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# A Classification and Analysis of Metal Content of some Irrigated Crops in Southern Kaduna, Kaduna State

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**Abstract**
*This study focuses on the identification of irrigated crops in southern Kaduna. It further classified and tested the heavy metal content of the selected crops. In other to achieve this aim, observation, interview, and laboratory analysis of the identified irrigated crops were carried out. This was done based on recognized irrigation sites in southern Kaduna, i.e., Saminaka, Ashafa, Kachia, and Kogum rivers. Results revealed that there are seventeen irrigated crops identified in the study area, which are made up of cereals, fruits, root crops, vegetables and perennial grass. These are mainly cultivated for commercial purpose, and the number of farmers cultivating each crop type have been identified as well as the cropping calendar for irrigated crops in the area. The study also relate that vegetables are the most dominant irrigated crops cultivated in the study area. The study further classified these crops into low, moderate, and high water intake crops based on their rate of water need. The classified crops were further selected for laboratory analysis to test for the concentration of heavy metals. These include spinach, pepper, tomatoes, and sugarcane. These were selected from each of the three classes because they are consumed on a daily basis and in large quantities in the study area. The laboratory analysis results show high concentration of the tested heavy metals (Cu, Pb, and Cd) in the crops, that is the heavy metals are above the permissible limit of 40mg/kg-1 (Cu), 0.2mg/kg-1 (Cd), and 0.3mg/kg-1 (Pb), thus, concentration level of these metals ranged from Cu > Pb> Cd. These findings imply that the water and soil used for the cultivation and watering of the crops are polluted. Finally, suggestions were given on how to improve and manage the river water resources available to us for sustainable irrigation practices in southern Kaduna.*

**Keywords: Irrigated Crops, heavy metals, classification, water intake, southern Kaduna**

## INTRODUCTION

The process of using equipment that are gravity driven or pressurized to apply water to crops is known as irrigation (Yadeta, Ayana, Yitayew, and Hordofa, 2022). Water is conveyed from the source to the field and apply to crops to make up for required soil moisture deficit in crop root zone. It is also defined as the application of water to crops artificially rather than rainfall (Eisenhauer, Martin, Heeren, and Hoffman, 2021). This implies that crops are cultivated without total dependence on rainfall. Irrigation is designed to allow crops and plants to thrive in areas such as the deserts and semi – arid or sub- humid regions.

Irrigated crops are agricultural crops that are grown using irrigation systems to provide water to plants. Irrigated crops are grown to complement crops grown during the rainy season. They are also grown in areas where rainfall is insufficient or irregular, or where the soil is too dry to support crop growth without additional water. According to FAO (2017) irrigated crops account for approximately 40% of the world's total food production, and play a vital role in ensuring global food security. Common irrigated crops include cereals (rice, wheat, and maize among others), vegetables (tomatoes, pepper, carrot, cabbage, and onions among others), fruits (banana, apple, grapes, and oranges among others), perennial grass (sugarcane), root crops (cassava and potatoes) and nuts among others. These crops need different amount of water in order to thrive well, moreover, every crop has its water intake rate. If the quality of water is poor and crops are irrigated with that water, it is expected that, as these crops take in water, they are taking it along with impure substances. Therefore, the higher the

water intake rate, the higher the possibility of the presence of chemical substances in the crop. On the other hand, if the water quality is good or excellent, if the rate of absorption is high, it is expected that the crops will thrive well with the absence of chemical substances in them.

Agriculture to a large extent strongly relies on irrigation to meet the growing demand of food for human and animal needs (Li and Troy, 2018). It sustains global food production because crops thrive better through irrigation than rain – fed production (Li and Troy, 2018; Rockstorms, Williams, Daily, Noble, Mathew and Gordon 2017). Irrigated agriculture is dependent on adequate and good quality water. It is no wonder, the sustainable development goals (SDGs) proposed by the united nations (UN) has one of its goals as; to ensure the availability and sustainable management of water and sanitation for all by the year 2030. The targets of the SDGs include amongst others: to improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials halving the proportion of untreated waste water; protecting and restoring water – related ecosystems; and support and strengthened the participation of local communities in improving water and sanitation management (UN, 2018). Therefore, there is need to protect our water bodies from pollution most especially our rivers from degradation.

In Southern Kaduna, there is inadequate supply of water during the dry season due to the absence or low rainfall that reduced volume of water in circulation. People in this area are left with no option but to use any available source to meet their needs be it domestic, irrigation, and recreation, among others. This available source may be contaminated or impure, and has been a leading cause of fatal diseases in humans (WHO, 2013; APEC, 2015). Such waterborne diseases as cholera, typhoid, dysentery, infectious hepatitis and guinea-worms do affect people in this area (Adams & Bonoh, 2016). The water used for irrigation in these rivers may have been polluted by different sources through inflow of water during the rainy and dry seasons. The presence of dissolved minerals high in salt concentration due to the presence of weathered rocks in the rivers, and processes like erosion, leaching, and dredging among others degrade the quality of water in rivers. Moreover, activities such as effluent and sludge discharge due to washing of cars, carpets, and animal slaughter, among others in quantities that are higher than the self – cleaning capacity of the rivers, can accumulate to levels that can be problematic to the production of crops in the area. Therefore, poor quality irrigation water is potentially dangerous to crop production and food supply which may affect the health of the populace in that area. Thus, it is imperative to identify and analyze the type of crops irrigated in southern Kaduna, taking into cognizance their rate of water intake which may influence the concentration of heavy metals in the irrigated crops.

## MATERIALS AND METHOD

### Study Area

Southern Kaduna is located between latitudes 9° 08' 00'' and 10° 48' 00'' of the Equator, and Longitudes 7° 15' 00'' and 8° 06' 00'' of the Greenwich Meridian (Soladeye, 1997, NIMET, 2017, & Bulus, 2021). The area is estimated to cover about 26,000km$^2$ (fig. 1). The area is characterized by Aw type of climate, classified by Koppen, that is, the tropical continental climate with two distinct seasons, wet and dry. The wet season begins in April and ends in October with the peak in August. While the dry season begins from November to March. These seasons are influenced by the tropical maritime and tropical continental air masses respectively. The mean annual rainfall ranges between 1,659.44mm – 1,800mm, this usually decrease to about 1,245.97mm in Kaduna (Abaje *et al*, 2010). The average minimum and maximum temperature are 15.1°C and 35.18°C, while relative humidity is about 62% (Ishaya & Abaje, 2008; Abaje *et al*, 2018). There is abundant sunshine in Southern Kaduna. The duration of sunshine at any given place is the function of its latitude and cloudiness (Aremu, 2014). The range is between 12.9 hours per day in the dry season, and 11.7 hours in the wet season. The study area is drained by rivers such as river Kaduna, Gurara, Kogum, Manchok, and Kachia among others. Most of the rivers take their source from the high lands of the Jos plateau, they are tributaries of the River Niger. Most of these tributaries are seasonal, that is they overflow their banks during the rainy season but reduced in volume or dry up during the dry season (Bonoh, 2012). The rivers have cataracts, rapids, falls and gorges.

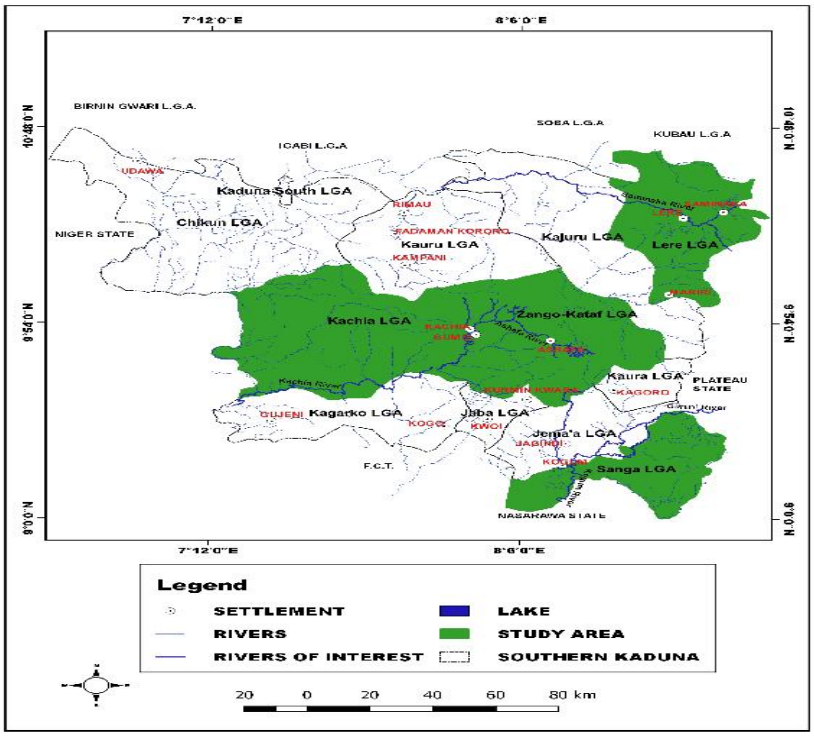


Fig. 1: Selected Irrigation Sites in Southern Kaduna, Kaduna State
Source: Adopted from Kaduna State Administrative Map

**Procedure and Methods of Data Collection**

Irrigated crops in southern Kaduna include cereals, legumes, fruits and vegetables among others. These were identified through direct observation, interview and photographs. In order to analyze the concentration of elements that might be hazardous to human health when consumed in large quantities. Vegetables and sugarcane were selected for this study because people in the study area make use of one type of vegetable or the other in their daily meals, and also consumed sugarcane in large quantities. Three of the considerably consumed vegetables were selected for this study from the irrigated farms under investigation. These include tomatoes, spinach, and pepper, as well as sugarcane making a total of four crops for investigation. The crops were randomly selected from the farms, and four samples of each crop was collected at a distance of 10meters on each farm, giving a total of sixteen samples for analysis. This technique was adopted from Adeoye *et al* (2018). The samples were initially washed with water at the sampling sites before they were taken to the laboratory for analysis.

At the laboratory the sampled plants were thoroughly washed with distilled water to remove soil particles before further analysis as described by Cui *et al*, 2004; Kalaskar (2012); and Adeoye *et al* (2018). They were thoroughly mixed to give a composite sample as a representative fraction of the vegetables. The samples were air – dried for almost seventy hours at 105$^{o}$C to remove excess water, and further ground into fine powder, heavy metals were extracted through acid digestion. Powdered samples 15g each were placed in silica crucibles and few drops of concentrated nitric acid were added to the samples. Furthermore, dry – ashing by step – wise increase in temperature of up to 550$^{o}$C was carried out. The dried samples were left to turn to ash at this temperature for six hours. The ash was kept in desiccators and subsequently rinsed with hydrochloric acid (WHO/ FAO, 2003; 2007). Concentration of metals were determined by the use of atomic absorption spectrophotometer (AAS) VARIAN 240FS, Sweden. Stock solutions of 1000mg/l each of the metals purchased from Sigma-Aldrich were used for the analysis. Calibration standard for each element was prepared using the

stock solutions through serial dilution technique. Thus, the mineral element for each sample was recorded from calibration curves, and presented in mg/kg-1 (WHO/FAO, 2003; 2007).

## RESULTS AND DISCUSSION

### Types of Irrigated Crops in Southern Kaduna

Irrigated crops in southern Kaduna include cereals, root crops, and vegetables among others. Table (1) and plates (1) display the different types of crops cultivated through irrigation in southern Kaduna. These include cereals, vegetables, root crops, fruits, and perennial grass. The study revealed (17) seventeen different types of crops irrigated in the study area based on the classes or categories enumerated above. Ashafa has the lowest number nine (9) irrigated crops followed by Kogum irrigation site with ten (10) crops. These are followed by Kachia with eleven (11), and finally Saminaka with seventeen (17) different types of crops which is the highest. The table also shows the number of farmers cultivating a particular crop.

### Classification of Irrigated Crops based on Water Intake Rates in Southern Kaduna

Irrigated crops in southern Kaduna have been classified in this study based on their water intake rates. Table 2 shows that out of the seventeen (17) irrigated crops in southern Kaduna, three (cabbage, spinach, and pumpkin) belong to the low water intake rate category. This class consumes 1mm to 2mm of water per day (FAO, 2016; Chaves *et al*, 2016). On the other hand, the moderate water intake class, that is crops that consume 3mm to 4mm of water per day include tomatoes, cassava, okra, pepper, melon, onion, green leaves (ugwu), and eggplant (Bhattari, 2016; FAO, 2016). The high water intake rate class is the last class and is made up of sugarcane, banana, jute and maize. These category takes in water 5mm and above per day (Soleyman et al, 2019; Abraham & Micheal, 2012; FAO, 2016; & National Jute Board, 2019).

### The Dominant Irrigated Crops in Southern Kaduna

The study further reveals the most occurring irrigated crops in the study area as eggplant, okra, tomatoes pepper, cassava, and sugarcane among others (table 1). These are cultivated in all the irrigation sites that were investigated. These are followed by green leaves (ugwu), finally by jute, pumpkin, lettuce, and melon among others. Potatoes is only cultivated in Saminaka as well as vegetables such as cabbage, jute and pumpkin among others.

Plate 1: Irrigated Crops at Saminaka
Source: Fieldwork, April, 2023.

### Number of Farmers Cultivating each Irrigated Crop in Southern Kaduna

Table 1 also shows the number of farmers cultivating a particular type of crop at the various irrigation sites. Spinach and tomatoes have the highest number of farmers (24 each) cultivating them. While crops such as potatoes, melon, cabbage, lettuce, and pumpkin are cultivated by one (1) at Saminaka. Other crops such as sugarcane, maize, pepper, okra, onions, and green leaves among others are cultivated by a number of farmers that ranged between five (5) and twenty (20).

### Cropping Calendar for Irrigated Crops in Southern Kaduna

The study observed that farmers practicing irrigated agriculture commenced their activities immediately after the rains start ceasing in the month of October. They usually start with land clearing, in October, followed by the cultivation of ridges and seed planting from that month to early November. This is supported by watering of the crops immediately they are planted. Watering takes about two to three weeks before they start weeding and application of pesticides and fertilizer to the crops by the month of December. These continue till the crops are mature for harvest. Harvesting of irrigated crops in the

study area start in ending December till around end of April of the next year which pave way for the rainy season farming to commence. These farmers use the same piece of land for both rainy and dry season farming.

Table 1: Irrigated Crops in Southern Kaduna.

| **Irrigated Crops** | **Irrigation** | | | **Sites** | **Summary** | **No of Farmers** |
|---|---|---|---|---|---|---|
| **Vegetables** | **Ashafa** | **Saminaka** | **Kachia** | **Kogum** | | |
| Egg plant | X | X | X | X | 4 | 16 |
| Spinach | X | X | X | X | 4 | 24 |
| Tomatoes | X | X | X | X | 4 | 24 |
| Pepper | X | X | X | X | 4 | 18 |
| Green leaves | ● | X | X | X | 3 | 9 |
| Jute | ● | X | ● | ● | 1 | 1 |
| Pumpkin | ● | X | ● | ● | 1 | 1 |
| Lettuce | ● | X | ● | ● | 1 | 1 |
| Cabbage | ● | X | ● | ● | 1 | 1 |
| Okra | X | X | X | X | 4 | 20 |
| **Fruits** | | | | | | |
| Banana | X | X | X | X | 4 | 5 |
| Melon | ● | X | ● | ● | 1 | 1 |
| **Root Crops** | | | | | | |
| Cassava | X | X | X | X | 4 | 10 |
| Potatoes | ● | X | ● | ● | 1 | 1 |
| Onions | X | X | X | X | 4 | 15 |
| **Perennial Grass** | | | | | | |
| Sugar cane | X | X | X | X | 4 | 20 |
| **Cereals** | | | | | | |
| Maize | X | X | X | X | 4 | 10 |

Source: Field work, 2023

**KEY**

● ---------- Absent

× ---------- Present

Table 2: Classification of Irrigated Crops based of Water Intake Rate in Southern Kaduna

| **CLASS** | **LOW (1 – 2mm/day)** | **MODERATE (3 -4mm/day)** | **HIGH (5mm and above/day)** |
|---|---|---|---|
| **Crops** | Cabbage | Potatoes | Maize |
| | Spinach | Cassava | Sugarcane |
| | Pumpkin | Onions | Banana |
| | | Tomatoes | Jute |
| | | Melon | |
| | | Pepper | |
| | | Okra | |
| | | Lettuce | |
| | | Eggplant | |
| | | Green leaves | |
| **Total** | **3** | **10** | **4** |

Source: Field work, 2023.

**Concentration Level of Heavy Metals in Vegetables from Irrigated Farms in Southern Kaduna.**

Furthermore, the irrigated crops, vegetables in particular were observed to be consumed on a daily basis by the populace in the study area. These were selected and taken to the laboratory for analyses. The selected crops include pepper, tomatoes, spinach and sugarcane. The following heavy metals were tested copper (Cu), cadmium (Cd), and lead (Pb). The laboratory analysis results for the selected crops are presented on table 3, and they reveal varying concentration levels of heavy metals in the vegetables collected for analysis in southern Kaduna based on sampling sites. In the present study, the concentration of Cu, Cd, and Pb in the vegetables are significantly above the safe limits given by FAO/WHO (2019) of 40mg, 0.2mg/kg-1 and 0.3mg/kg-1 respectively for the tested variables. Moreover, some of the crops from the three different classes were selected and analysed in the laboratory to verify if the rate of consumption of water by these crops influence the level of concentration of chemical substances in the crops. Spinach was selected from the low water intake class, tomatoes and pepper from the moderate class, and sugarcane from the high intake class. Apart from this, another reason for selecting these crops is because they are consumed daily in large quantities by the populace in the study area when in season. From the table Saminaka irrigation site shows that, spinach which has a low water intake rate has the highest concentration of Cu (201.25mg/kg-1), the highest Cd concentration of 5.70mg/kg-1 was recorded for sugarcane, which is a high water intake plant, and the concentration level of 43.25mg/kg-1 for Pb as the highest was again recorded for spinach which is a low water intake plant. Kachia irrigation site has tomatoes a moderate water intake plant with 186.50mg/kg-1 of Cu, Cd with concentration level of 11.58mg/kg-1 (highest) for sugarcane, and Pb has spinach with highest concentration of 11mg/kg-1. In Ashafa irrigation site pepper with 182.75mg/kg-1 is the highest, and is a moderate water intake plant. Sugarcane a high water intake plant recorded the highest concentration of 17.48mg/kg-1 conversely, 45.50mg/kg-1 was recorded for pepper as the highest for Pb. Finally, Kogum irrigation site has pepper a moderate water intake plant with the highest concentration of 236.25mg/kg-1 of Cu, followed by sugarcane for Cd with 16.98mg/kg-1, and sugarcane again for Pb with 91.98mg/kg-1.

Generally, based on the results of the present study, it can be deduced that crops with high water intake rate have low concentration of heavy metals compared to other crops with moderate and low water intake rates. This implies that there are other factors that might be responsible for high concentration of variables in plant rather than their water intake rates only. These can be related to soil type and other environmental and human factors. Furthermore, high concentration of these heavy metals in tested vegetables in the study area as revealed in the results is of serious concern. The human body can be interrupted based on its numerous biochemical processes when these vegetables with toxic metals are consumed for a long time (Anhwange et al, 2013; NIEHS, 2021).

Cu generally act as a biocatalyst. It is essential for body pigmentation in addition to iron. It aids in preserving a healthy central nervous system, hindering anemia, and also aid the functioning of zinc and iron in the body (Maleki et al, 2013). Cu plays an important role in many oxidative processes, deficiency in Cu affects the function of these oxidative enzymes, which may lead to anemia. Furthermore, Cu act as a protection to the enzymes found in the brain, blood, liver, lungs, and thyroid against oxygen toxicity. High concentration of Cu on the other hand leads to oxidative damages and alterations in the function of cell membranes, abnormalities in liver function, decline in fluidity, and inhibition of receptors from functioning. It further causes headache, dizziness, nausea, diarrhea, difficulty in breathing, renal failure and even death among others (Karim, 2018; NIEHS, 2021).

Cd has no advantageous effects in the human body as observed by Malan et al (2014). Cd is a human carcinogen that is associated with various cancers in humans (Gidlow, 2004). Exposure to Cd is primarily by eating crops cultivated on contaminated soil or sea food (Grum & Bresnitz, 1990; WHO, 2016). Once absorbed by the human body, it can stay for a long period in the system, most especially the kidneys, lungs and liver (Bernard, 2008; NHMRC, 2015; NIEHS, 2021). It affects the bones of humans known as itai – itai disease which first occurred in Japan. It also causes pleuritic chest pain, abnormal cramps, mental fume fever, and yellowing of teeth among others. Conversely low level of Cd leads to deterioration of

sight and hearing, it affects pregnancy and its outcome, as well as kidney, liver and cardiovascular system (WHO, 2016; NIEHS, 2021).

Pb does not have any known health benefit to the human system. High concentration of Pb in human systems causes high blood pressure, abnormally low hemoglobin, abnormal kidney and brain function. In severe cases, it is characterized by irritability, agitation, poor attention span in children, low IQ in children, uncoordinated walking or movement, and even death in some cases (NHMRC, 2015). It also leads to decreased kidney function, reduced fetal growth, increased incidence of essential tremor, changes in sperm and difficulty in pregnancy among others (NHMRC, 2015; NIEHS, 2021).

Table 3: Heavy Metals Concentration in Irrigated Crops in Southern Kaduna

| Irrigation Sites | Tomatoes | | | Spinach | | | Pepper | | | Sugarcane | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cu | Cd | Pb | Cu | Cd | Pb | Cu | Cd | Pb | Cu | Cd | Pb |
| | (mg/kg-1) | | | (mg/kg-1) | | | (mg/kg-1) | | | (mg/kg-1) | | |
| **Saminaka** | 190 | 5.30 | 16 | 201 | 4.65 | 43.25 | 166 | 5.28 | 20 | 187 | 5.7 | 4.25 |
| **Kachia** | 187 | 6.25 | 1.75 | 118 | 7.58 | 11 | 176 | 8.48 | 2.5 | 152 | 11.85 | 5.50 |
| **Ashafa** | 165 | 15.68 | 7.75 | 182 | 15.5 | 28.75 | 183 | 17.18 | 45.5 | 121 | 17.48 | 43.25 |
| **Kogum** | 181 | 6.28 | 46.75 | 197 | 16. 10 | 61.76 | 236 | 16.48 | 72.6 | 167 | 16.98 | 91.90 |

Source: Fieldwork, 2023.

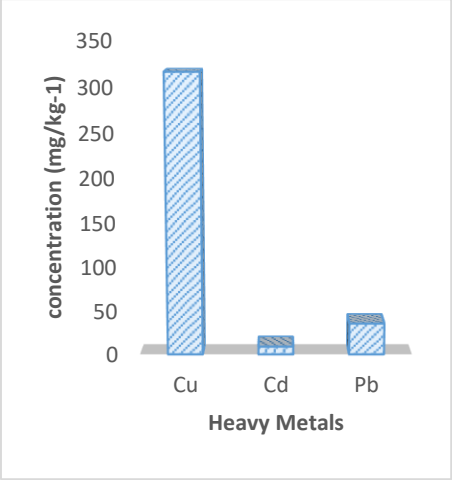


Fig. 2: Saminaka Irrigation Site.

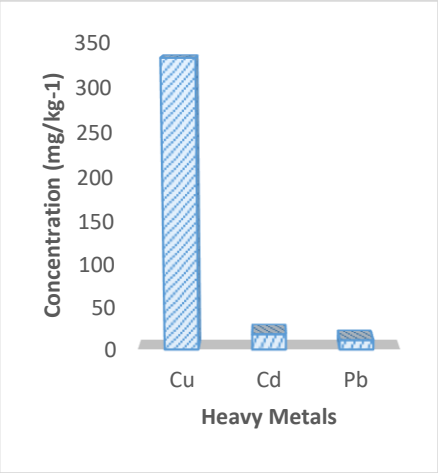


Fig 3: Kachia Irrigation Site

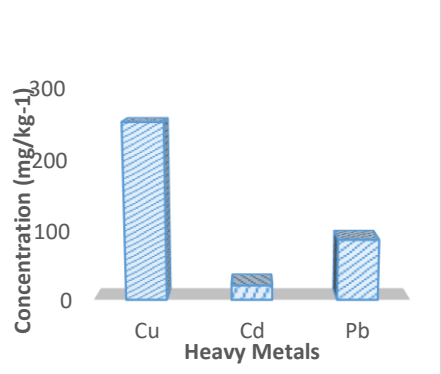


Fig. 3: Ashafa Irrigation Site

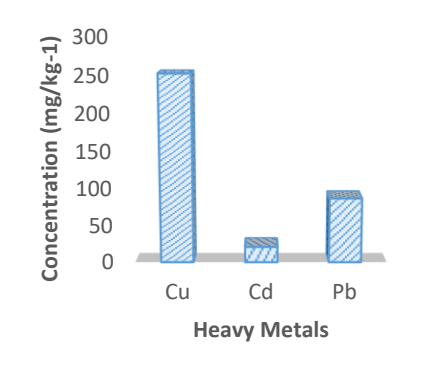


Fig. 4: Kogum Irrigation Site

Heavy Metals Concentration in Irrigated Crops in Southern Kaduna.
Source: Fieldwork, 2023.

## CONCLUSION

This study revealed that there are seventeen different types of irrigated crops in southern Kaduna, and are grouped into vegetables, root crops, fruits, cereals, and perennial grass. Vegetables are the dominant irrigated crops in the study area, while maize is the only cereal crop irrigated in the area. The study also showed the number of farmers cultivating various crops in the study area, and attempted a description of the cropping calendar in the area. Irrigated crops were classified into low, moderate, and high water intake crops in southern Kaduna based on their water intake rate. It was established that crops with high water intake rate have low concentration of heavy metals compared to the high and moderate water intake crops. Furthermore, results depict high concentration of heavy metals in the selected crops which are consumed daily by the populace in large quantities. The study shows that Cu is highly present in the tested crops compared to Pb and Cd. Therefore, it is not surprising that most of the people in the study area are suffering from health related issues caused by these heavy metals as identified by Karim, 2018; Bernard, 2008; NHMRC,2015; & NIEHS,2021). The findings of this study is similar to that of Maleki *et al* (2014), in Iran, Malan *et al* (2014) in South Africa, Lawal *et al* (2017) on kubanni river in Zaria Kaduna State, and that of Ahmed *et al* (2019) in Bangladesh. This is an issue of great concern, as it can affect productivity in the study area due to ill health, as these crops are consumed daily in large quantities by the populace.

Based on the findings of this study, the following are recommended:

a) This study revealed that maize is the only cereal cultivated by irrigation in the study area. Therefore, there is need to introduce rice as one of the irrigated crops in southern Kaduna to complement the one cultivated during the rainy season since it is used for both subsistence and commercial purposes.
b) In all the irrigation sites investigated, the study discovered that it is only in Saminaka crops such as cabbage, lettuce, melon, and potatoes among others are cultivated. There is need to encourage irrigation farmers to venture into the cultivation of such crops instead of restricting themselves to pepper, okra, and tomatoes among others. These would lead to the cultivation of different varieties of crops and also increase their sources of income through diversification.
c) The study further revealed that the concentration of heavy metals in irrigated crops in the study area are above the acceptable limits given by WHO. Therefore, the need to protect our water bodies and soil from further degradation by checking activities that can lead to increase in the concentration of heavy metals in soil and water so as to check that of the crops. This is supported by FAO (2017), where the importance of protecting our natural resources from pollution to ensure sustainability was emphasized.
d) Water bodies and soil in the study area need to be treated so as to check further degradation of the environment by heavy metals. This can be done through bioremediation, that is biological treatment from plants, physical processes like sedimentation, filtration and adsorption can also be adopted, electrochemical and chemical treatment among others can be used to remove heavy metals from irrigation water (United States Environmental Protection Agency, 2020; FAO, 2017).

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