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Heavy Metal Characterization of Edible Aroids (Colocasia Esculenta (Taro) and Xanthosoma Sagittifolium (Tannia) Growing in Parts of Rivers State

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Abstract **Original Research Article**

Edible aroids, particularly Colocasia esculenta (taro) and Xanthosoma sagittifolium (tannia), are crucial for food security and livelihood in developing countries, including Nigeria. However, environmental pollution, notably heavy metal contamination, poses a significant threat to their productivity and safety, especially in the oil-rich Niger Delta region. This study investigated the presence and accumulation of heavy metals in edible cocoyam genera and their growing soils across three local government areas in Rivers State, Nigeria: Obio/Akpor, Emohua, and Ikwerre.

The field experiment was carried out from June, 2021 to January, 2022 and repeated in June, 2022 and January, 2023 across three local government areas in Rivers State, Nigeria: Obio/Akpor, Emohua, and Ikwerre. Two genera of cocoyam, Colocasia esculenta (cultivars: NCe001 - Coco India, NCe002 - Ede ofe green, NCe003 - Ede ukpong) and Xanthosoma sagittifolium (cultivars: NXs001 - Ede ocha, NXs002 - Ede uhie, NXs003 - Okorokoro), were obtained from the National Root Crop Institute (NRCRI), Umudike. A Randomized Complete Block Design (RCBD) with four replications was used, with plant spacing of 50cm x 50cm. Pre-planting soil analysis revealed significant variations in certain physicochemical parameters across the locations. For instance, pH, electrical conductivity (EC), organic carbon (OC), phosphorus (P), calcium (Ca), acidity, aluminum (Al), exchangeable cation exchange capacity (ECEC), manganese (Mn), iron (Fe), copper (Cu), and zinc (Zn) showed significant differences ($p<0.05$) between locations, indicating varying soil conditions and potential for heavy metal presence. Heavy metal concentrations in soil, corms, cormels, petioles, and roots were determined using Atomic Absorption Spectrophotometry (AAS). The findings indicate that the levels of heavy metals varied across different plant parts irrespective of ascensions and locations, in corms as cobalt < nickel < zinc < lead < copper, in cormlets as cobalt < nickel < lead < zinc < copper, while in leaves, roots, and petioles, the metals followed the order: cobalt < lead < nickel < copper < zinc. Significantly, the lead content in all plant parts (corms, cormels, leaves, roots, and petioles) was found to be significantly different ($p<0.05$) across the locations, suggesting that lead levels might be influenced by the specific environmental or anthropogenic conditions of the different regions. This finding emphasizes the potential for lead contamination in these crops, which could pose a health risk to consumers. Similarly, copper content in the leaves, roots, and petioles was significantly different ($p<0.05$) between locations, although the copper levels in the corms and cormlets did not show significant differences ($p>0.05$). This suggests that copper may accumulate more in the aerial parts of the plant, such as leaves and petioles, potentially due to the absorption of copper through the soil or via atmospheric deposition. Interestingly, nickel and zinc concentrations in the leaves, roots, and petioles were also significantly different ($p<0.05$) across the locations, while their concentrations in the corms and cormels did not show significant variation. Finally, cobalt levels showed significant differences ($p<0.05$) in cormels, leaves, and roots, but no significant differences in corms and petioles ($p>0.05$). This finding suggests that cobalt may be more readily absorbed into the plant's above-ground tissues than the tuberous parts..

Keywords: Cocoyam, edible aroids, environmental pollution, food, soil, plants, heavy metals.

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INTRODUCTION

1.1 Background of the Study

Edible aroids play a significant role in the livelihood of millions of relatively poor people in the developing countries (Sharma *et al*., 2016). These crops have the ability to improve household nutrition, generate revenue, and ensure food security. Their energy production per hectare per day is higher, and they may thrive in harsh environments where other crops perish (Onwueme, 1999). The tropical plants Xanthosoma and Colocasia are farmed for their cultural ceremonies, edible corms, cormels, and leaves, and they are members of the Araceae (aroid) family. Colocasia has about 25 species and Xanthosoma has about 50. There are around 1500 species in this huge family, which includes epiphytes, terrestrial plants, vines, and creepers, and hundreds of genera.

Colocasia esculenta Schott commonly known as taro, dasheen, or old cocoyam is a staple vegetable crop that has been used as food for over 9,000 years making it one of the world's oldest food crops. Root and tuber crops are common in the tropical regions, and taro is no exception. It has been praised for its therapeutic virtues, yet, like most cassava cultivars, it is toxic when raw but edible when cooked. This crop is typically found in lower elevations due to its sensitivity to temperature changes and high water requirements, which are likely caused by its expansive transpiration surfaces.

Xanthosoma sagittifolium (L.) The edible aroid Schott, which is a member of the Araceae family, is sixth important root and tuber crop globally, following potatoes, cassava, sweet potatoes, yams, and taro (Bown, 2000). In terms of significance, it ranks third among the food crops grown and eaten, behind only cassava and yam. In terms of nutrition, it outshines cassava and yam was easily digestible starch, higher protein, mineral, and vitamin contents, and overall superiority.

The Food and Agriculture Organisation (FAO) database on main crop production shows that all Colocasia and Xanthosoma species are grown as taro. The numbers show that taro is most abundant in West Africa. From 2008 to 2012, the majority of the world's taro harvest (86% of the total) and production (74% of the total) occurred in Africa. Half of the world's output and 61% of the world's harvested area were in the West African subregion. The region's contribution to global taro output declined in preceding 5 years (2003 - 2007), according to these figures.

According to Alloway (2013), cocoyams originally hail from the northern region of South America. A large number of people in the Pacific, Asia, Africa, and the Caribbean have become naturalised citizens (Ponce, 2010). This crop is most commonly found in lowlands, likely due to its sensitivity to temperature changes and high water requirements during production (as a result of its abundant transpiration). Most types of taro cannot withstand dry conditions and thrive in damp surroundings. This crop has heart-shaped leaves and can reach a height of one to two meters. It is best to have 250 cm of rain per year, although they can still be cultivated in upland regions with 175 cm of equally distributed rain if that's all that's needed. When subjected to moisture shortage stress, taro exhibits a considerable decrease in leaf output, but tannia (Xanthosoma sagittifolium) displays just a little decrease in leaf number. The majority of a taro plant's roots are located within a shallow root system that is 40 cm wide and 9 cm deep.

It is commonly produced in multiple cropping systems alongside other root crops such as bananas, plantains, and tree crops, but it is also grown as a monocrop on occasion. The crop does not do well in salty environments, although it does best in slightly acidic (5.5-6.5) soil. Furthermore, taro does better when planted in partial shade, even though it produces more when grown in full sun later on. There are very few crops that can be produced effectively and yield optimally in flood-prone environments; three of these are rice, lotus, and taro (Onyeka, 2014). Since taro has a lot of air space in its petiole, even when inundated, its portions can still exchange gas with the atmosphere. The increased yield when flooding occurs is because the leaves have more surface area and can develop more suckers. As a result, flooding conditions slow the process of leaf senescence. Currently, Africa is the leading producer, with more than 60% of the entire output coming from the western and central regions of the continent, specifically Nigeria, Ghana, and Cameroon (Owusu-darko et al., 2014). Tropical America was its birthplace, and it travelled from Western Africa to Eastern Africa. The actual date and means of its introduction to Ethiopia are unknown, but it is well-known that it is exotic because of this. The native food system places a premium on root and tuber crops to ensure food security, but cocoyam has spread and become an essential component of this system.

According to FAO (2007b) and NRCRI (2009), Nigeria produces 37% of the world's cocoyam, making it the leading producer globally. Nigeria's cocoyam production went from 0.73 million metric tonnes in 1990 to 3.89 million metric tonnes in 2000 (Ojiako et al., 2007). The amount made went up by 30.30% in 2007, reaching 5.068 million metric tonnes (FAO, 2007b). An additional estimate for Nigeria estimated the annual cocoyam output at 5,387 million metric tonnes, out of a total of 11.77 million metric tonnes produced globally since 2008 (FAO STAT, 2010).

Xanthosoma sagittifolium Schott, often known as white cocoyam, and Colocasia esculenta (L) Schott, well known as red cocoyam, are the two most widely grown species of cocoyam in the world, according to Mwenye (2011). As a staple crop for many people's diets, these crops also carry deep symbolic, cultural, and economic meanings (Mwenye, 2011). You can eat corms and cormels in stew, special soups and sauces, beans, or other vegetables cooked in ways like boiling, baking, roasting, or frying with palm oil. Onwueme (1999) notes that the leaves are commonly cooked in various ways or mixed with other items like spinach. Because of their high mineral content and delicious flavour, melon soup is made using the young leaves. Recent years have seen an increase in environmental contamination, which is a big concern globally. This refers to the discharge of undesirable or hazardous substances into the environment from either natural or anthropogenic (human-made) sources. Changes to the environment's physical, chemical, and biological aspects can be aided by this. When people release toxic substances into the environment, it's called pollution. Pollutants are defined as substances introduced to the environment that exceed

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permissible levels (Anyanwu *et.al.* 2020, 2023).

However, pollution is one of the human-mediated challenges that have impeded the productivity of crops in the Niger Delta region of Nigeria. Pollution that originate within a variety of sources, comprising human-generated solid waste, crude oil, heavy metals, and incorrect disposal of this material. Injecting specific types of waste and by-products into the biosphere in sufficient quantities to disrupt the normal functioning of ecosystems has negative effects on plants, animals, and humans. This is true in all societies, whether they are rural, urban, industrial, or technologically advanced (Anyanwu *et. al.*, 2020, 2023).

Pollution includes the point of sources which are emission, wastes and solid release from industries, vehicle tiredness and metals from heat up and mining, non-point bases such as soluble salts (natural and artificial), practice of insecticides and pesticides, discarding of industrialized and civic wastes in agriculture, and unnecessary use of fertilizer (Nriagu, 1996). every source of infection owns its damaging effects to plants, animals and human strength, but the effect of heavy metals to soil and water are severe worry because of tenacity in environment and carcinogenicity to human existence. Heavy metals were elements that occur naturally in the Earth's crust. They were impervious to even little degradation or destruction. They penetrate the human body through the food, water, and air we consume (Orish, et al 2014).

Plant accumulates heavy metals through their roots which affects the food chain. During travel, cars release these metals for a number of reasons, such as burning fuel, wear and tear on parts, leaking fluids, and corrosion of the metal. Gasoline combustion, oil leakage, battery corrosion, and radioactive decay are just a few of the processes that release metals including lead, cadmium, copper, and zinc. These metals are often found on the side of the road.

There is evidence of elevated trace metal concentrations due to human activities dating back to ancient times (Nriagu, 1996). It wasn't until the 1960s, when man-made lead pollution of roadside environment was first identified, that the health implications of the excessive release of harmful traces into the environment became apparent. Due to their increasing concern for the environment and their health, roadside environmental studies have grown into a worldwide phenomenon spanning several continents. Research has demonstrated that metal pollution pose a threat to roadside plants, wildlife, and nearby human populations (Tunres and Maynard, 2001; Awofolu, 2005).

Cocoyam has been understudied and underexploited despite its nutritional benefits, role in economy and livelihood of rural poor, broad adaptability, and historical celebration in the Southern parts of Nigeria called "Ede Oye" (Ubalua et al., 2007/2018). The crop has also been criticised for its lack of research attention (Goenaga & Heperly, 1990; Tam, et al 1987; Giacometti & León, 1994). For a long time, cocoyam production was flat. Growing cocoyam to its full potential such that millions of rural families can afford to eat it has proven to be an impossible dream. This is mainly due to the low production of planting materials (shafer, 1999), low availability of traditional planting material (corn cuttings) and viral and fungal infection (Xu et al, 1995). The International Institute of Tropical Agriculture (IITA) said during the First International Workshop on Cocoyam in Cameroon that the situation for crops like cocoyam, which are important for the food and income security of millions of poor farm families, will only get worse if we don't do something to change it (IITA, 2008/2009).

MATERIALS AND METHOD

3.1 Study Area

The study was conducted in three local government areas of Rivers State namely: Obio/Akpor, Emohua and Ikwerre. However, planting of plants, watering, experimental set up and sample collection were done in one community, each, from these local government areas. The research farm for Omuoko in Aluu lies on longitude 04 56’ 01.3N and latitude 006 55’17.2E. That of Isiodu in Emohua lies on longitude 04 55’ 25.4N and latitude 006 52’09.5E. Ozuoba in Obio/Akpor lies on longitude 04 52’ 20.4N and latitude 006 55’47.8E.

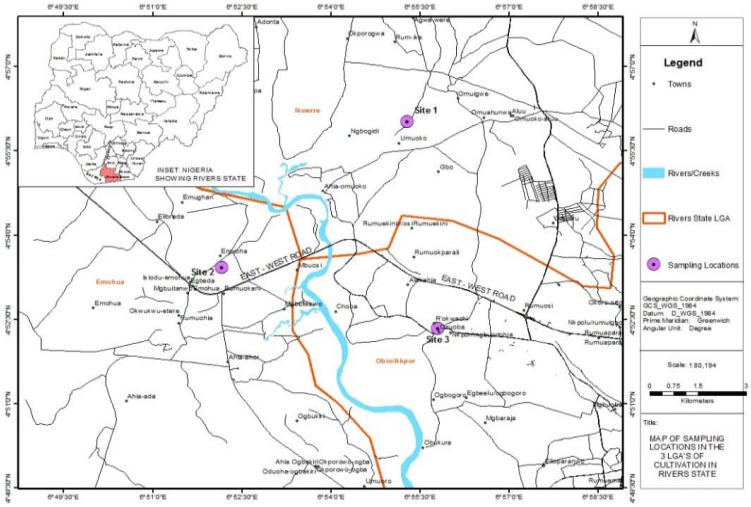

Figure 3.1: Map of Study Area Showing the Study Locations

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Sources of Materials: The materials used for this study comprised of two genera of cocoyam namely: *Colocasia esculenta* (taro) and *Xanthosoma sagittifolium* (tannia). Out of these genera, three cultivars each, were obtained from each communities. The cultivar was: Coco India (NCe001), Ede ofe green (NCe002), and Ede ofe purple (NCe003) were the Colocosia species. Both the NXs001 (Ede ocha) and the NXs003 (Okorokoro) Xanthosoma species were used.

Duration of the Study: This field experiment was conducted in June, 2021 to January, 2022 and repeated in June, 2022 and January, 2023 cropping seasons on fourteen point 10meters by six point five meters (14.10m x 6.5m) plot size.

Experimental Design: The RCBD was the experimental design used in the investigation. Nonetheless, a four-replica Randomized Complete Block Design (RCBD) was used to set up the experiment. Plot size measured 14.10m x 6.5m consisting of 12 rows of 3m each – 2 rows for each assertion and crop spacing was 50cm x 50cm, giving 240 plants/plot. Plants were planted in the open. Total plant stand on a replicate is 60 – including all six accession; two row of five (5) for each accession. Alloway between replicates is 0.7m. Plantings were done from the 9th -11th of June in each season and harvested in January, respectively. The study area is noted for an average of seven (7) raining months. The soil in the area is a sandy loam texture, slightly acidic to neutral and fertile (high level of organic matter present).

Plants Used for the Study: Taro (*colocasia esculanta*): coco india - NCE 001, Ede ofe green – NCE 002, Ede ukpong – NCE 003. *Xanthosoma sagittifolium*: Ede ocha – NXS 001, Ede uhie – NXS 002, Ede okorokoro – NXS 003. All accessions were gotten from National Root Crop Institute (NRCRI), Umudike, South East Nigeria. The planting materials which included the sprouted small cocoyam corm of the accession were collected from National Root Crop Institute (NRCRI), Umudike with moderated sized corm of weight 50-100g.

Preparation of Planting Materials: The collected vegetation was then divided into portions and spaced 50 cm apart before being planted 10 cm deep. The experimental plots showed many sprouts of cocoyam. When necessary, weeds were pulled by hoe or by hand to keep them from competing with the crops.

Soil Used for the Study: The soil in the areas are sandy loam texture, slightly acidic to neutral and fertile (high level of organic matter present). The soil samples were collected prior to planting from the different locations at the experimental sites at depth of 0-20cm with a soil auger in 2021 and 2022 cropping seasons. Samples were properly mixed together to get a whole sample from which a subsample was taken to the laboratory for analysis to determine physio-chemical characteristics of soil. Soil pH, electrical conductivity, nitrogen, phosphorus, alkalinity, and organic carbon were the physicochemical factors that were investigated.

Determination of Heavy Metals in Soil: A uniform weight was achieved for the soil samples after being dried in an oven at 65 °C for 120-150 minutes. After the samples were chilled, the wetting method was used for digestion. The following was added to a 250 mL balloon: 25 mL of concentrated sulphuric acid, 20 mL of 7 millimolar nitric acid, and half a gramme of the sample. Using a 3:1 ratio of nitric acid to hydrochloric acid, the soil samples were broken down. Gently adding 20 ml of 1:1 mixture of concentrated perchloric acid and nitric acid came after the samples had cooled. After that, the acid's white vapours were extinguished by heating the combination. Ten millilitres of distilled water was gradually added to cooled liquid as balloon was spun. The mixture was heated for approximately 100 minutes until it became a clear solution. Once cooled, it was transferred to 100 ml balloon (10, 47, 48). We used an Atomic Absorption Spectrophotometer (AAS) to find out how many heavy metals were in the soil samples.

Sample Preparation/wet digestion for plants and soil samples

The plant samples were first sliced into smaller pieces and then dried in an oven at 1000 °C for 48 hours in a large, clean crucible to make sure that no dirt particles remained after rinsing with distilled deionized water. Using a mortar and pestle in conjunction with clean acid, the dried plant samples were ground into small particles.

The plant sample was digested using a method described by Awofolu (2005). 50 microgrammes of the sieved leaf samples were added to 100 millilitres of beaker along with 5 millilitres of concentrated trioxonitrate (IV) acid and 2 millilitres of perchloric acid. Then, the mixture was brought to a volume of around 2 millilitres by heating it on low heat with a hot plate. Wait for the digestion to cool off before using a 0.45um Millipore filter kit to filter it into a 50 ml standard flask. Before filtering into the flask, the beaker was washed with little volumes of double distilled water. In addition to running a blank digest devoid of plant material, we digested each sample three times. Utilising the flame atomic absorption spectrophotometry model AA650, the metal content of digested samples was quantified.

To ensure consistency, soil samples were mixed and then air-dried in oven set at 350°C until they reached a constant weight. After that, they were passed through a 2mm sieve. I used a 100 ml breaker with 5 grammes of soil samples. 3 millilitres of 30% hydrogen peroxide was added and allowed to stand for 60 minutes according to a method previously detailed by Sharidah (1999). Following the cessation of the strong reaction, 75 ml of a 0.5 m Hcl solution was added to the combination, which had been cooked on a hot plate over low heat for nearly two hours..

Triplicative digestion of each sample and the bank was thereafter filtered into a 50 cc standard flask. To measure amount of metals in digested samples, the AA650 flame atomic absorption spectrophotometry model was used.

Heavy Metal Determination in Corm, Cormels and Petioles and Roots: The determination of mineral followed method described by AOAC (2010) for wet digestion of samples,0.1g of powdered sample was weighed in digestion flask. Before being left at room temperature overnight, 12 millilitres of concentrated HNO3 were added. After adding 4.0 millilitres of HCLO4, the mixture was cooked in the digesting block, with the temperature ramped up from 50 to 250 degrees Celsius. The

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presence of fumes after 70 to 80 minutes indicated that digestion was complete. After adding the distilled water and transferring the liquid to a 100 ml volumetric flask, the mixture must be allowed to cool. Specifically, a model 205 atomic absorption spectrophotometer manufactured by Buck Scientific, made by Nowalk Connecticut, USA) utilising standard wavelengths was used to analyse it for heavy metal concentration, which includes lead, zinc, copper, nickel, and cobalt.

SOIL ANALYSIS (PRE-PLANTING)

Soil Proximate Parameter based on Locations

Table 3.1a: Mean and Standard Deviation of Soil Proximate Parameter based on Locations

Locations	pH	Ec (u/cm)	N (%)	O.C (%)	P (mg/Kg)	Ca (cmol/Kg)	Mg (cmol/Kg)	K (cmol/Kg)
Emohua	5.24±0.42a	13.5±0.71 a	0.09±0.01 a	14.16±0.04 c	12.74±0.15 a	2.09±0.71a	0.7±0.37a	0.08±0.02a
Aluu	6.09±0.02a b	29±1.41c	0.23±0.02 a	2.67±0.3a	81.39±7.78 b	17.51±1.98c	1.88±0.89a	0.5±0.21a
Ozuoba	6.74±0.4b	18±1.41b	0.18±0.1a	12.44±0.78 b	66.78±5.44 b	10.18±0.69b	0.95±0.21a	0.33±0.19a
ANOVA (p-value)	10.076 (0.047)	84.778(0.002)	3.007 (0.192)	331.571 (0.000)	87.043 (0.002)	72.785 (0.003)	2.378 (0.241)	3.311 (0.174)
Decision	Significant	Significan t	Not Significan t	Significant	Significant	Significant	Not Significant	Not Significant

NB: Mean (rows) with different alphabet is significantly ($p<0.05$) different for each Parameter (column).

Table 3.1b: Mean and Standard Deviation of Soil Proximate Parameter based on Locations

Locations	Na (cmol/Kg)	Acidity (cmol/Kg)	Al (cmol/Kg)	ECEC (cmol/Kg)	Mn (mg/g)	Fe (mg/g)	Cu (mg/g)	Zn (mg/g)
Emohua	0.47±0.07a	10.3±0.71b	12.75±0.21b	26.28±1.94a	25.28±1.45a	99.24±1.41c	1.96±0.12a	3.91±2.12a
Aluu	1.02±0.57a	4.7±0.71a	12.7±0.42b	38.89±1.63b	81.57±8.9c	68.25±6.36b	4.23±0.44b	159.95±2.63c
Ozuoba	0.66±0.13a	5.6±1.41a	8.1±0.71a	24.33±1.24a	42.12±1.41b	34.85±1.35a	3.01±0.69ab	27.09±2.21b
ANOVA (p-value)	1.37 (0.378)	18.087 (0.021)	59.014 (0.004)	47.223 (0.005)	60.185 (0.004)	140.398 (0.001)	11.323 (0.04)	2611.846 (0.00)
Decision	Not Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant

NB: Mean (rows) with different alphabet is significantly ($p<0.05$) different for each Parameter (column).

Soil Particles based on Locations

Table 3.2: Mean and Standard Deviation of Soil Particles based on Locations

Locations	Sand (%)	Silt (%)	Clay (%)
Emohua	74.2±2.26a	14.4±1.41b	28.9±2.12a
Aluu	76.2±2.26a	15.9±0.71ab	25.9±0.71a
Ozuoba	73.7±1.27a	17.9±0.71c	26.9±2.12a
ANOVA (p-value)	0.885(0.499)	6.167(0.087)	1.474(0.358)
Decision	Not Significant	Not Significant	Not Significant

NB: Mean (rows) with different alphabet is significantly ($p<0.05$) different for each Parameter (column).

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Heavy Metals in Soil based on Locations

Table 3.3: Mean and Standard Deviation of Heavy Metals in Soil based on Locations

Locations	Cu (mg/kg)	Zn (mg/kg)	Co (mg/kg)	Pb (mg/kg)	Ni (mg/kg)
Emohua	10.29±4.68a	31.4±34.53a	0.45±0.64a	0.89±1.26a	0.03±0.05a
Aluu	13.92±5.57a	97.3±123.48a	1.05±1.49a	1.27±1.79a	0±0a
Ozuoba	16.59±6.04a	124.71±107.34a	0.13±0.18a	1.01±1.42a	0.06±0.08a
ANOVA (p-value)	0.669 (0.575)	0.494 (0.653)	0.495 (0.652)	0.033 (0.968)	0.519 (0.640)
Decision	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant

NB: Mean (rows) with different alphabet is significantly ($p<0.05$) different for each Parameter (column).

Environmental Conditions Irrespective of Locations

Table 3.4: Mean and Standard Deviation of Environmental Conditions Based on Year

Period		Temperature	Relative Humidity	Wind Speed	Pressure	Rainfall
2021		25.2±2.51	83.68±4.54	1.49±0.42	100.46±0.77	252.42±177.78
2022		29.98±2.87	87.48±2.9	1.5±0.4	100.26±0.92	236.58±171.36
Total		27.59±3.59	85.58±4.17	1.5±0.39	100.36±0.83	244.5±168.88

Statistical Analysis: The data that collected was subjected to statistical analysis by using Statistical package for Social Sciences (SPSS), Version 25. Mean comparison and separation were conducted using Turkey's Test. Duncan Multiple Range Test (DMRT) were employed to dispersed means at 0.05 level of significant.

RESULTS AND DISCUSSIONS

HEAVY METALS

Analysis of Heavy Metals in Leaves, Roots, Tubers and Petioles of Xanthosoma spp and Colocasia esculenta in Locations

Difference between Lead Content based on Accessions and Locations

The highest level of lead content in corms was present in NCE03 (4.811±0.718) accession in Ozuoba whereas the least was present in NXS02 (0.145±0.028) accession in Emohua locations. In cormlet, the highest lead content was present in NCE03 (2.037±0.008) accession in Ozuoba and the least was present in NXS01 (0.012±0.006) accession in Emohua location. The highest level of lead content in leaves was present in NCE03 (0.043±0.018) accession in Emohua whereas the least was present in NXS03 (0.007±0.005) accession in Aluu and NXS01 (0.007±0.005) in Ozuoba location. In roots, the highest lead content was present in NCE03 (0.12±0) accession in Aluu and Emohua, while the least was present in NCE02 (0.009±0.001) accession in Aluu location. Also in petioles, the highest lead content was present in NCE03 (0.083±0.004) accessions in Aluu and the least was present in NCE01 (0.004±0.001) accession in Aluu location. The ANOVA result shows that mean lead content in samples are significantly different ($p<0.05$) irrespective of location. The multiple comparison using Duncan test shows that samples are significantly different. This implies that mean lead of samples are not same for corms, cormlet, leaves, roots and petioles (see Table 4.1a).

Table 4.3a: Mean and Standard Deviation of Lead Content across Accessions based on Locations

Location	Cultivar	Corms	Cormels	Leaves	Roots	Petioles
Aluu	**NCE01**	3.548±0.742b	1.523±0.721b	0.012±0.002ab	0.018±0.003ab	0.004±0.001a
	NCE02	3.549±0.734b	1.519±0.719b	0.013±0.003abc	0.009±0.001a	0.007±0.001abc
	NCE03	3.561±0.736b	1.525±0.721b	0.021±0.001bc	0.12±0d	0.083±0.004k
	NXS01	0.318±0.151a	0.063±0.042a	0.012±0.001ab	0.019±0.001ab	0.014±0.002abcdef
	NXS02	0.332±0.161a	0.026±0.007a	0.021±0.001bc	0.027±0.001abc	0.027±0.004hij
	NXS03	0.321±0.156a	0.019±0a	0.007±0.005a	0.024±0.006abc	0.019±0.001fghi
Emohua	**NCE01**	4.121±0.991b	1.533±0.723b	0.013±0.004abc	0.008±0.003a	0.005±0.006ab
	NCE02	4.105±0.993b	1.535±0.724b	0.014±0.009abc	0.017±0.004ab	0.007±0.001abc

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	NCE03	3.61±1.709b	1.538±0.725b	0.043±0.018e	0.1±0.014d	0.03±0.014j
	NXS01	0.145±0.049a	0.012±0.006a	0.016±0.006abc	0.023±0.011abc	0.015±0.005bcdefg
	NXS02	0.145±0.028a	0.015±0.005a	0.019±0.001abc	0.023±0.004abc	0.024±0.001ghij
	NXS03	0.154±0.028a	0.013±0.001a	0.026±0.006cd	0.015±0.005ab	0.018±0.004defgh
Ozuoba	**NCE01**	4.811±0.718b	1.54±0.721b	0.016±0.006abc	0.017±0.001ab	0.008±0.004abcd
	NCE02	4.306±1.549b	1.54±0.733b	0.011±0.001ab	0.013±0.004a	0.008±0abcde
	NCE03	4.681±0.792b	2.037±0.008b	0.035±0.001de	0.043±0.032c	0.029±0.001ij
	NXS01	0.327±0.143a	0.051±0.001a	0.007±0.004a	0.029±0.005abc	0.017±0.002bcdefg
	NXS02	0.38±0.106a	0.052±0.013a	0.022±0.003ab	0.036±0.013bc	0.023±0.001fghij
	NXS03	0.453±0.007a	0.06±0.004a	0.014±0.002abc	0.018±0.004ab	0.018±0.003efgh
ANOVA (p-value)		13.585 (0.000)	5.605(0.000)	5.325(0.000)	19.959(0.000)	33.177(0.000)
Decision		Significant	Significant	Significant	Significant	Significant

NB: Accessions (rows) with different alphabet is significantly ($p<0.05$) different for each morphology (column).

4.3.2 Difference between Copper Content across Accessions based on Locations

The highest level of copper content in corms was present in NXS02 (10.815±1.506) accession in Ozuoba whereas the least was present in NCE (8.66±2.185) accessions in Aluu locations. In cormlet, the highest copper content was present in NXS02 (8.522±0.709) accession in Ozuoba and the least was present in NCS03 (7.531±2.135) accession in Aluu location. The highest level of copper content in leaves was present in NCE01 (2.9±0.141) accession in Ozuoba whereas the least was present in NCE03 (0.295±0.035) accession in Aluu location. In roots, the highest copper content was present in NCE01 (2.1±0.141) accession Ozuoba, while the least was present in NCE03 (0.395±0.078) accession in Aluu location. Also in petioles, the highest copper content was present in NCE01 (1.675±0.177) accession in Aluu and the least was present in NCE03 (0.575±0.318) accession in Emohua location. The ANOVA result shows that mean copper content in samples were significantly different ($p<0.05$) irrespective of location. The multiple comparison using Duncan test shows that samples are significantly different. This implies that mean copper content in samples are not same in leaves, roots and petioles (see Table 4.1b). However, ANOVA result shows that samples mean copper content were not significantly different ($p>0.05$) in corms and cormlet irrespective of location (see Table 4.1b).

Table 4.3b: Mean and Standard Deviation of Copper Content across Accessions based on Locations

Location	Cultivar	Corms	Cormels	Leaves	Roots	Petioles
Aluu	**NCE01**	8.666±2.198a	7.532±2.136a	1.91±0.127fg	1.945±0.092fg	1.675±0.177f
	NCE02	8.67±2.191a	7.532±2.138a	1.6±0.283ef	1.55±0de	1.35±0def
	NCE03	8.66±2.185a	7.531±2.135a	0.295±0.035a	0.395±0.078a	0.695±0.445ab
	NXS01	10.044±1.448a	7.542±2.123a	1.41±0.269de	1.185±0.021bc	1.2±0cde
	NXS02	10.045±1.45a	8.062±1.442a	0.89±0.156bc	1.035±0.092b	1.1±0cde
	NXS03	10.03±1.431a	8.031±1.425a	0.855±0.064bc	1.1±0.141b	0.975±0.049bcd
Emohua	**NCE01**	9.117±2.406a	8.014±1.419a	1.3±0.028de	1.905±0.134fg	1.475±0.106ef
	NCE02	9.106±2.408a	7.515±2.126a	1.2±0.283cd	1.725±0.106ef	1.29±0.127de
	NCE03	9.118±2.413a	7.517±2.124a	0.36±0.198a	0.6±0.424a	0.575±0.318a
	NXS01	10.546±1.718a	8.031±1.428a	1.205±0.134cd	1.085±0.021b	1.36±0.198def
	NXS02	10.512±1.657a	8.036±1.418a	0.725±0.035b	0.95±0.071b	1.15±0.141cde
	NXS03	10.413±1.668a	7.528±2.129a	0.81±0.028b	1.1±0.212b	0.895±0.007abc
Ozuoba	**NCE01**	8.871±2.348a	8.011±1.414a	2.9±0.141h	2.1±0.141g	1.45±0.071ef
	NCE02	8.818±2.274a	8.011±1.407a	2.565±0.163h	1.85±0.071efg	1.31±0.014def
	NCE03	8.862±2.289a	8.012±1.417a	1.545±0.134de	1.42±0.042cd	0.61±0.156a
	NXS01	10.633±1.715a	8.017±1.421a	0.95±0.071bc	1.035±0.049b	1.15±0.071cde
	NXS02	10.815±1.506a	8.522±0.709a	2.84±0.085h	0.91±0.014b	1.06±0.085cd
	NXS03	10.66±1.713a	8.52±0.714a	2.21±0.042g	1.065±0.078b	1.1±0cde
ANOVA (p-value)		0.131 (1.00)	0.119 (1.00)	17.767 (0.00)	39.27 (0.00)	25.203 (0.00)
Decision		Not Significant	Not Significant	Significant	Significant	Significant

NB: Accessions (rows) with different alphabet is significantly ($p<0.05$) different for each morphology (column)

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Difference between Zinc Content across Accessions based on Locations

The highest level of zinc content in corms was present in NXS01 (2.682±0.791) accession in Ozuoba whereas the least was present in NCE01 (2.012±1.417) accession in Emohua location. In cormlet, the highest zinc content was present in NXS01 and NXS03 (2.02±0.006) accessions in Ozuoba and the least was present in NCE01 (1.515±0.711) accession in Aluu location. The highest level of zinc content in leaves was present in NXS02 (2.775±0.177) accession in Ozuoba whereas the least was present in NXS02 (0.85±0.141) accession in Aluu location. In roots, the highest zinc content was present in NXS02 (2.8±0.212) accession in Emohua, while the least was present in NXS01 (0.97±0.042) accession in Emohua location. Also in petioles, the highest zinc content was present in NXS02 (2.56±0.17) accession in Aluu, and the least was present in NXS01 (0.76±0.057) accession in Ozuoba location. The ANOVA result shows that mean zinc content in samples are significantly different ($p<0.05$) irrespective of location. The multiple comparison using Duncan test shows that samples are significantly different. This implies that mean zinc content in samples are not same in leaves, roots and petioles (see Table 4.1c). However, ANOVA result shows that samples mean zinc content are not significantly different ($p>0.05$) in corms and cormlet irrespective of location (see Table 4.1c).

Table 4.3c: Mean and Standard Deviation of Zinc Content across Accessions based on Locations

Location	Cultivar	Corms	Cormels	Leaves	Roots	Petioles
Aluu	**NCE01**	2.51±0.708a	1.515±0.711a	2.17±0.523cd	2.05±0.071de	1.725±0.177cd
	NCE02	2.511±0.709a	1.518±0.704a	1.375±0.389ab	1.89±0.156d	1.765±0.049cd
	NCE03	2.013±1.416a	1.523±0.703a	1.28±0.028a	1.41±0.212c	1.325±0.035b
	NXS01	2.539±0.728a	1.52±0.704a	1.04±0.057a	0.99±0.014a	0.995±0.007a
	NXS02	2.028±1.435a	1.528±0.704a	0.85±0.141a	2.54±0.127g	2.56±0.17f
	NXS03	2.544±0.726a	1.534±0.684a	0.905±0.134da	2.01±0de	1.99±0.014de
Emohua	**NCE01**	2.012±1.417a	1.505±0.714a	2.62±0.255de	1.865±0.049d	1.73±0.099cd
	NCE02	2.514±0.711a	1.51±0.705a	1.945±0.078c	1.88±0.113d	1.54±0.057bc
	NCE03	2.513±0.711a	1.52±0.707a	0.94±0.495a	1.51±0.127c	0.985±0.021a
	NXS01	2.025±1.433a	1.575±0.641a	1±0a	0.97±0.042a	2.535±0.064f
	NXS02	2.523±0.721a	1.515±0.718a	2.775±0.163e	2.8±0.212h	1.95±0.071de
	NXS03	2.028±1.423a	1.529±0.702a	2.35±0.354cde	2.17±0.156ef	1.99±0.014de
Ozuoba	**NCE01**	2.673±0.725a	1.511±0.711a	2.505±0.035de	1.925±0.106de	1.33±0.41b
	NCE02	2.179±1.438a	1.516±0.716a	1.825±0.177bc	1.82±0.17d	1.64±0.085bcd
	NCE03	2.676±0.732a	1.517±0.709a	1.36±0.057ab	1.315±0.04bc9	1.45±0.071bc
	NXS01	2.682±0.791a	2.021±0.001a	0.95±0.071a	1.075±0.035ab	0.76±0.057a
	NXS02	2.183±1.499a	1.521±0.71a	2.775±0.177e	2.05±0.071de	2.47±0.099f
	NXS03	2.73±0.728a	2.02±0.006a	2.19±0.127cd	2.32±0.028fg	2.25±0.354ef
ANOVA (p-value)		0.348 (0.983)	0.078 (1.00)	53.918	24.32	7.048
Decision		Not Significant	Not Significant	Significant	Significant	Significant

NB: Accessions (rows) with different alphabet is significantly ($p<0.05$) different for each morphology (column).

4.3.4 Difference between Nickel Content across Accessions based on Locations

The highest level of nickel content in corms was present in NXS02 (0.046±0.018) accession in Ozuoba whereas the least was present in NCE03 (0.015±0.007) in Aluu location. In cormlet, the highest nickel content was present in NXS02 (0.015±0.005) accession in Ozuoba and the least was present in NXS01 (0.008±0.004) accession in Emohua location. The highest level of nickel content in leaves was present in NXS02 (0.048±0.003) accession in Aluu whereas the least was present in NXS01 (0.01±0) accession in Aluu location. In roots, the highest nickel content was present in NXS01 (0.05±0.004) accession in Ozuoba, while the least was present in NXS03 (0.01±0.001) accession in Emohua location. Also in petioles, the highest nickel content was present in NCE03 (0.018±0.001) accession in Emohua, and the least was present in NCE01 and NXS03 (0.007±0.001) accession in Emohua location. The ANOVA result shows that mean nickel content in samples are significantly different ($p<0.05$) irrespective of location. The multiple comparison using Duncan test shows that samples are significantly different. This implies that mean nickel content in samples are not same in leaves, roots and petioles (see Table 4.1d). However, ANOVA result shows that samples mean nickel content are not significantly different ($p>0.05$) in corms and cormlet irrespective of location (see Table 4.1d).

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Table 4.3d: Mean and Standard Deviation of Nickel Content across Accessions based on Locations

Location	Cultivar	Corms	Cormels	Leaves	Roots	Petioles
Aluu	**NCE01**	0.019±0.007a	0.012±0.001a	0.012±0.003a	0.017±0.005abc	0.01±0.001ab
	NCE02	0.023±0.002a	0.013±0.001a	0.014±0.002ab	0.013±0.004ab	0.014±0.002abc
	NCE03	0.015±0.007a	0.013±0.002a	0.013±0.002a	0.038±0.011defgh	0.018±0.001c
	NXS01	0.035±0.016a	0.009±0.001a	0.01±0a	0.019±0.001abc	0.009±0.003ab
	NXS02	0.034±0.018a	0.011±0.001a	0.048±0.003e	0.044±0.005fgh	0.015±0.007bc
	NXS03	0.033±0.018a	0.009±0.002a	0.024±0.001bc	0.026±0.007abcde	0.012±0.005abc
Emohua	**NCE01**	0.016±0.008a	0.015±0.005a	0.017±0.004abc	0.013±0.004ab	0.007±0.001a
	NCE02	0.015±0.01a	0.015±0.002a	0.01±0.001a	0.033±0.018cdefg	0.009±0.004ab
	NCE03	0.041±0.018a	0.012±0.002a	0.018±0.004abc	0.032±0.011cdefg	0.011±0.002ab
	NXS01	0.035±0.007a	0.008±0.004a	0.038±0.013d	0.039±0.01defgh	0.015±0.001bc
	NXS02	0.037±0.017a	0.009±0.004a	0.019±0.008abc	0.012±0.001ab	0.011±0.001abc
	NXS03	0.034±0.016a	0.013±0.004a	0.027±0.004c	0.01±0.001a	0.007±0.001a
Ozuoba	**NCE01**	0.016±0.007a	0.012±0.004a	0.019±0.001abc	0.05±0.004h	0.012±0.001abc
	NCE02	0.029±0.002a	0.011±0.001a	0.015±0.007ab	0.04±0.008efgh	0.012±0.002abc
	NCE03	0.022±0.005a	0.009±0.006a	0.013±0.001ab	0.025±0.001abcde	0.01±0.002ab
	NXS01	0.041±0.018a	0.011±0.001a	0.011±0.001a	0.048±0.004gh	0.011±0.001abc
	NXS02	0.046±0.018a	0.015±0.005a	0.015±0.001ab	0.022±0.003abcd	0.012±0.002abc
	NXS03	0.045±0.023a	0.013±0.001a	0.009±0.001a	0.027±0.004bcdef	0.012±0.002abc
ANOVA (p-value)		1.233 (0.337)	1.063 (0.448)	10.388 (0.000)	6.648 (0.000)	1.997 (0.078)
Decision		Not Significant	Not Significant	Significant	Significant	Not Significant

NB: Accessions (rows) with different alphabet is significantly ($p<0.05$) different for each morphology (column).

4.3.5 Difference between Cobal Content across Accessions based on Locations

The highest level of cobal content in corms was present in NXS02 (0.024±0.006) accession in Ozuoba whereas the least was present in NCE01 (0.01±0.001) in Aluu and Emohua location. In cormlet, the highest cobal content was present in NXS02 (0.01±0.003) accession in Emohua and the least was present in NCE01 and NCE 03 (0.003±0.001) accession in Emohua location. The highest level of cobal content in leaves was present in NXS02 (0.023±0.004) accession in Aluu whereas the least was present in NCE01 (0.004±0.003) accession in Emohua location. In roots, the highest cobal content was present in NXS03 (0.018±0) accession in Ozuoba, while the least was present in NCE02 (0.006±0.001) accession in Emohua location. Also in petioles, the highest cobal content was present in NCE03 (0.01±0) accession in Emohua, and the least was present in NCE02 (0.004±0.001) accession in Emohua and NCE01, NXS 03 in Ozuoba location. The ANOVA result shows that mean cobal content in samples are significantly different ($p<0.05$) irrespective of location. The multiple comparison using Duncan test shows that samples are significantly different. This implies that mean cobal content in samples are not same in cormlet, leaves and roots (see Table 4.1e). However, ANOVA result shows that samples mean cobal content are not significantly different ($p>0.05$) in corms and petioles irrespective of location (see Table 4.1e).

Table 4.3e: Mean and Standard Deviation of Cobal Content across Accessions based on Locations

Location	Cultivar	Corms	Cormels	Leaves	Roots	Petioles
Aluu	**NCE01**	0.01±0.001a	0.006±0.004abcd	0.01±0.001abcd	0.014±0.001efg	0.007±0.005abc
	NCE02	0.015±0.005abc	0.005±0.002abc	0.013±0.004bcd	0.017±0.001fg	0.01±0.002bc
	NCE03	0.015±0.007abc	0.008±0.002bcd	0.015±0.004cd	0.014±0.005defg	0.006±0.004abc
	NXS01	0.013±0ab	0.003±0.001ab	0.011±0.005abcd	0.012±0.002bcde	0.01±0.001bc
	NXS02	0.017±0.002abc	0.004±0.002abc	0.023±0.004e	0.007±0.003ab	0.007±0.003abc
	NXS03	0.013±0.001ab	0.008±0.001bcd	0.01±0.002abcd	0.015±0.005efg	0.009±0.003abc
Emohua	**NCE01**	0.01±0a	0.003±0.001a	0.004±0.003a	0.009±0.002abcd	0.006±0.001abc
	NCE02	0.019±0.007abc	0.004±0.001abc	0.009±0abc	0.006±0.001a	0.004±0.001a
	NCE03	0.015±0.004abc	0.003±0.001a	0.011±0.004abcd	0.011±0.001abcde	0.01±0c
	NXS01	0.015±0.002abc	0.008±0.001cd	0.017±0.002d	0.012±0.003bcdef	0.007±0.001abc
	NXS02	0.018±0.002abc	0.01±0.003d	0.006±0.004ab	0.012±0.002bcde	0.006±0.001abc
	NXS03	0.012±0.001ab	0.008±0.002bcd	0.011±0.001abcd	0.011±0bcde	0.007±0.002abc
Ozuoba	**NCE01**	0.012±0.006ab	0.005±0abc	0.004±0.001a	0.011±0.001abcde	0.004±0.001a
	NCE02	0.016±0.004abc	0.006±0.003abcd	0.008±0.002ab	0.013±0.001cdef	0.008±0.001abc

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	NCE03	0.015±0.001abc	0.005±0.001abc	0.009±0.002abc	0.015±0.001efg	0.007±0.003abc
	NXS01	0.022±0.001bc	0.006±0.003abcd	0.007±0.003ab	0.008±0abc	0.005±0.001ab
	NXS02	0.024±0.006c	0.006±0.001abcd	0.009±0.004abc	0.011±0.001abcde	0.006±0.001abc
	NXS03	0.019±0.007abc	0.007±0abcd	0.01±0.002abcd	0.018±0g	0.004±0a
ANOVA (p-value)		1.848 (0.103)	2.519 (0.030)	4.913 (0.001)	4.509 (0.001)	1.686 (0.141)
Decision		Not Significant	Significant	Significant	Significant	Not Significant

NB: Accessions (rows) with different alphabet is significantly ($p<0.05$) different for each morphology (column).

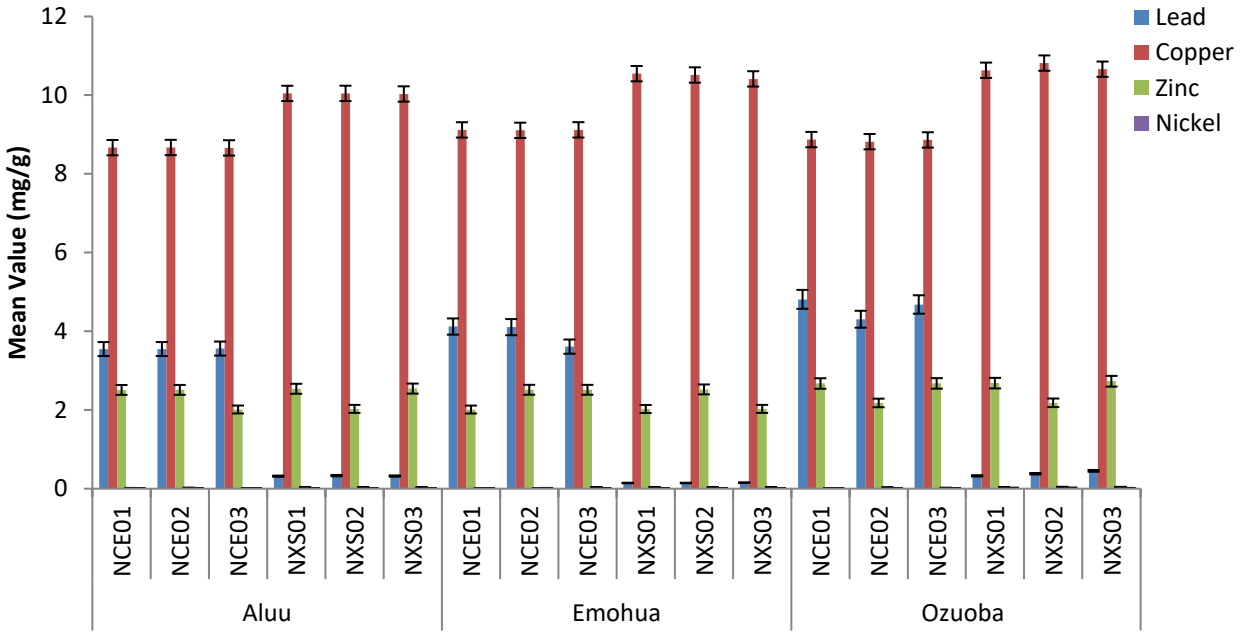

Figure 4.1: Heavy Metal in Corms based on Accessions and Locations

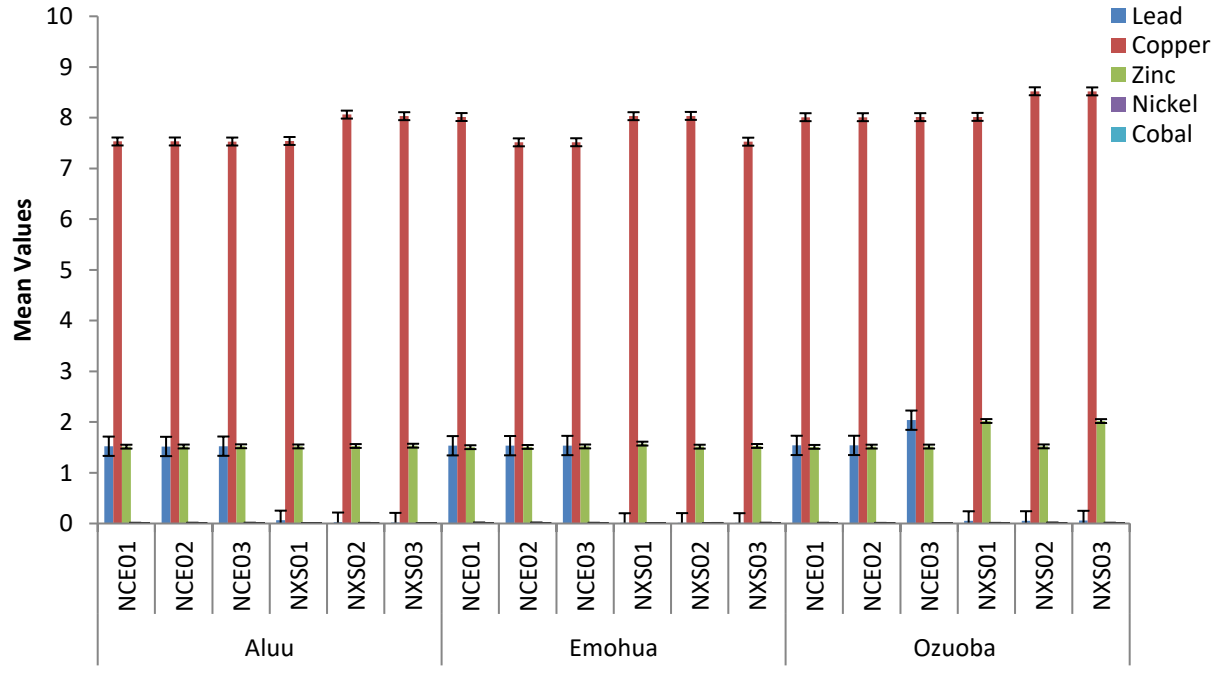

Figure 4.2: Heavy Metal in Cormels based on Accessions and Locations

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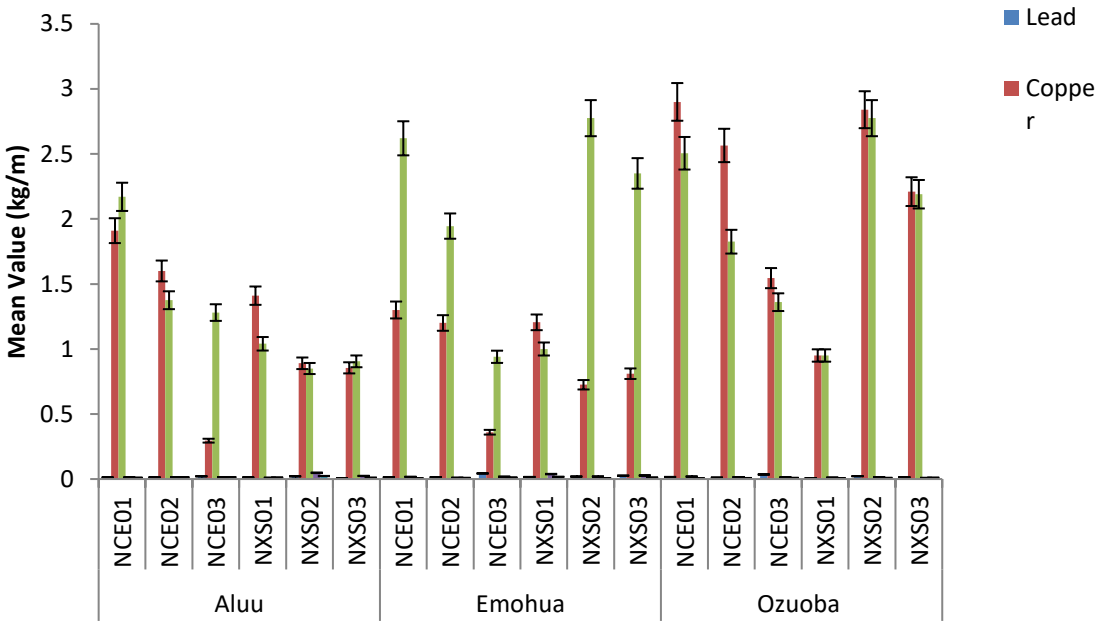

Figure 4.3: Heavy Metal in Leave based on Accessions and Locations

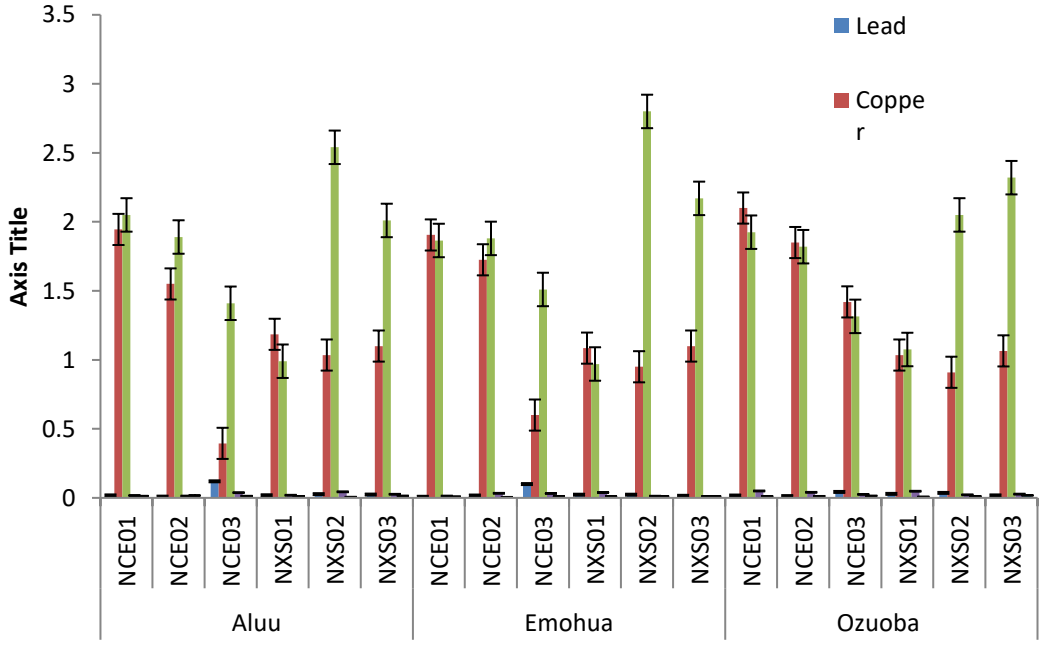

Figure 4.4: Heavy Metal in Roots based on Accessions and Locations

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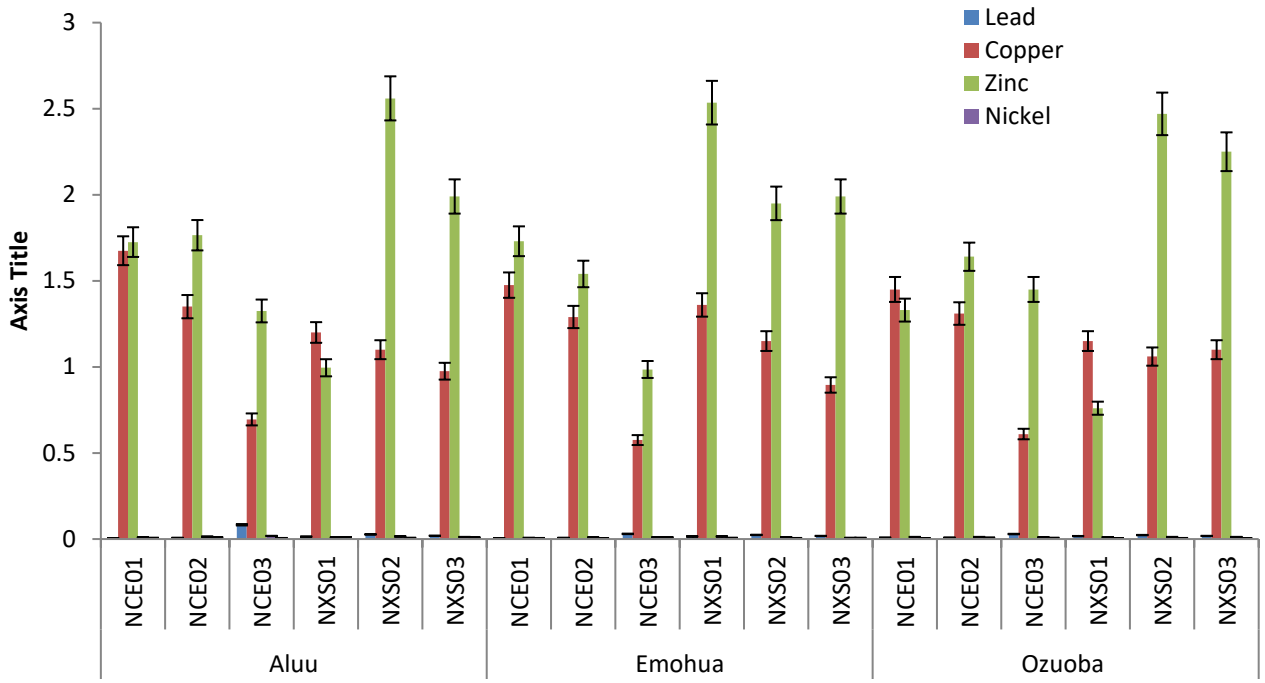

Figure 4.5: Heavy Metal in Petioles based on Accessions and Locations.

DISCUSSION

Analysis of Heavy Metals and Proximates in Leaves, Roots, Tubers and Petioles of Xanthosoma spp and Colocasia esculenta in Locations.

Heavy metal present in corms are in ascending order i.e cobalt<nickel<zinc<lead<copper, in cormlet are cobalt<nickel<lead<zinc<copper and there were same in leaves, roots and petroles in ascending order cobalt<lead<nickel<copper<zinc in all accessions irrespective of locations. Result shows that lead content in corms, cormlet, leaves, roots and petioles of accessions were significantly different ($p<0.05$) irrespective of location. Also, copper content in leaves, roots and petioles of accessions were significantly different ($p<0.05$) irrespective of location. But copper content in corms and cormlet of samples were not significantly different ($p>0.05$) irrespective of location. Zinc and nickel content in leaves, roots and petioles of accessions were significantly different ($p<0.05$) irrespective of location. However, zinc and nickel content in corms and cormlet of accessions were not significantly different ($p>0.05$) irrespective of location. More so, cobal content in cormlet, leaves and roots of accessions were significantly different ($p<0.05$) respectively irrespective of location. But cobal content in corms and petioles of samples are not significantly different ($p>0.05$) respectively irrespective of location. These findings were in concordance with Koubová et al., (2018), Sangeetha et al., (2022) and Karuma et al., (2024) They found that zinc (Zn) is an essential mineral for development, immunity, and enzyme activity, and that these processes require a steady supply of Zn in the diet. Roots and leaves contain copper (Cu), which is necessary for many bodily functions, such as blood vessel and connective tissue production, neurological and immune system maintenance, and brain development (Chove et al., 2006; NIH, 2022; Karuma et. al., 2024). Iron, copper, zinc, and nickel are essential heavy metals that living things require in minute amounts for critical growth (Wuana and Okieimen, 2011; Chaiyarat et al., 2011; Khoramnejadian and Saeb, 2015; Marrugo-Negrete et al., 2015; Donkor, 2016). The presence of potassium (K) and magnesium (Mg) in leaves has been documented in numerous studies (Alcantara, 2013; Özenç et al., 2014; Temesgen and Retta, 2015; Azubuike et al., 2018; Cruz et al., 2018; Mulugeta and Tebeka, 2017; Gerrano et al., 2021; Beato et al., 2024). A variety of biological functions, including development, digestion, reproduction, energy production, and the immune system, rely on manganese (Mn) (Chen et al., 2018; Gerrano et al., 2021). There is a high concentration of vitamin C in iron (Fe) in corms and leaves, which helps with iron absorption (Temesgen and Retta, 2015; Clifford et al., 2015, Karuma et al., 2024) and with hypertension prevention or control, reducing the risk of stroke and heart disease (Huang et al., 2007; Amagloh and Nyarko, 2012; Özenç et al., 2014; Soudy et al., 2016; Koubová et al., 2018). According to several studies, including those by Ngetich et al. (2015), Akwee et al. (2015), Chivenge et al. (2015), and Palapala and Akwee (2016), the leaves and corms of this plant contain a lot of carbs. Chronic liver illness, peptic ulcer, gall bladder, inflammatory bowel, and pancreatic cancer patients can all benefit from taro starch (Enwelu et al., 2014; Buke and Gidago, 2016). Higher level of Ni metal accumulation in plant parts especially in upper parts (leaves) of Colocassia esculentum showed biomagnification of metals and thus these plants can be considered as accumulator accessions (Singh et al., 2010; Parmar et al., 2012). According to research

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conducted by Huang et al. (2007), Alcantara (2013), Usman et al. (2015), Hota et al. (2016), Alam et al. (2019), and others, there are several variables that might affect the nutritional profile of cocoyam, including the variety, cultivation conditions, country of origin, soil type, moisture, fertilizer application, harvest ripeness, management after harvest, and storage. It is beneficial to eat varieties of corms and cormels that are high in fibre and protein because they provide protection against certain health problems. On the other hand, varieties that are low in fibre can lead to constipation, which in turn can cause colon diseases like piles, appenditics, and cancer (Wiesler et al., 2010; Mwenye et al., 2011; Olaleye et al., 2013; Matikiti et al., 2017; Adeyanju et al., 2019). You can tell what kinds and amounts of minerals are in cocoyam by looking at its ash content (Lewu et al., 2010).

SUMMARY AND CONCLUSION

Summary

Globally there is food insecurity and economy meltdown. Many countries are developing innovations several areas such in agriculture to achieve sustainable food sufficiency and economic development. In Sub-Sahara Africa, agricultural crops such as cocoyam are neglected due to poor knowledge of the enormous benefits of these crops. The situation, however, is worsened by the increasing human population and decline in agricultural activities due to crude oil boom. Hence there is urgent need to intensify efforts on the breeding of improved varieties of these crops in order to make it more attractive to consumers and farmers in River State and Nigeria at large. Thus, this study seeks to determine the heavy metal characterization of edible aroids growing in in three locations (Emohua, Aluu, and Ozuoba), of Rivers State. These locations were selected based on their agricultural importance for root crop cultivation, and they also represent areas where different environmental conditions (such as soil type, climate, oil industrial and human activities) may influence contamination levels.

The major aspects of this research was to determine the levels of heavy metals (cobalt, nickel, zinc, lead, and copper) present in various parts of the plants, including the corms, cormlets, leaves, roots, and petioles. Heavy metal contamination is a growing concern for crops consumed by humans, as these metals can accumulate in food chain and pose health risks. The results showed the levels of heavy metals varied across different plant parts irrespective of ascensions and locations, in corms as cobalt < nickel < zinc < lead < copper, in cormlets as cobalt < nickel < lead < zinc < copper, while in leaves, roots, and petioles, the metals followed the order: cobalt < lead < nickel < copper < zinc.

Significantly, the lead content in all plant parts (corms, cormlets, leaves, roots, and petioles) was found to be significantly different ($p<0.05$) across locations, suggesting that lead levels might be influenced by the specific environmental or anthropogenic conditions of the different regions. The discovery highlights the possibility of lead contamination in these crops, which could endanger consumers' health. Likewise, there were notable variations in the copper concentration between locations for the leaves, roots, and petioles ($p<0.05$), but no significant differences were found for the corms and cormlets ($p>0.05$). This suggests that copper may accumulate more in aerial parts of the plant, such as leaves and petioles, potentially due to the absorption of copper through the soil or via atmospheric deposition. Interestingly, nickel and zinc concentrations in the leaves, roots, and petioles were also significantly different ($p<0.05$) across the locations, while their concentrations in the corms and cormlets did not show significant variation. Finally, cobalt levels showed significant differences ($p<0.05$) in cormlets, leaves, and roots, but no significant differences in corms and petioles ($p>0.05$). This finding suggests that cobalt may be more readily absorbed into the plant's above-ground tissues than the tuberous parts.

Conclusion

The study provided critical insights into the environmental and agronomic factors influencing the cultivation of Xanthosoma spp. and Colocasia esculenta in the studied regions. The findings on heavy metal accumulation in various plant parts indicate that these crops may pose a potential health risk due to the significant levels of lead, copper, zinc, and nickel in some locations, particularly in the leaves, roots, and petioles. These results emphasize need for continued monitoring heavy metal contamination in crops grown in these regions to safeguard consumer health.

Contribution to Knowledge

The study offers a detailed profile of heavy metal contamination in these crops, revealing the distribution of toxic metals in different plant parts. This data can help inform future studies on the health risks associated with consuming these crops and guide efforts to reduce contamination.

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