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Lead in Earthworms of Vegetable Farms in Peri- urban Lagos: Evidence of Soil Pollution Threatening Soil- based Food Security in Nigeria

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ABSTRACT
Lead (Pb) is a toxic heavy metal having devastating impact on the environment. This study was carried out in Lagos State, with the aim to determine Pb levels in soils and earthworms, as well as the implications of soil pollution on food security in Nigeria. Experimental and review research designs were adopted. Samples of soil and earthworms were collected using appropriate tools, from various farm sites of arable vegetable farms and uncultivated sites at Isheri, LASU, Okokomaiko, Ejigbo and Shasha. Samples were collected in clean polythene bags and bottles for AAS analysis. Results were presented in a table, and a graph while scholarly works were reviewed on the implications of soil pollution on food security. Results showed that the concentrations of Pb in both earthworms and soils of Ejigbo, LASU, Okokomaiko and Shasha were higher than at Isheri and the Control site; suggesting that Pb uptake rates of earthworms are proportional to soil Pb concentration within the studied soil. The presence of higher concentrations of Pb in most of the locations portend health risk to members of the ecosystem, as it can enter food chain to affect human health. The literature reviewed showed that only about 37% of Nigeria's soil resources is acclaimed productive, while the 63% is unproductive and degraded, with consequential reduction in crop yields posing high costs of food items, and making the country food insecure. It was recommended that farmers should reduce the application of agro-chemicals to allow for natural regeneration of soils by earthworms, and they should use environmentally-friendly fertilizers to produce crops, under the supervision of relevant authorities.
Keywords: *Vegetable farms, lead, pollution, food security, earthworms.*

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I. Introduction

One of the most critical challenging issues being faced by the world's governments is how to feed the nearly 8 billion people. Soil is the main resource base and the most productive natural capital in both the developed and developing countries. Many non-pedologists often describe soil as any 'dirt', 'building material', 'heap of sand, silt and clay' or 'overburden' that needs to be removed to extract minerals below the surface of the Earth (Ahn, 1974; Asthana & Asthana, 2012). Soil is however, much more than that. Soil is a multifunctional entirety full of matter, capable of supporting plentiful of crop-plants and animal life that human beings are depending on for survival. Soil comprises mineral matter, water, air, organic matter and organisms. Hence any damage to one of these components is damage to all, which may result in low crop yields, capable of threatening food security. Soil is utilized for crop production, grazing, forestry and other purposes to meet dietary needs of human beings (Ahn, 1974; Mather, 1988; Numonaya, Maton, Dibal, Galadima & Olowolafe, 2022). The Food and Agriculture Organization (FAO) (2018) aptly describes the functions of soil as: control of substance and energy cycles, basis for life of plants, animals and man, basis for the stability of buildings and roads, basis for agriculture and forestry, carrier of genetic reservoir, document of natural history and archaeological and paleo-ecological documents.

The role of earthworms in fertilizing the soil was known since 1881, when Darwin (1809-1882) watched them drag leaves, sand and stones into their burrows; and by calculations, he estimated 53,767 earthworms occupying each acre of English countryside (Bhadauria & Saxena, 2010). Earthworms are the most important members of the soil biota promoting microbial activity greatly by accelerating the breakdown of inorganic and organic matter to stabilize soil aggregates (Edward & Bohlen, 1992). According to Are, Igbokwe, Asadu and Bawa (2010), earthworms aid in conversion of raw vegetable matter to humus, mixing of humus with mineral portion of the soil, carrying of organic matter to the subsoil as they burrow, formation of soil through their burrowing activities, which enhance percolation and aeration, formation of casts to give the soil granular structure and heaping of leaves to form middens. Fragmentation, aeration and breakdown of organic matter in the soil by organisms help to release nutrients, secrete the plant-growth hormones, enhance nitrogen fixation, carbon and phosphorus dynamics which become accessible to crop-plants.

Plant nutrients are regularly regenerated by decay, decomposition and mineralization of organic matter deposited by living organisms, which also solubilize the nutrients from rock fragments and soil particles (Asthana & Asthana, 2012). However, the use of agro-chemicals is detrimental to the soils as they deprive such soils of organic matter on which earthworms and other soil microbes thrive and eventually, the soils may lose nutrient regeneration capacity. Earthworms act as the soil conditioners and are often described and acknowledged as "the farmer's friends", "ecological engineers", "biological indicators", "intestines of the Earth" or "the plowman of the field" (Bhadauria & Saxena, 2010; Little, 2011; Thejesh, 2020). Earthworms constitute a substantial proportion of macro-fauna biomass, where they regulate the mineralization and humification processes as well as accumulate biogenic structures such as casts, pellets, galleries and middens.

The presence of pollutants is the cause of soil pollution which is posing serious threat to sustainable agricultural food supplies to meet the dietary needs of nearly 8 billion people across the world. Urban agriculture can be at great risk to soil contamination and crops by Pb and other heavy metals when the farm produce are consumed (Dong, Taylor & Gulson, 2020; Mahuta, 2020). Insufficient arable land in cities is compelling farmers to apply sludge waste, chemical fertilizers, and pesticides as well as wastewater to irrigate vegetable farms to meet urban nutritional needs, which poses health risk to humans, as heavy metals like lead, copper, iron, cadmium and arsenic can easily bio-accumulate (Tu, Zheng & Chen, 2000; Nicholson et al., 2008; Amit et al., 2020). Despite increase in the public awareness of the environmental pollution in recent years, little attention is being paid to soil pollution emanating from warfare, agriculture, transport, industry, mining and quarrying.

Lead is one of the heavy metal pollutants found in the air, soil and water bodies, which emanates from smelting, combustion of leaded gasoline and lead-contaminated media such as sludge, solid waste, fertilizers and other agro-chemicals applied to farmlands. The most diffusive chemicals occurring in the soil are heavy metals, pesticides, poly-chlorobiphenyl (PCBs) and petroleum hydrocarbons; exacerbated by intensive agricultural practices, mining, industrialization and rapid urbanization that leads to poor municipal waste management (Ogundele, 2012; Ying, 2020; Numonaya et al., 2022). When profits from the sales of the tonnes of farm produce or finished products of industrial activity are shared annually by the beneficiaries, little or no information is made public on the negative impact of the pollutants on soil ecosystem and food security (Adewole, 2015).

Many studies have been conducted on soil pollution in different places of the world, including Nigeria (Little, 2011; Pourrut et al., 2011; Ogundele, 2012; Werkenthin & Wessolek, 2014; Oketola & Olaoye, 2015; Mahuta, 2020; Dong, Taylor & Gulson, 2020; Numonaya et al., 2022). However, the analysis of existing literature shows that studies conducted so far, have largely been limited to developed countries. Thus, vital information gaps still exist regarding the presence of Pb in earthworms as evidence of soil pollution threatening soil-based food security in peri-urban Lagos of Nigeria. The present study aims to investigate Pb levels in earthworms of soils under vegetable farms in peri-urban Lagos, as well as the implications of soil pollution on food security. It is hoped that the outcome of the study will guide relevant authorities to make policies that will ensure croplands are safe to guarantee sustainable crop production in compliance to the Sustainable Development Goal 2 (SDG2) of the United Nations, which is to: "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by 2030.

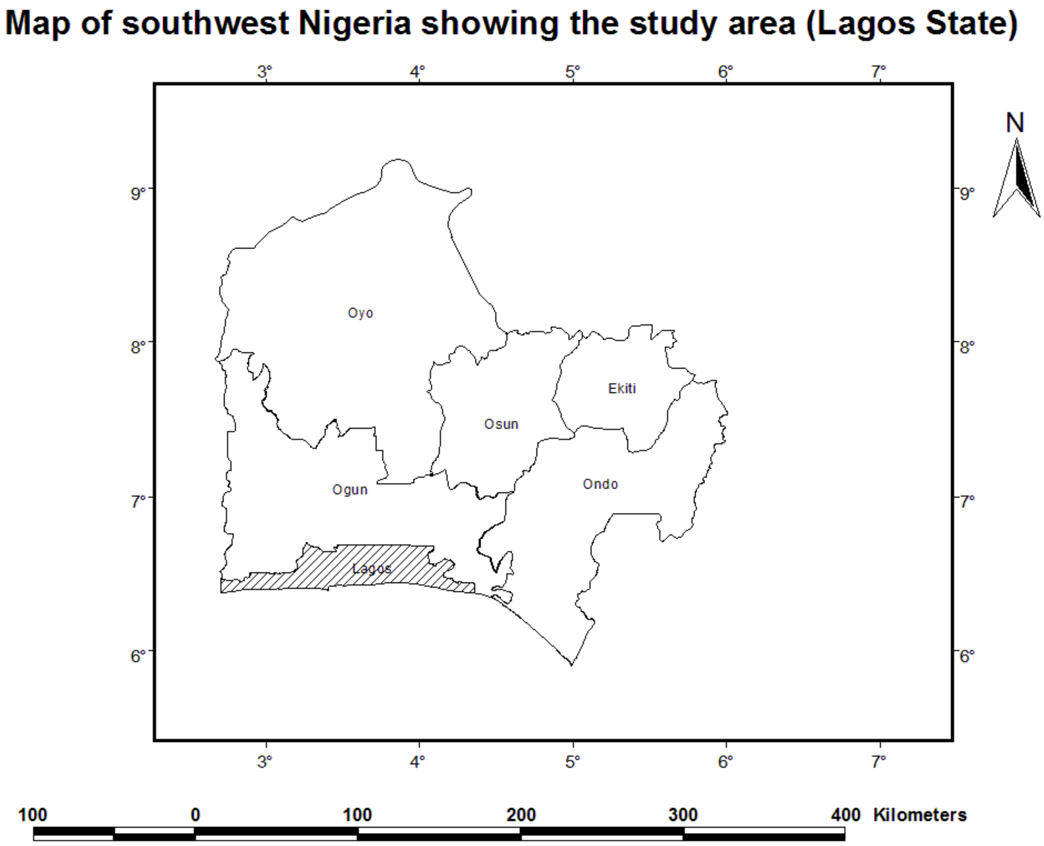
II. Materials and Methods

The Study Area: Lagos State

Lagos, the former Federal Capital of Nigeria is located at 6°27'15" N & 3°23'41" E (Figure 1). Lagos occupies an area of 500km², with little arable farmlands for extensive agriculture. Lagos falls within the Koppen's "Am" climate type, with two distinct rainy and dry seasons. The more intense wet season occurs from April to July, with a milder one in October to November (Ogundele, 2015). Rainfall vary between 1,380mm and 2,700mm per year, while the mean annual temperature is about 27°C. Lagos is dominated by numerous Islands, sand bars and lagoons, located around the western coast of Nigeria. Four soil groups covers Lagos State, namely: the juvenile soils of the recent wind-borne sands on the Western side of coastal margins; the juvenile soils on fluvio-marine alluvial Mangrove Swamp to the East; hygromorphic soils in the middle and Northern and Eastern sections of the State; and the red ferrallitic soils on loose sandy sediments occurring in tiny discontinuous patches in the Northern limit. All these soil groups support two main vegetation types namely, the swamp forest of the coastal belts thriving under the brackish water and the tropical rainforest zone which lies North of the swamp forests.

Lagos is one of the largest cities in Nigeria, being occupied by over 14 million people, which makes it the 7th most populous city in the world. Although, Lagos is a cosmopolitan area, some residents engaged in urban farming, producing mainly perishable crops for immediate consumption. Farms are privately owned mainly by individuals, with the exception of farms located at LASU. While some arable farmlands in LASU, Okokomaiko, Shasha, Isheri and Ejigbo settlements are intensively cultivated, using municipal solid wastes and agro-chemicals. Hence, farmlands here were used as the experimental sites, while the uncultivated arable areas served as the control point for this study.

Fig. 1: Map of Southwest Nigeria showing the Study Area (Lagos State)
Source: Culled from Ogundele (2012: 246).



Sampling and Treatment

The first set of the sampling point which constitute the experimental were arable farmlands under vegetable where farmers use fertilizers and pesticides intensively for urban crop production, while the second set called the Control site is a bare arable land with no visible agricultural activities. Soil samples were collected from both the experimental and Control sites around November. Samples were picked from vegetable farms located in Lagos State University (LASU) (6°28'08"N & 3°11'00"N), Okokomaiko (6°27'11"N & 3°24'00"E), Shasha (6°36'11"N & 3°17'52"E), Isheri (6°34'31"N & 3°16'53"E) and Ejigbo (6°33'08"N & 3°18'26"E). Each site was divided into rectangular sections (3m x 3m), which makes 18 sampling points. Three sampling points from each of the sites were sampled at depths of 10-20cm. A total of 18 soil samples and earthworms were collected within the study area. The soil samples were kept in properly labelled clean polythene bags, while earthworms in plastic bottles. The soil samples of each point was thoroughly mixed, air dried for four days and ground in an agate mortar with pestle. Each of the 18 soil samples were ground separately. They were then sieved with a 5mm sieve. Thereafter, the fractions were collected and stored in polythene bags, for further treatment. Chemicals and reagents used were of analytical grade and were directly used without further purification. Other materials used were soil auger, digger, shovel, soil-test kits, Whatman filter paper, polyethylene bags, soil sugars, quartz beaker, plate, flask, distilled water, mortar and pestle. Geographic positioning system (GPS) device was also employed to get the location of each chosen settlement.

Earthworms were obtained from similar sites to soil sampling points by digging holes: 20cm x 20cm wide and 10cm deep. They were collected by hand sorting and kept in labelled plastic bottles. They were stored and frozen in a freezer. Earthworms in each of the frozen bottles were thawed, digested with 3ml concentrated citric acid (HNO3), and heated up to dry over an oven at 100°C. The digest was re-dissolved in 2ml concentrated HN03 and thereafter, added up to 25ml mark with distilled water in readiness for atomic absorption spectrometry (AAS) analysis. The formula (Oketola & Olaoye, 2015) used for Pb analysis was:

Concentration (mg/kg)= con.(mg/liter) x volume of sample x (0.025liter)/weight of sample (kg) __________________ (1)

For the soil samples of each location, 2g of the soil samples were weighed into a quartz beaker with 10mls of HNO_3 added and gently heated in the oven. The heating continues till the brown fumes disappeared, leaving white dense fumes. The beaker was brought down to cool down to room temperature. The mixture was rinsed with 20mls of deionised water and filtered with Whatman filter paper into a standard 25mls volumetric flask and made up to the mark in readiness for the AAS analysis. The aqua regia was used in digesting the soil sample. The resultant solution in the conical flask was placed on the plate in the fume cupboard until the mixture boiled. The heating continued till the brown fumes disappeared, leaving behind white dense fumes. The clear colourless digest was cooled. It was then made up to 25mls mark, with distilled water in a volumetric flask and later filter with the aid of a funnel and Whatmann filter paper into the immersed bottle ready for AAS analysis.

III. Presentation of Results and Discussion

Data obtained from the cultivated and uncultivated soils as well as the earthworms found were duly processed, analyzed and presented in a table and a compound graph in this section. Thereafter, the highlights of the results were discussed as well as the implications of soil pollution on food security in Nigeria.

Lead concentration in soils under vegetable farms of peri-urban Lagos

Table 1 shows the Pb concentrations at various sites of soils under vegetable farms and the Control site in peri-urban Lagos. While no amount of Pb was detected at Isheri and the Control site, it was found to be present in all the other sites of LASU, Okokomaiko, Ejigbo and Shasha farms.The highest mean concentration of over 2.53mg/kg (2,530mcg) was found at Ejigbo vegetable farms in all the 3 sites, which was followed by those of LASU, Okokomaiko and Shasha, with the mean Pb concentrations of: 1.1510mg/kg (1,151mcg), 0.7773mg/kg (777.3mcg) and 0.1273mg/kg (127.3mcg) respectively. The presence of Pb in soils of Ejigbo, Okokomaiko and LASU could be attributed to their proximity to the busy motorable roads. The result obtained for Pb concentration in soils of Isheri is not in agreement with the Oketola and Olaoye's (2015) report of Pb concentration of 0.19mg/kg at the control site and between 0.70-15.82mg/kg at various sites of Isheri cattle market.

Heavy concentration of Pb in soils is known to induce a broad range of toxic effects to living organisms, including those that are morphological, physiological and biochemical in origin that maintain the fertility of the soil (Pourrut et al., 2011). Lead impairs plant growth, seed germination and development, chlorophyll production, root elongation, transpiration, cellular organization in chloroplast and cell division. Thus, Pb pollution decreases soil fertility, alters soil structure, interferes with the balance between the flora and fauna in the soil, contaminates crops, surface and groundwater, thereby posing a serious threat to the organisms and food security. The United Nations Environment Programmes (UNEP) as quoted in Izuaka (2021), also asserts that in all the studied animals, Pb has been shown to adversely affect blood, central nervous, kidney, reproductive and immune systems because of the neutrotoxicity and nephrotoxicity, while in plants Pb impairs photosynthesis and growth.

Table 1: **Lead concentration in soils under vegetable farms (mg/kg)**

location	Pb in Site 1	Pb in Site 2	Pb in Site 3	Mean Pb
Ishere	0.0000	0.0000	0.0000	0.0000
LASU	1.1520	1.1510	1.1500	1.1510
Okokomaiko	0.7730	0.7750	0.7720	0.7773
Ejigbo	2.5500	2.5300	2.5100	2.5300
Shasha	0.1870	0.1600	0.03490	0.1273
Control Point	0.0000	0.0000	0.0000	0.0000

Lead concentration in soils and earthworms under vegetable farms

Analysis of data on Pb levels in soils and earthworms under vegetable farms in peri-urban Lagos are presented in figure 2. Results have indicated that Ejigbo has the highest concentration of Pb in both soils and earthworms, whereas at LASU, the Pb level is very high in soils (1.151mg/kg) but nil in earthworms. The absence of Pb in earthworms of soils in LASU could mean the earthworms had taken un-leaded soil prior to their harvest while the presence of Pb in both the soils and earthworms of Okokomaiko is an indication that the earthworms had eaten the leaded soils prior to their harvest. It was found that some amount of Pb were present in both soils and earthworms of farms in Shasha but at low concentrations of 0.1273mg/kg (127.3mcg) and 0.032mg/kg (32mcg) respectively.Therefore, it is safe to conclude that Pb distribution varies even within the same garden. The anayzed result also showed there was no Pb in both soils and earthworms in Isheri farms and the Control site, contrary to the 0.32-1.79mg/kg values reportedly obtained by Oketola and Olaoye (2015) at the sampled points of Isheri market. This suggests that Pb uptake rates of earthworms are to a large extent, proportional to Pb concentration within the studied soils. The presence of earthworms in most of the gardens could mean most of the soils are not abrasive to earthworms and contain appreciable quantities of Pb pollutant that can be hazardous to human health when it gains entry into food chain.

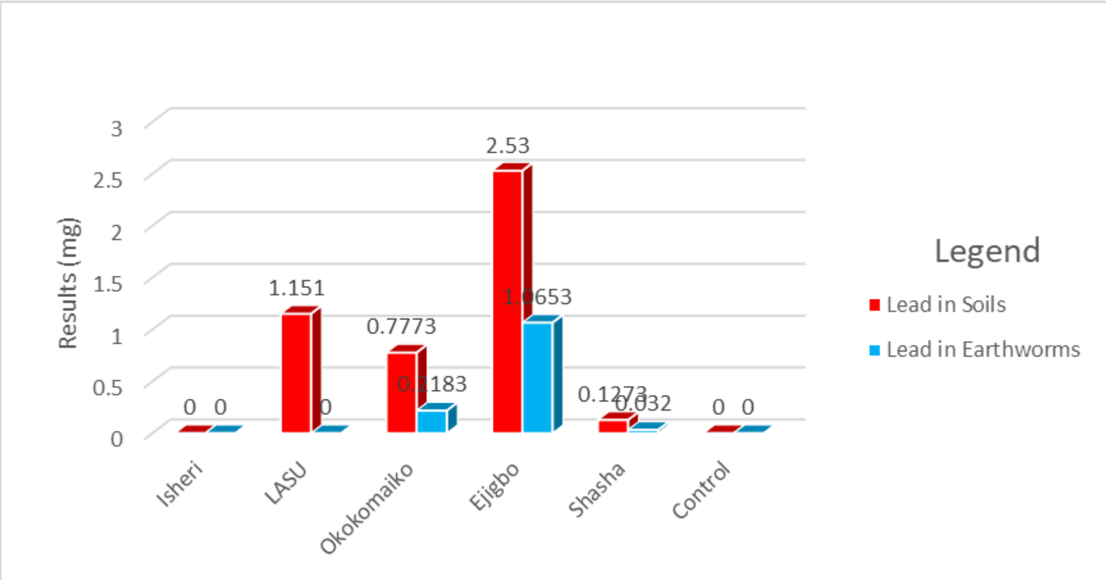


Fig.2: Pb levels in soils and earthworms under vegetable farms (mg/kg)

IV. IMPLICATIONS OF SOIL POLLUTION ON SOIL-BASED FOOD SECURITY

The term "food security" refers to the citizens' access to enough food at all times and at affordable prices to meet dietary energy needs. Food security exists when all people at all times have physical and economic access to safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (Yusuf & Francis, 2019). Food security has gained prominence in the political and scientific arena after the global food crisis, caused by the 83% increase in global prices (Dangulla and Hassan, 2017). The protection of soil from getting degraded is essential to the SDG2 which is to: "end hunger, achieve food security and improve nutrition and promote sustainable agriculture" by 2030. The importance of soil to organisms and human well-being in supporting sustainable agriculture, empowering small-scale farmers, ending rural poverty, ensuring healthy lifestyles, and other issues addressed within the set of 17 SDGs in the Post-2015 Development Agenda cannot be over-emphasized. Soil pollution, which is the presence in the soil of a chemical or substance out of place or present at a higher than normal concentration that has adverse effects on any non-targeted organisms is undermining the achievement of healthy lifestyles and food security in developing countries, including Nigeria. Anything detrimental to the earthworms and living community within soils tends to cause its degeneration, loss of fertility and increases the rate of soil erosion (Asthana & Asthana, 2012). Soil pollution presents a serious threat to earthworms, soil productivity, crop yields, food safety and human health. Activities such as industrialization, mineral mining, and intensification of agriculture using agro-chemicals have impacted the global soils negatively. The chemicals used in or produced as by-products of fertilizer and allied industrial activities which infuse heavy metals into soils are the major sources of soil pollution.

Soil pollution is not limited to developing countries alone, it affects the developed countries of the world too. According to FAO (2018), worldwide pressures on soil indicates that Australia have 80,000 sites estimated to suffer from soil pollution; China has 16% of its soils and 19% of its agricultural soils polluted; in the European Economic Area and the West Balkans, around 3 million potentially polluted sites exists; and in the United States, 1,300 sites appear on a national list of pollution hotspots. With the estimated growth from the current 900 million to 1.4 billions by 2030, the sub-Sahara African's soil (including Nigeria) will experience increasing pressure to provide for the vital dietary and industrial needs of its people (Nnabuife, 2019).

According to UNEP (Izuaka, 2021), the global use of pesticides has increased by 75% between 2000 and 2017, and with some 109 million tonnes of synthetic nitrogen fertilizers applied worldwide in 2018. The use of plastics in agriculture also increased significantly in recent decades with 708,000 tonnes of non-packaging plastic consumed in agriculture in the European Union in 2019, while the global annual production of industrial chemicals has doubled to 2.3 billion tonnes since the beginning of the 21st century, which is projected to increase by 85% by the end of 2030. The report further asserts that the world's annual waste production has risen to 2 billion tonnes and has been projected to increase to 3.4 billion tonnes by 2030 due to population growth and urbanization.

According to Akinbode (2002), the population of Nigeria has been rising rapidly since the beginning of 1901, when it was only 11 million; by 1911 it rose to 16 million; increasing to 19 million in 1931; to 30.4 million in 1952; to 55.7 million in 1963; to 75 million in 1973; and the 1991 census gave a figure of 88.5 million. The National Population Commission (NPC) announced Nigeria's population in 2006 to be 140 million people, with annual growth rate of 2.5% or 5.5 million people. Therefore, the current population figure stands at over 222 million people. Nigerians are occupying a land area of 91,077,000 hectares, of which about 72,000,000 hectares are under rain-fed and 1,000,000 hectares under irrigation crop production. By simple calculations, the per capita arable land is just 0.304 hectare, which is grossly inadequate to guarantee adequate supply of food sustainably to end hunger, achieve food security, improve nutrition and promote sustainable agriculture by 2030. This explains in part why Nigerian farmers can hardly feed the Nation for even half a year, compared to their American counterparts who are able to produce enough food to feed the entire nation and grow raw materials for the allied industries. In Nigeria, the agricultural sector has declined from 80% in the 1960s to merely 34% in 2003, resulting in hunger, malnutrition, and kwashiorkor among individuals and households (Yusuf & Francis, 2019). The National Bureau of Statistics (NBS) as quoted in Allegheny (2021), asserts that about 40% or 83 million Nigerians live in poverty and the number was projected to reach 45% or 90 million by 2022. The report further asserted that Nigeria's population has been growing by about 2.6% per annum, while agricultural value added is merely 2.0% . This has further proved that agricultural output is barely keeping pace with consumption which is signalling shortage of food, manifesting in high prices of food items and poverty. This may be the reason why averagely, 21.4% of Nigerians had experienced hunger between 2018 and 2020; and in severe food insecurity, they would go for entire days without food due to lack of purchasing power.

There are natural and man-made factors undermining soil fertility in Nigeria. Apart from such processes like leaching, gleization, laterization, gully and sheet erosion, human factors are also contributing to soil impoverishment. Modern agricultural practices such as the advancing agro- technology, huge quantities of fertilizers, pesticides, herbicides and weedicides meant to increase yields of crops we eat sometimes pose serious threat to the water we drink and earthworms that maintain soil health. Excessive agro-chemicals usage enhances heavy metals accumulation, water eutrophication and accumulation of nitrate that is capable of killing earthworms and other soil-dwelling organisms; as living communities in the soil are the basis of its fertility and other properties which promote growth of a healthy plant life on it years after years in succession (Asthana & Asthana, 2012). The introduction of pollutants into Nigerian soils has reduced productivity such that only 37% of the agricultural land is acclaimed to be of good productivity, while 63% is presently not very fertile (Akinbode, 2002). Soil pollution impacts food security by harming earthworms and other soil micro-and macro-fauna, impairing plant metabolism, reducing crop yields as well as making crops unsafe for animal and human consumption, thereby increasing costs of food production to the farmers. The decline in agricultural production resulting in food shortages, high food prices and famine adversely affects nutrition and health of the population and causes decline of labour productivity (Enabor & Sagua, 1988).

Akinbode (2002) reported that in a survey of 10 villages in Ovia LGA of Edo State, it was discovered that 50.25% of the farmers interviewed wished to quit farming because it was no longer a profitable venture, as crop yields were low and vary widely from year to year. As a result, farmers were finding difficulty in meeting their financial obligations, such as school fees for their children, community development funds and religious contributions. The report by FAO (2021) on Nigeria indicates that about 14.4 million people, including 385,000 internally displaced persons (IDPs) in 21 States and Federal Capital Territory (FCT) are already in food crisis; and the number is projected to reach 19.4 million between June and August 2022, against the estimated 12.8 million in 2021 (FAO, 2018). Those affected are Abia, Adamawa, Benue, Borno, Cross-River, Edo, Enugu, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Lagos, Niger, Plateau, Sokoto, Taraba, Yobe and Zamfara States and the FCT. Although the report identified insurgency in North-Eastern States, banditry in the North-West and North-Central States, it is an indisputable fact that soil degradation is contributing immensely to low crop yields and food insecurity. The World Bank (Allegheny, 2021) has asserted that inflation in Nigeria has plunged about 7 million people into poverty by increasing food prices to 22%. Rising food prices is exacerbating poverty because it reduces the real purchasing power of households, and shifts expenditure away from essential items such as health, education and housing. An average Nigerian household spends 56% of income on food, which is the highest in the world, as countries like United States of America, United Kingdom, Canada and Australia spend just 6.4%, 8.2%, 9.1% and 9.8% respectively. Further analysis has indicated that on average, 21.4% of Nigerian population have experienced hunger between 2018 and 2020 and those in severe food insecurity may even go whole day without food due to lack of purchasing power.

It is therefore obvious that Nigeria's polluted soils are hindering the achievement of nine of the United Nations' Sustainable Development Goals (SDGs), including those related to: poverty elimination (SDG1), zero hunger (SDG2), good health and well-being (SDG3), vulnerable children and women (SDG5), supply of safe, un-polluted groundwater and surface water (SDG6), degradation and loss of terrestrial (SDG15) and aquatic (SDG14), biodiversity and decreased security and resilience of cities (SDG11) (FAO & UNEP, 2021). This means, halting and reversing soil degradation should be critical to meeting the food needs of the citizenry because eradicating poverty and hunger are integrally linked to boosting food production.

V. CONCLUSION AND RECOMMENDATIONS

Lead pollutant abounds in earthworms of most soils studied under vegetable farms in peri-urban Lagos. High concentrations of Pb was detected in two-thirds of the studied locations in Lagos area. The sources of Pb are likely the application of agro-chemicals to soils under vegetable farms, the discharge of sludge, municipal wastes, constant combustion of leaded gasoline by automobiles plying the urban roads of Lagos, among others. Lead is a threat factor to earthworms that maintain soil fertility and poses threat to food security in Nigeria. This paper has argued that for the people to be food secure, they must have access to sufficient nutritious and safe food that does not expose consumers to Pb and other heavy metal concentrations through food chain. Sequel to this, the paper recommends that:

1. Farmers should substitute chemical fertilizers with animal wastes and minimize the use of harmful agro-chemicals, instead, they should substitute them with environmentally friendly agro-chemicals.
2. Importation of harmful agro-chemicals should be banned and solar panel should be developed for use as an energy option for automobiles.
3. The State's Ministries of Agriculture and Environment should encourage farmers to use organic fertilizers in order to avoid accumulation of Pb and other heavy metals and their entry into food chain to pose health risk to the residents.
4. The State's Ministry of Agriculture should carry out soil quality assessment at regular intervals and promptly rehabilitate any severely polluted soil in order to safeguard the health of residents.
5. Farmers should guard against further damage to soil by planting only pollution- tolerant crops such as tomatoes, peppers, melons, okro, apples, oranges, corn, peas and beans.

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