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Analysis of Lead Toxicity and Organic contents in Soils under Vegetable Farms in Lagos urban area of Nigeria

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Abstract
Soil is one of the vital environmental resources utilized by human beings for crop production, forestry, grazing and industrial purposes. This study was carried out in Lagos State, with the aim to determine lead toxicity, total organic carbon, organic matter and the soil pH under vegetable farms. The study adopted the experimental research design. Soil samples were collected from various farm sites of arable vegetable farms and uncultivated sites located at Isheri, LASU, Okokomaiko, Ejigbo and Shasha. Samples were collected in clean polythene bags and taken to laboratory for AAS analysis. Results of the analyzed soil samples from cultivated and uncultivated sites were compared and thereafter presented in tables and charts. Results revealed that the lead concentration in Ejigbo, LASU, Okokomaiko and Shasha were higher than that of control site. It was noted however, that while the lead level for Isheri was zero, the total organic carbon and organic matter were higher than the values obtained from the control site. The pH values for all the locations range from 7.0 to 7.5, indicating the soil's pH was neutral-alkaline. The presence of higher concentration of lead in most of the locations portend health risk to humans, as lead can enter food chain. It was therefore, recommended that farmers should henceforth reduce the application of chemical fertilizers and resort to the use of organic manure which is more environmentally friendly.

Keywords: *Lead, toxicity, organic carbon, organic matter, soil pH, vegetable farms.*

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I. Introduction

Much of the surface of the Earth is covered with different soil types which are frequently utilized for crop production, grazing, forestry and other purposes to meet today's and future needs of human beings (Ahn, 1974; Mather, 1988). Soil is one of the vital environmental resources occupying important position in the overall welfare of plants, animals and human beings. This is why Henry Ahlgren once asserted that, "the soil comes first, it is the basis and foundation of good farming, without it nothing, with poor soil, poor farming and poor living. An understanding of good farming begins with an understanding of soil" (as quoted by Ahn, 1974). This implies that the greater our understanding of soil, the greater is the chance of using it judiciously, wisely and sustainably.

The continued search for improved quality of life is currently leading to increased anthropogenic activities in both the urban and rural areas. In order to boost crop yields and guarantee food security for the teeming population of over seven billion (7,000,000,000) people globally, the introduction and use of agro-chemicals have become imperative in agricultural production. While the use of chemicals increase soil fertility by ensuring high crop yields per unit area of land, such an exercise sometimes lead to high concentrations of some heavy metals, thereby causing soil pollution. Soil pollution has increased nowadays due to intensive use of biocides and fertilizers in the agricultural sector. Heavy metals can be found in traces in water sources yet highly toxic, imposing health problems to humans and other members of the ecosystem. This is because the toxicity level of a metal depends to a large extent on factors such as: the organism which is exposed to it, its nature, its biological role and the period at which such an organism is exposed to the metal (Lee, Bugham & Farre, 2002).

Despite a long history of its beneficial use by human beings, lead has no biological function in living organisms, hence is now a pollutant of great concern to the scientific world. Lead can be found in all the component parts of the environment (air, soil and water). It is one of the most toxic material that is widely used in transport and industrial processes, which in its natural level remains below 0.50 mg/kg and occurs in all environmental compartments such as soil, air, water and organisms (Pourrut, Shahid, Dumat, Winterton & Pinelli, 2011; Ogundele, 2012). These sources include smelting, combustion of leaded gasoline, applications of lead-contaminated media, such as sludge, solid waste and fertilizers to arable land. Run-offs from roadways is also one of the sources of lead poisoning in the soil, which most times finds itself from the soil to the water bodies (Cicek, Malkoc & Koparal, 2012). The contribution of road transport to the global emissions of atmospheric pollutants is regularly increasing (Vachova, Vach & Najnarova, 2017; Cicek et al., 2012; Serbula, Miljkovic, Kovcicevic & Illic, 2012). The most diffusive chemicals occurring in the soil are heavy metals, pesticides, petroleum hydrocarbons and polychlorobiphenyl (PCBs), which are exacerbated by intensive agricultural practices, mining, industrialization and rapid urbanization that leads to poor municipal waste management (Ogundele, 2012; Ying, 2018).

According to Dong, Taylor and Gulson (2020), urban agriculture, which is widely practiced in urban areas of developing countries, including Lagos in Nigeria, can be a great risk to soil contamination by lead and other heavy metals. This view was supported by Mahuta (2020), who argued that great risk to human health ensues when polluted soils are used to grow crop plants for consumption. Lack of sufficient arable land in cities is compelling farmers to apply manure, sludge, chemical fertilizers and pesticides, as well as wastewater to irrigate vegetable farms to meet urban nutritional needs, thereby posing health risk to humans (Tu, Zheng & Chen, 2000; Nicholson et al., 2008).

Indeed, heavy metal concentrations in urban soils is a major concern, because it is known to induce a broad range of toxic effects to living organisms, including those that are morphological, physiological and biochemical in origin (Pourrut et al., 2011). Lead impairs plant growth, root elongation, seed germination, seedling development, transpiration, chlorophyll production, a cellular organization in chloroplast and cell division. High concentration of lead in the soil can lead to their bio-accumulation in the food chain, which affects organisms and human health (Peralta-Videa et al., 2009). Thus, soil pollution decreases soil fertility, alters soil structure, interferes with the balance between the flora and fauna in the soil, contaminates crops and groundwater, thereby posing a serious threat to organisms.

Heavy metals released during traffic pose the greatest threat to areas directly adjacent to roadways. Road dust is a mixture of pollutants floating through the air, but it is also washed from road surfaces by rainwater or splashed by the wheels of moving vehicles onto the roadside to contaminate the soil, especially in major cities (Werkenthin & Wessolek, 2014). Lead poisoning occurs when people are exposed to lead and chemicals that contain lead, breathing air, taking drinks such as water and milk, eating foods such as fruits, vegetables, meats, grains and seafood, swallowing or touching dust or dirt that contains lead. Some aspects of lead effect on environment like soil, food and water has been catalogued by Seema, Tripathi and Tyroller (2013). Lead is absorbed by plants through roots which could have adverse effects on the produce from these farms which may bio-accumulate in the food chain and affects human health (Peralta-Videa et al., 2009).

Many studies have been conducted on soil pollution in different areas of the world, including Nigeria (Ahn, 1974; Mather, 1988; Pourrut, Shahid, Dumat, Winterton & Pinelli, 2012; Ogundele, 2012; Werkenthin & Wessolek, 2014; Mahuta, 2020; Dong et al., 2020). However, none of these studies have adequately covered the study area. Therefore, there is still a gap in knowledge as to how much lead, total organic carbon and organic matter are in soils under vegetable farms of Lagos urban area. It was against this backdrop that this study set to investigate the soil quality under vegetable farms in urban area of Lagos State. It is hoped that the outcome of the study will guide relevant authorities to make policies that will ensure vegetables are produced in soils devoid of polluting substances in order to safeguard people's health.

II. MATERIALS AND METHODS

Study Area

Lagos is one of the 36 States of the Federal Republic of Nigeria, located at 6°27'15" North of the Equator; and 3°23'41" East of the Prime Meridian (see figure 1 culled from Ogundele, 2012). Lagos occupies an area of 500km², with little arable land for extensive agriculture. It has a population of over 14 million people, making it the 7th most populous city in the world and is classified under Koppen-Geiger climate as "Am", which is wet and dry, with two distinct rainy seasons. The more intense season occurs April to July, with a milder one in October to November. Rainfall vary between 1,380mm and 2,700mm per year while the mean yearly temperature is 27°C.

The physical landscape of Lagos is dominated by its numerous Islands, sand bars and lagoons. The Islands are connected by bridges and the land is characterized by low-lying terrain. Lagos is endowed with very little arable land altogether. According to Ogundele (2012), four soil groups are identifiable in the 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.

The residents of Lagos engage in primary, secondary, tertiary and quaternary sectors of the economy. Though only a negligible number of residents of the state are into farming, the agricultural areas are five and privately owned namely; LASU (6°28'01"N & 3°11'00" E), 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). The sixth arable area was used as a control site where no visible agricultural activities involving the use of pesticides, fertilizers and organic manures take place. This, LASU, Okokomaiko, Shasha, Isheri and Ejigbo settlements have some agricultural lands where some residents practice intensive urban farming to feed the teeming population of Lagos State. The sites used for the study are private farmlands owned by individuals. The first site is an agricultural farmland where there is intensive use of organic manure, fertilizers and pesticides while the second site is a bare land with no visible agricultural activities which is used as the control site in this study.

Materials

The chemicals and reagents used were of analytical grade, manufactured by BDH, England. They were use directly without further purification. Others materials used were 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.

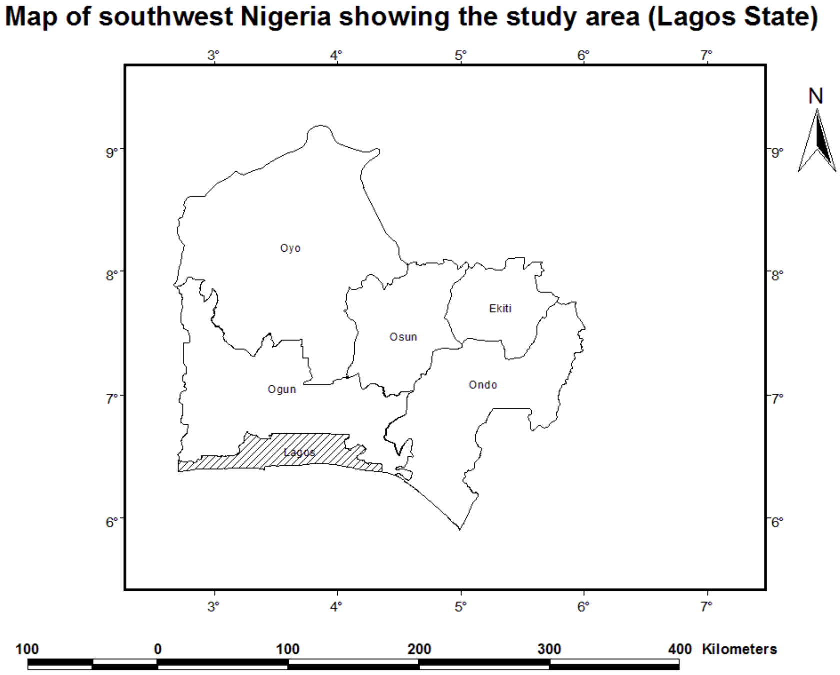

Fig. 1: Map of Southwest Nigeria showing the Study Area (Lagos State)
***Source**: Ogundele (2012).*

Sampling and Treatment

Soil samples were collected from the five sites before commencement of farming season around November. Each site was divided into square sections (3m x 3m), which makes 18 sample points. Three sampling points from each of the sites were sampled at depths of 10 to 20cm. A total of 18 soil samples were collected within the study area. The soil samples were put into black polythene bags and properly labelled. 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 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.

Determination of Heavy Metals in the Soil

Two (2) grams of the soil samples was weighed into a quartz beaker with 10mls of HNO_3 added and gently heated on a hot plate. The heating continues till the brown fumes disappeared leaving white dense fumes. The beaker was brought down to cool to room temperature. The mixture was rinsed with 20mls of deionized water and filtered with Whitman filter paper into a standard 25mls volumetric flask and made up to the mark in readiness for atomic absorption spectrometry (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 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 Whitman filter paper into the immersed bottle ready for AAS analysis.
The data of each of the samples were analyzed with the aid of Statistical Package for Social Sciences (SPSS) version 20 software. The mean of the sample from each location was calculated and in combination with percentages, results were presented in tables. Presentation of the findings were followed by highlights of what the results depict.

Results
The data obtained from soils under vegetable farms and uncultivated farms were analyzed and results are presented in tables and bar charts below.

Table 1: **Lead Concentration in Soils Under Vegetable Farms in Lagos**

location	Site 1	Site 2	Site 3	Mean
Isheri	0.000	0.0000	0.0000	0.0000
LASU	1.152	1.1510	1.1500	1.1510
Okokomaiko	0.773	0.7750	0.7780	0.7773
Ejigbo	2.530	0.0330	0.0320	0.1273
Shasha	0.031	0.0330	0.0320	0.1273
Control Point	0.000	0.0000	0.0000	0.0000

Table 1 shows the lead levels in soils of vegetable farms in Lagos State. Results indicated that there was absence of lead poisoning in soils of Isheri. However, it was detected in varying amounts in Okokomaiko, LASU, Ejigbo and Shasha sites, compared to the control site where lead was not detected at all. This implies that most soils under vegetable farms contains appreciable quantities of lead pollutant that can be hazardous to human health when it gains entry into food chain.

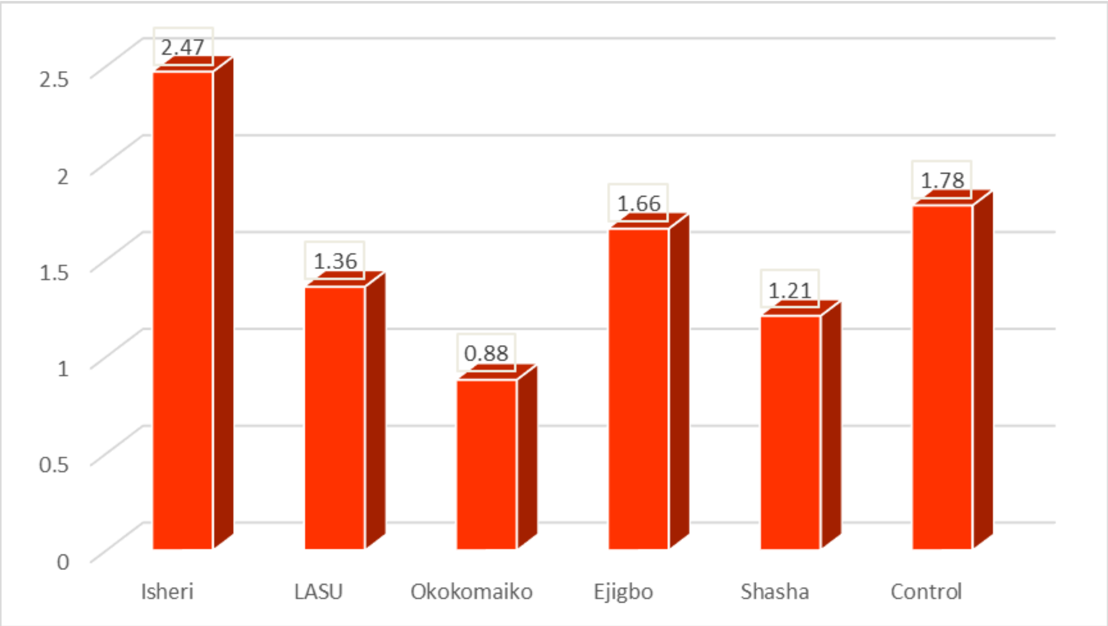

Fig. 2: Total Organic Carbon in Soils Under Vegetable Farms in Lagos

Figure 2 displays the amount of total organic carbon from soils of the six sites in the study area. Results indicated that two-thirds of all the study sites have comparably low total organic carbon, ranging from 0.88 to 1.66% as against 1.78% in soils at the control site. It is obvious that soils in Isheri have the highest total organic carbon and lowest in Okokomaiko. This indicates that there is little usage of organic matter in the study area generally.

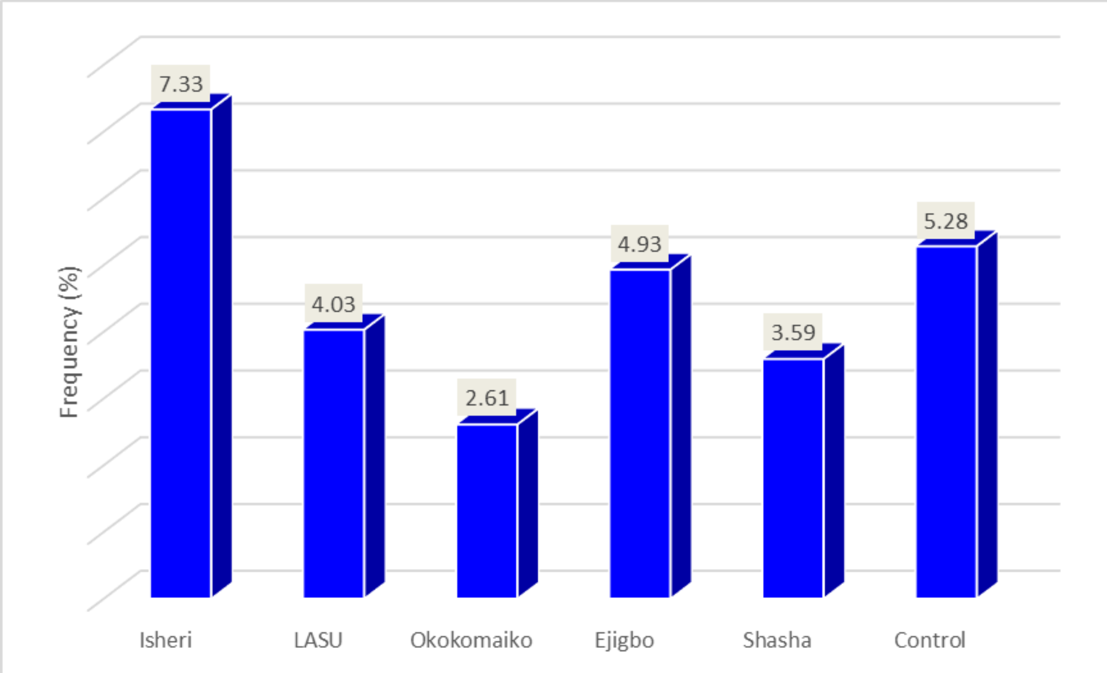

Fig. 3: Organic Matter in Soils under Vegetable Farms in Lagos

Figure 3 shows the amount of organic matter in soils under vegetable farms in the study area. Findings indicate that farms in Isheri have higher organic matter (7.33%), compared with the control site which measured just 5.28%. However, there is a progressive reduction in the amount of organic matter in soils under vegetable farms in Ejigbo (4.93%), LASU (4.03%), Shasha (3.59%) and Okokomaiko (2.61%). This requires the use of more quantity of manure in such organic matter-deficit soils in order to maintain high production of vegetable crops in Lagos State.

Table 2: **pH of Soil Under Vegetable Farms in Lagos State**

Location	pH
Isheri	7.0
LASU	7.3
Okokomaiko	7.0
Ejigbo	7.5
Shasha	7.5
Control	7.5

Table 2 shows the soil pH values of soils under vegetable farms in the study area. Results have revealed that the pH values obtained for the study range from pH 7.0- 7.5. Most of the soils were found to be neutral - slightly alkaline with both positive and negative implications on the crops grown.

III. Discussion of Results

The mean concentration of lead in soils under vegetable farms were found to be higher in Okokomaiko, LASU, Ejigbo and Shasha while that of Isheri, compared well with one from the control site. Lead is a non-essential element and it is well documented that lead can cause neurotoxicity, nephrotoxicity, and many other adverse health effects (Garcia, Mendez & Laffon, 2010). Lead (Pb) usually get into the soil mostly from road traffic and agricultural activities (Sabin et al., 2006). Lead concentration in soils under vegetable farms seem to be true for Ejigbo, Okokomaiko and LASU that are located very close to high vehicular traffic density. On the other hand, Isheri and the control site which are areas far from roads with high vehicular traffic density record less of lead concentration. The relative low concentrations of these metals in this study however indicate that they might have originated from a natural source (Cai et al., 2012). Lead exposure can induce neurological, respiratory, urinary and cardiovascular disorders due to immune modulation, oxidative, and inflammatory mechanisms. The United Nations Environment Programme (UNEP) (2021), asserts that in all the studied animals, lead has been shown to adversely affect blood, central nervous, kidney, reproductive and immune systems while in plants, lead impairs photosynthesis and growth.

Analysis of the total organic carbon, as presented in figure 2, indicated that the highest content 2.47% was recorded at Isheri farmlands and the lowest (0.88%) was at Okokomaiko, while at the control site it was about 1.78%. The presence of organic carbon increases the cation exchange capacity (CEC) of the soil which retains nutrients assimilated by plants (Tautau et al., 2014). Results presented in figure 3 have revealed that majority of the farmlands in the study area are deficient in organic matter. Soil organic matter has been found to enhance the usefulness of soils for agricultural purposes and by supplying essential nutrients, has the capacity to hold water and absorb cations (ibid). It also functions as a source of food for soil microbes, thereby helps enhance and control their activities (Brady, 1996).

The pH of the agricultural soils was discovered to vary from pH7.0 - pH7.5 which is neutral to slightly alkaline (see table 2). Highest pH value of 7.5 was recorded for Shasha, Ejigbo and the control site, while the lowest (pH7.0) was noticed in Okokomaiko and Isheri. The pH values of 7.0 -7.5 obtained for the study area seem to be suitable for such crops suggested by Courtney and Trudgill (1984) as alfalfa, sugar beet, lettuce, peas and carrots. According to Oliver et al. (1998), neutral-alkaline soils are good because as pH decreases, the solubility of metallic elements in the soil increases thereby becoming more readily available to plants. Lower pH also favours availability, mobility and redistribution of lead and cadmium metals in the various fractions due to increased solubility of the ions in acidic environment (Oviasogie & Ndiokwere, 2008).

IV. Conclusion and Recommendations

Lead has been used by mankind for a long time for development. It has been recognized as being the second hazardous substance and higher concentration was detected in two-thirds of the studied locations in Lagos area. The sources are likely linked to the increased anthropogenic activities such as the application of chemical fertilizers to soils under vegetable farms, discharge of sludge, municipal waste, combustion of leaded gasoline by automobiles crisscrossing the urbanized city of Lagos, among others. High concentration of lead in soils poses great health risks to consumers of vegetables as lead readily enters food chain. Also worthy of note was the fact that most farmlands lack sufficient total organic carbon and organic matter. Sequel to this, the following recommendations are proffered:

1. There is need to detoxify the urban farmlands by using organic manure to avoid the entry of lead into food chain to pose health risk to residents depending on vegetables grown in leaded soil in the course of meeting their nutritional needs.
2. With the pH values ranging from 7.0 to 7.5, tomatoes which requires acidic soil (pH 4-6.5) should not be grown. Instead, sugar beet, clovers, lettuce, peas and carrots that need alkaline soil condition (pH 7- 8) should be produced in the study area to maximize for yields.
3. Soil quality assessment should be conducted at regular intervals by the State Government, through the Ministry of Agriculture and proper actions be taken to rehabilitate the soil that are fast deteriorating in order to safeguard the health of the general public.

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Appendix A: Total Organic Carbon of Soil Under Vegetable Farms in Lagos

Location	Total organic carbon (%)
Isheri	2.47
LASU	1.36
Okokomaiko	0.88
Ejigbo	1.66
Shasha	1.21
Control	1.78

Appendix B: Organic Matter of Soil Under Vegetable Farms in Lagos State

Location	Organic matter (%)
Isheri	7.33
LASU	4.03
Okokomaiko	2.61
Ejigbo	4.93
Shasha	3.59
Control	5.28