0.69	0.74 ± 0.07^{a}
C: Pb	1.88	1.45	1.89	1.74 ± 0.25^{cd}
D: SEO	1.10	1.78	1.09	1.32 ± 0.4^{bc}
E: Pb+SEO	1.29	1.87	2.21	1.79 ± 0.47^{d}
F: Pb + G	1.07	1.38	1.27	1.24 ± 0.16^{b}
G: SEO+G	0.89	0.96	1.03	0.96 ± 0.07^{ab}
H: Pb+SEO+G	1.04	1.32	0.97	1.11 ± 0.19^{ab}

Results are expressed in mean ± standard deviation of triplicate determination. Values with the same superscript have no significant difference between groups, while Values with different superscripts significantly differs between groups within the same column at P< 0.05. A stands for Normal (i.e., soil without prior contamination nor treatment), B= Positive control (uncontaminated soil treated with ginger), C= Pb (negative control 1) (tomato planted in lead contaminated soil), D= SEO (negative control 2) (Spent Engine Oil contaminated soil), E:Pb+SEO (tomato planted in lead and SEO contaminated soil combined), F:Pb+Ginger (tomato planted in lead contaminated soil with ginger extract treatment), G:SEO+Ginger (tomato cultured in SEO contaminated soil with ginger extract treatment), H:Pb+SEO+Ginger (tomato cultured in soil contaminated with both lead and SEO and along with ginger extract treatment), AVE±STDDEV= Average± Standard Deviation

DISCUSSION

Tomato is unarguably a very important component of the average Nigerian diet and its safety must be enxured in all its value chain (Oladitan and Oluwasemire, 2108). Lead was detected in all the samples (including the normal soil, where no lead was added to the soil), with 100% of samples seen to be higher than 0.01 ppm which is the maximum allowable limit set by WHO/FAO. They were also more than the maximum threshold of 0.02 ppm

by EU and 0.05 ppm limit set by USEPA respectively. Therefore, Pb poses a threat through the consumption of tomatoes planted in soils with such concentrations as those in this study (Orisakwe *et al.,* 2015). The most alarming of the results is the level of lead bioaccumulation in the tomato fruits from soils without induced contamination. With these figures, it could be put forward that most soil types within Taraba state are contaminated with some levels of Pb. The presence of Persistent Organic Pollutants (POP) and heavy metals like lead used in producing synthetic pesticides and herbicides that are known not to biodegrade but remain in the soil for hundreds of years is a major possible causative factor (Marchand, 2017) of lead accumulation in soil. Lead is among the heavy metals noted for having no health benefit in any living system but rather deleterious effects (Abu-Deiyeh *et al.,* 2018). Thus, it should be totally avoided in all food commodities and environmental aspects to prevent the impending public health challenge. This is more important for children who play with soil not knowing the contaminants present in them. Furthermore, the International Agency for Research on Cancer (IARC) has categorized lead as a human carcinogen (IARC, 2012). Chronic exposure to low doses of Pb could therefore result into many types of cancers (Tchounwou *et al.,* 2014).

Ginger could be said to have caused a significantly caused a decrease in Pb bioaccumulation in the tomato fruits studied. To further elaborate, the lead bioaccumulated in tomato fruits planted in the three negative control groups namely group C: Pb contaminated soil gave a value of 1.74 ± 0.25 ppm of lead; while group D (tomato fruits from SEO contaminated soil) had an average of 1.32 ± 0.4 ppm and group E (tomato fruits from soils co-contaminated with Pb and SEO) 1.79 ± 0.47 ppm. These values were significantly higher than those recorded in tomato fruits from ginger treated soils which peaked at 1.3 ± 0.15 ppm obtained for group F: Pb + T (soil contaminated with lead and treated with ginger). Furthermore, the tomato fruits in the normal soil also presented with a mean Pb concentration with 0.68 0.68 ± 0.13 ppm which is a bit lower than the positive control group that had 0.74 ± 0.07 ppm likely due to some level of lead already present in the ginger used for the study. However, the significant decrease of Pb bioaccumulation in the tomato fruits from the ginger treatment groups compared to the negative control groups indicate the possibility of curbing bioaccumulation of heavy metals like Pb in fruits through biological means as the healthiest possible method of reducing theit deleterious effects on animal and human health when consumed.

In similar studies by Yaradua *et al.* (2019) in the three senatorial districts of Katsina state, North-West Nigeria, the bioaccumulation of Pb in tomato planted in soils without prior contamination was found to be on the average 1.248 ± 0.0007ppm for Daura Senatorial District, 1.171 ± 0.0004 ppm in Katsina Senatorial District and in Funtua, 1.260 ± 0.0001 ppm. The Pb concentration of Negro pepper cultivated in Abuja, Nigeria were also found to have an average of 5ppm in the findings of Salihu and Umar (2014). These figures suggest that on a comparative scale, there is a widespread Pb contamination in soils throughout Nigerian soils at rates that threaten public health.

The tomato fruits harvested from Spent Engine oil contaminated soils (Group D) in this research were found to have the highest average circumference and lengths given as 6.15 ± 2.93 cm and 5.61 ± 2.66 cm respectively while the tomato fruits from group H (Pb and SEO induced co-contamination) also presented as having the lowest mean circumferences and lengths with 4.49 ± 2.34 cm and 4.19 ± 2.45 cm respectively. One common trend in this study is that the tomato fruits from all the groups treated with ginger presented with lower tomato fruit indices like weight, length and circumference with the exception of group F (Pb induced contamination alongside ginger treatment) showing the likelihood of ginger causing a shrinking in tomato fruit size. One possible explanation is the report that ginger increases the risk of dehydration in human gastrointestinal tract on prolonged use as posited by Nikkhah Bodagh *et al.* (2019). However, the tomato fruit indices from group F which came out with the second highest average fruit weight may not allow making such categorical conclusion.

The inability of ginger to cause a significant increase in tomato fruit sizes may be due to the seemingly low 100 ppm of soil weight concentration of ginger used as treatment in this study. Also, the low concentration of 100 ppm soil weight of SEO used in this research could be said to have led to the relative increase in tomato fruit indices in some of the study groups. These findings were inconsistent with the outcome of researches Ilahy *et al.* (2022) in which the growth indices of tomato fruits like water content, yield per plant and physical and chemical properties of ripe fruits were used as a measure of the effect of the possible inhibition of tomato fruit growth, as a result of induced contamination with two different levels each of SEO and salinity. Also, the non-enzymatic antioxidant content of tomato fruits from the study were found to drastically increase due to the severity of the damage caused by the induced contamination in the research by Ilahy *et al.* (2022). The enormity of the contaminants were so much in some of the tomato plants of their research

compared to the present study that some plants could not adapt to them and died as a result while others could not produce fruits. To be more specific, the tomato seedlings of Ilahy *et al.* (2022), 10 days after transplant were exposed to two salinity categories (EC1: 3.5 dS/m and EC2: 7.0 dS/m, corresponding to about 5.46 and 10.93 g NaCl/L, respectively); two levels of SEO [SEO1: 5 ml SEO/L (0.5%) and SEO2: 10 ml SEO/L (1%)], two microcosms of induced co-contamination with saline and SEO levels (EC1/SEO2: 3.5 dS/m, 1% SEO and EC2/SEO1: 7dS/m, 0.5% SEO) and a control group to which 0.4 dS/m EC but no induced SEO was applied. Their results showed that salinity and SEO applied individually and in combination, caused a significant 27.1–32.7%, 40.3–47.5%, and 52.6–60.9% decrease in total tomato fruit yield per plant, respectively. In terms of total fruit weight, these drops in fruit yields per plants were found to have decreased from the mean yield of 1,201.7 g/plant in the tomato plants of the control group, down to only 466.0 g/plant in those tomato fruits from plants exposed to a combined 7 ds/m EC and 0.5% SEO (EC2/SEO1). Likewise, Ilahy *et al.* (2022) observed a significant fall of 8–18%, 28–33%, and 40–46% in the average weight tomato fruits from induced contamintation with salinity and SEO applied individually and in combination respectively. This percentage decreases implied that mean tomato fruit weight of 90 g in the control group went down to 48.66 g under 7 ds/m EC and 0.5% SEO combined exposure (EC2/SEO1). Their research however did not test the effect of any agent in ameliorating the effects of the induced contamination as done in the present study.

The implications of these results is thus that when tomato plants are exposed to exceedingly high contamination, fruit properties like the total yield of the fruits per plant and the average weights of the fruits produced would be drastically reduced. However, these changes may not be so significant when the contaminant level are not overwhelmingly higher than globally acceptable limits as found in this study. Studies by Ezeonu *et al.* (2022b) where growth of maize seedlings were significantly reduced and oxidative stress was significantly hiked in maize planted in soils with induced lead, cadmium and boron contamination. The bioaccumulation 0.5 g metal contaminant per kg of soil used in the study of Ezeonu *et al.* (2022a) were also found to considerably decrease in the groups where induced contaminations were done alongside treatment of such soils with ginger extract. This also corroborates the findings of the current study that ginger has the potential to cause a decrease in Pb bioaccumulation in plants.

Further biological factors that could be explored in the bioremediation of soils contaminated with either organic or inorganic contaminants include use of biosurfactants produced from microorganisms like fungi and bacteria in the bioremediation of environmental contaminants; a promising option. For instance, two fungal isolates, *Mucor spp* and *Fusarium spp.* have been shown in the study of Ezeonu *et al.* (2022a) to have genuine potentials in the remediation of kerosene contaminated soils. In addition, some bacteria species of genus *Desulfococcus, Thauera, Dechloromonas* and *Azoarcus* have been shown to have hydrocarbon degradation capacity (Weelink *et al.,* 2010). More researches should thus be targeted at the induced mutations that enhance the overproduction of the microbial metabolites responsible for the biodegradation processes in such microbes.

CONCLUSION

Results of the study indicated that tomato fruit Pb bioaccumulation was significantly reduced by soil treatment with ginger. This finding could be supported by the chelating effect of ginger on heavy metals as reported in many studies. Nevertheless, the Pb content of these tomato fruits were significantly higher than the globally accepted limits set by bodies like WHO/FAO, USEPA and EU in all groups in the research and as such raising a great public health concern, while also hindering many of the Sustainable Development Goals (SDGs) set by the United Nations, UN from being actualised. In addition, the decrease of tomato fruit size and weight which may be attributed to the dehydrating potential of ginger reported in many studies may not make ginger a suitable ameliorative agent for soil contamination as these may cause a decrease in the total yield of tomato fruits and thus put farmers at a loss.

To ensure a more sustainable soil contamination and its attendant effects in plants like oxidative stress, stunted growth, delayed fruiting and perhaps most concerning to humans, food poisoning, It is suggested that parts of plants known to exhibit antioxidant properties in solving the contamination menace like the rhizomes, foliage, peels, chaff, roots, leaves and even total shoot waste from plants such as tomato itself, ginger, garlic, turmeric, orange and watermelon should be studied. Also, research works to prove the viability of these biological specimens are encouraged.

REFERENCES

Abioye, O.P., Agamuthu, P. and Abdul Aziz A.R. (2012). Biodegradation of Used Motor Oil in Soil Using Organic Waste Amendments. *Biotechnology Research International. Hindawi Publishing Corporation* 2012:1-8.

Abu-Dieyeh, M.H., Usman, K., Alduroobi, H. and Al-Ghouti, M. (2018). Mercury toxicity: The importance of microbial diversity for improved environmental remediation. *Heavy metals in the environment. CRC Press,* 2018:248–267.

Abu-Dieyeh, M.H., Usman, K., Zouari, N. and Al-Ghouti, A.M. (2020). Lead (Pb) bioaccumulation and antioxidative responses in *Tetraena qataranse. Scientific Reports* 10:17070-79.

Adriano, D.C. (1986) Trace elements in the terrestrial environment. *Springer-Verlag New York.*1986. 105123, 533

Agency for toxic substances and disease control, (2011). (www.astdr.cdc.gov/es/toxfaqs /es_tfascts143). División de Toxicología y Medicina Ambiental. Departamento de Salud y Servicios humanos de los EEUU. Washington (USA): *Servicio de Salud Pública* 269.

Ardisana E.F.H., Suárez A.M. and Álvarez S.P. (2018). Molecular and biochemical characterization of oxidative stress in tomato plants cultivated with lead (Pb). *Horticult Int J*. 2(6):399–402.

Balogun, J.K. (2017). Assessment of trace elements concentration in tissues of Tilapia Fish (*Tilapia guineensis*) from Badagry creek, Nigeria. *Journal of Applied Life Sciences International.* 10(2):1-9.

Balogun, J.K. Kareem K.O. and Ajani E.K. (2021). Trace Metals in Selected Fish Species from Five Cowries Creek, Southwest Nigeria: Consumer Safety Assessment. *Asian Journal of Fisheries and Aquatic Research.* 12(6):38-48.

Dendooven, L., Alvarez-Bernal, D. and Contreras-Ramos. S.M. (2011). Earthworms, a means to accelerate removal of hydrocarbons (PAHs) from soil? A mini-review. *Pedobiologia*. 54:187–192.

Encyclopedia of Life, (2014). Garden Tomato. *Solanum lycopersicum* L. http://eol.org/pages/ 392557/overview.

Ezeonu, C.S., Egwuatu, P.I., Imo, C., Amoo, A.O., Abah, M. A , Habibu, B., Elijah, B. D, Umeh,. Richard, N. D. and Ibo M. E (2022a). Physicochemical Properties Of Shea Butter Synthesized Biodiesel. *Int J Petro Chem Natur Gas*, 2(1):23-29.

Ezeonu, C.S., Tagbo, R., Anike, E.N., Oje, O.A., Onwurah, I.N.E. (2012). Biotechnological tools for environmental sustainability: prospects and challenges for environments in Nigeria—a standard review. *Biotechnology Research International* 2012.

Ezeonu, C.S., Tatah, V.S., Imo, C., Yakubu, O.E., Garba, Q.H. and Arowora, K., (2022b). Antioxidant potential of ginger extract on metals (lead, cadmium and boron) induced oxidative stress in maize plant. *Asian Journal of Tropical Biotechnology,* 19(2):45-51.

FAO/WHO. Joint FAO/WHO food standards programme codex committee on contaminants in foods. 5th Session; The Hague Netherlands; 2011. Available: ftp://ftp.fao.org/codex/meetings/CCCF/cccf 5/cf05_INF.pdf

Hikon, B.N., Egah, G.O., Ngantem, G.S. and Bwede, D.D. (2018). Bioavailability and Plants Uptake of Selected Heavy Metals (Pb, Zn, Cr, Cd, Ni, As and Hg) in Akwana Mining Sites and Environs, Wukari, Taraba State. Nigeria. *International Journal of Modern Chemistry*, 10(2):154-171

Hosea, Z.Y., Kator, L. and Rhoda, E. (2018). Phytochemical Properties and Antimicrobial Activities of Aqueous Extract of *Curcuma longa* (Ginger) Rhizome Extract. *Asian Journal of Research in Crop* Science 2(1):1-8.

http://www.tarabastate.gov.ng/about (2022) About Taraba State.

https://archive.epa.gov/wastes/conserve/materials/usedoil/web/html/oil.html (2016). Wastes - Resource Conservation - Common Wastes & Materials

https://www.iarc.org. (2012). A review of human carcinogens. Part C: Arsenic, metals, fibres, and dusts/ IARC Working Group on the Evaluation of Carcinogenic Risks to Humans Publish by the International Agency for Research on Cancer, 150 cours Albert Thomas, 69372 Lyon Cedex 08, France © International Agency for Research on Cancer;.

Ilahy, R., Tlili, I., Siddiqui, M.W., Montefusco, A., Daood, H., Azam, M., Siddiqui, M.W., R'him, T., Durante, M., Lenucci, M.S. and Helyes, L. (2022). Effect of Individual and Selected Combined Treatments with Saline Solutions and Spent Engine Oil on the Processing Attributes and Functional Quality of Tomato (*Solanum lycopersicon L.*). Fruit: In Memory of Professor Leila Ben Jaballah Radhouane (1958-2021). *Front. Nutr.* 9:844162

Kathuria P. and Ramachandran S.T. (2020). Lead Toxicity. www.emedicine.medscape.com /article/1174752

Koyashiki, G.A.K., Paoliello, M.M.B. and Tchounwou P.B. (2010). Lead levels in human milk and children's health risk: A systematic review. Rev Environ Health. 25(3):243–253

Lam S.S., Russell, A.D., Lee, C.L. and Chase, H.A. (2012) Microwave-heated pyrolysis of waste automotive engine oil: Influence of operation parameters on the yield, composition, and fuel properties of pyrolysis oil. *Fuel.* 92(1):327-339.

Lam, S.S., Russell, A.D. and Chase, H.A. (2010) Microwave pyrolysis, a novel process for recycling waste automotive engine oil. *Energy*, 35(7):2985-2991.

Lipińska, A., Kucharski, J., and Wyszkowska, J. (2013). Urease activity in soil contaminated with polycyclic aromatic hydrocarbons. Polish Journal of Environmental Studies. 22(5):1393–1400.

Marchand, C. (2017). Phytoremediation of petroleum hydrocarbons and trace elements contaminated soil, Linnaeus University Dissertation No 279/2017, ISBN: 978-91-88357-63-2.

Molina, L. and Segura, A. (2021) Biochemical and Metabolic Plant Responses toward Polycyclic Aromatic Hydrocarbons and Heavy Metals Present in Atmospheric Pollution. Plants. 10(11):2305-2334

National Institute of Environmental Health Sciences (NIEHS) grant #P42 ES016465), Copyright ©2021 Oregon State University

Nikkhah Bodagh, M., Maleki, I., Hekmatdoost, A. (2019) Ginger in gastrointestinal disorders: A systematic review of clinical trials. *Food Sci Nutr.* 7:96– 108

Oladitan T.O. and Oluwasemire K. O. (2018). Influence of weather condition on selected tomato varieties in response to season of sowing in akure, a rainforest zone of Nigeria. *Art Human Open Acc J*. 2(6):422-426.

Onuah, F and Abrak, I. (2015). At Least 28 Children Killed by Lead Poisoning in Nigeria. Medscape Medical News. Available at http://www.medscape.com/viewarticle/844746.

Orisakwe, O.E., Herbert, O.C.M., Godwin, C.A., Ukeme, W.E. and Patrick, U. (2015). Heavy Metals in Seafood and Farm Produce from Uyo, Nigeria, Levels and health implications. *Sultan Qaboos University Med J*. 15(2):275-282.

Pepoyan, A., Harutyunyan, N., Kushugulova, A., and Hovhannisyan, N., (2022). One Health Probiotics as Biocontrol Agents: One Health Tomato Probiotics. *Plants*.11:1334-1339.

Salihu Z.O., Umar MA. (2014). Heavy metal of some spices available within FCT Abuja Nigeria, Journal of Agricultural and Food Science. 2:66-74.

Schnaas L, Rothenberg SJ, Flores M, Martinez S, Hernandez C, Osorio E, Perroni E. (2006) Reduced intellectual development in children with prenatal lead exposure. *Environmental Health Perspectives*.114(5):791-797.

Siddiqui M.W., Lara I., Ilahy R., Tlili I., Ali A., Homa F, Prasad K., Deshi V., Lenucci, M. S., and Hidder C. (2018) Dynamic changes in health-promoting properties and eating quality during off-vine ripening of tomatoes. *Compr Rev Food Sci Food Saf*. 17(6):1540-1560.

Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K and Sutton, D.J. (2014). Heavy metal toxicity and the environment. *Molecular Clinical and Environmental Toxicology*. 101:133-164.

Umaru, I.J., Boyi, R.H., Miyel, M.H., Kukoyi, A.J., Umaru, K.I., Umaru, H.A. and Kanati, M. (2018). Antdiabetc Potentals of Leaves Extract of *Barringtonia Racemosa* (L) in Alloxan-Induced Albino Rats. *Am J Pharmacol Pharmacother* 5(2):1-5.

Weelink, S.A.B., van Eekert, M.H.A. and Stams, A.J.M. (2010). Degradation of BTEX by anaerobic bacteria: physiology and application. *Rev Environ Sci Biotechnol* 9:359–385

Yaradua, A.I., Alhassan, A. J., Nasir, A., Bala, M., Usman, A., Idi, A., Muhammad, I. U., Yaro, S. A. and Muhammad, I. (2019). Heavy Metal Burden and Evaluation of Human Health Risks in Tomato Fruits Cultivated in Katsina State, North West Nigeria. *Asian Food Science Journal* 9(1):1-10.

Zhang, K.; Chai, F.; Zheng, Z.; Yang, Q.; Zhong, X.; Fomba, K.W.; Zhou, G. (2018) Size Distribution and Source of Heavy Metals in Particulate Matter on the Lead and Zinc Smelting Affected Area. *J. Environ. Sci.* 71:188–196.