ASSESSMENT OF HEAVY METALS (MERCURY AND ARSENIC) LEVELS IN LEMONGRASS AT KIHONDA AND MAFISA (VIWANDANI) IN MOROGORO, TANZANIA.

ABSTRACT

The study aims to assess the presence and concentration of heavy metals in lemon grasses. These could have implications for the safety and quality of the lemon for various uses, including culinary and medicinal purposes. The research employs analytical techniques such as atomic absorption spectroscopy (AAS) to determine the levels of mercury and arsenic in the lemon grass samples. The findings of the study provide valuable insights into the environmental conditions and potential health risks associated with the consumption of lemon from Kihonda and Mafisa in Morogoro. Public Health Implications: High levels of heavy metals in food, including lemongrasses, can pose serious health risks to consumers. According to studies, resulting from chronic exposure to heavy metals through contaminated food can lead to various health issues, including neurological disorders, gastrointestinal problems, and kidney damage.

1.0 INTRODUCTION

The important issues to be discussed include; the general introduction, the statement of the problem, the research objectives, the significance of the study, the research hypothesis and the literature review.

1.1 General Introduction

Lemongrasses are important components of a healthy diet, providing essential vitamins, minerals, and fibers. However, the quality and safety of these lemongrasses can be compromised by environmental factors, including the presence of heavy metals such as mercury and arsenic. Elevated levels of these metals in food can pose serious health risks to consumers, ranging from acute toxicity to long-term health effects.

Morogoro Municipality, located in Tanzania, is known for its agricultural activities, including cultivation of Lemongrasses. As urbanization and industrialization continue to expand, there is a growing concern about the potential contamination of crops with heavy metals from various sources, including industrialization, infrastructures, pollution and agricultural practices.

This study aims to investigate the levels of mercury and arsenic in Lemongrass grown in Morogoro Municipality, providing valuable information on the safety and quality of these popular lemongrasses. By assessing the contamination levels of heavy metals in these lemongrasses, we can better understand the potential risks to human health and inform strategies for ensuring food safety and security in the region.

The study on “Determination of mercury and arsenic Levels in Selected Popular lemongrasses Grown around Morogoro Municipality” is crucial for assessing the safety and quality of commonly consumed lemongrasses in Tanzania. According to Asante et al. (2020), lemongrasses play a significant role in providing essential nutrients to individuals, but the presence of heavy metals such as mercury and arsenic can pose health risks to consumers. Furthermore, a study by Mdegela et al. (2018) emphasized the importance of monitoring heavy metal levels in food crops, especially in urban agricultural areas like Morogoro Municipality. Therefore, investigating the levels of mercury and arsenic in Lemongrass grown in this region is essential for ensuring food safety and protecting public health.

A method has been developed for the accurate determination of arsenic and mercury deposited on suspended particulate matter (SPM) collected by high volume sampler (HVS) from various locations of Delhi (Capital city of India) by using hydride generator with flame/flameless Atomic Absorption spectrometry (AAS). Several diverse sites has been monitored for arsenic and mercury content in environment by analyzing the samples by the method proposed, but in the present study we are reporting data from seven diverse sites Ashram (S–1; heavy traffic zone), Azadpur (S–2; industrial zone), Loni Road (S–3; densely populated + traffic zone), Pitampura (S–4; urban background zone), Highway no. 56 (S–5; traffic zone), Naraina (S–6; industrial zone) and NPL (S–7; mix zone(Nahar (2010).

The standard deviation of the measurements has been calculated on the basis of six observations of two replicates (three each) of each analyzed species and was found to be less than 3.5% by the proposed method. The validity of the method proposed has been established by standard addition of arsenic and mercury in the procedural blank (without sample) and also to check the loss during the process. It has been found that in five replicates, arsenic and mercury recoveries were 99.3% and 99.1% respectively within 95% confidence level. The method proposed is highly reproducible and can be used for accurate determination of arsenic and mercury in the atmospheric particulate matter samples. The arsenic concentration varied from 1.3ng/m^3 to 5.1ng/m^3, while concentration of mercury varied from 1.4ng/m^3 to 12.5ng/m^3, in seven diverse sites of the Delhi (Nahar (2010). Rodriguez, et al. (2024) projected on way of Tackling Arsenic and Mercury Contamination together with Implications for Sustainable Mining and Occupational Health Risks,

Nejad and, Sheibani (2022), assessed Mercury (Hg) and arsenic (As) as two of the toxic and non-biodegradable heavy metals which can be emitted into the aquatic ecosystem, accumulated in the food chain, and pose a serious threat to the aquatic organism and human health. In this study, the effect of engineered biochar with poly 2-aminothiophenol on removal of mercury and arsenic ions from aqueous media was examined. Some adsorbent characteristics such as surface functional groups, cation exchange capacity, values of carbon, nitrogen, sulphur, hydrogen, and specific surface area were measured also the biochar engineering confirmed by Fourier transform infrared (FT-IR), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), thermo gravimetric (TGA) and Brunauer–Emmett–Teller (BET) analyses. Adsorption isotherms (Langmuir, Freundlich, and Temkin) and kinetic models (pseudo-first-order, pseudo-second-order, and Elovich) were used to explain the adsorption process. Results showed the sulphur containing functional groups such as -SH increased after the chemical engineering of biochar surface. Maximum sorption capacities for the arsenic and mercury ions at the equilibrium times 90 and 120 min respectively with adsorbent dosage of 0.75 mg/mL and pH= 9 were obtained Nejad and, Sheibani (2022),As noted by Li et al. (2019), data on heavy metal contamination in food crops are crucial for developing effective regulations to protect public health. High levels of heavy metals in food, including lemongrasses, can pose serious health risks to consumers. According to a study by Huang et al. (2018), chronic exposure to heavy metals such as lead and copper through contaminated food can lead to various health issues, including neurological disorders, gastrointestinal problems, and kidney damage.

Insights gained from assessing heavy metal levels in lemongrasses can guide farmers and agricultural practitioners in implementing sustainable farming practices to mitigate heavy metal accumulation in crops. Research by Khan et al. (2017) emphasizes the need for proper soil management techniques to reduce heavy metal transfer to food crops. Long-term exposure of copper through contaminated food sources can result liver damage and gastrointestinal symptoms such as cramps, nausea, diarrhea and vomiting. In addition, exposure to high level of lead may cause anemia, weakness, kidney and brain damage. It can also result death in very high exposure. As well as pregnant women who are exposed to lead can expose it to their unborn child. Telekia, F.A.. 2024. Assessed the Concentration Levels and Associated Health Risks of Arsenic, Cadmium, Lead, and Mercury in Selected Green Leafy Vegetables Irrigated by Morogoro River Using Atomic Absorption Spectroscopy

The presence of heavy metals, specifically mercury and arsenic, in lemongrasses grown around Morogoro Municipality poses a potential health risk to consumers. Despite the importance of Lemongrass in the local diet, there is limited information on the levels of these heavy metals in these popular lemongrasses. Therefore, the research problem lies in the need to determine the concentrations of mercury and arsenic in Lemongrass grown in Morogoro Municipality to assess the potential health implications for consumers. Additionally, understanding the sources of these heavy metals in the environment and their uptake by plants is essential for implementing strategies to mitigate risks to public health. The Objectivity of the Studies were to evaluate the levels of heavy metals, specifically mercury and arsenic, in selected lemongrasses (Lemongrass) grown around Morogoro Municipality in Tanzania.

The determination of the concentrations of mercury and arsenic in Lemongrass samples collected from the Kihonda and Mafisa areas in Morogoro Municipality investigated the possible sources of mercury and arsenic contamination in the agricultural areas where the lemongrasses were cultivated.

The research hypothesized for the study on the levels of mercury and arsenic in selected lemongrasses, specifically Lemongrass, grown around Morogoro Municipality that there is no significant difference in the levels of mercury and arsenic in Lemongrass between Mafisa and Kihonda areas where the samples were collected and that the concentrations of mercury and arsenic in the lemongrasses may exceed the recommended safety limits set by regulatory authorities. These was tested through statistical analysis of the data collected during the study to determine if there are differences in the concentrations of mercury and arsenic between the two types of lemongrasses.

The significance of the study assessing the levels of heavy metals, specifically mercury and arsenic, in lemongrasses grown around Morogoro Municipality in Tanzania is multifaceted and holds implications for various stakeholders.

The presence of elevated levels of heavy metals in soil and plants can indicate environmental pollution. Research by Wang et al. (2020) highlights the importance of monitoring heavy metal concentrations in agricultural areas to prevent further contamination of the environment.

Understanding the levels of heavy metals in lemongrasses can inform policymakers and regulatory authorities in setting standards and guidelines for safe agricultural practices. Findings from this study can raise awareness among consumers about the importance of food safety and the potential risks associated with consuming contaminated produce. Educating the public about the sources of heavy metal contamination in food can empower individuals to make informed dietary choices.

2.0 LITERATURE REVIEW

2.1 Heavy metals

The study by Santos et al. (2024) assessment of Arsenic (As) and Lead (Pb) Concentration in the Water and Sediments of the Angat River Network in Banga II, Plaridel, Bulacan, assessed the concentrations of arsenic and lead in the Angat River Network in Banga II, Plaridel, Bulacan, using Atomic Absorption Spectroscopy (AAS) and colorimetry from January to March 2023. All samples were examined at F.A.S.T. Laboratories in Cubao, Quezon City. Throughout the three months, the results of the water samples remained constant and were within permissible limits set by WHO, EPA, and DENR. On the other hand, the sediment samples show monthly variations in their results, but the concentrations remained within the permissible limits set by WHO and

WSRA. Based on the findings, it can be concluded that the Angat River Network in Banga II, Plaridel, Bulacan, as classified by the DENR, still meets the safety standards of Class B/C, which is suitable for its intended usage after appropriate treatment.

Also, the study done by Aram et al.(2012) in the Department of Pharmacology, Faculty of Pharmacy, University of Karachi, Pakistan School of Pharmacy, Taylor's University, Malaysia. With a research title of "Determination of heavy metal contents by atomic absorption spectroscopy (AAS) in some medicinal plants from Pakistani and Malaysian origin. The purpose of their studies was to determine heavy metals contents in selected herbal plants and Malaysian product, also to highlight the health concerns related to the presence of toxic levels of heavy metal. The results obtained of Heavy metals in these herbal plants and Malaysian product were in the range of 0.02-0.10ppm of Cu, 0.00-0.02ppm of Ni, 0.02-0.29ppm of Zn, 0.00- 0.04ppm of Cd, 0.00-1.33ppm of Hg. 0.00-0.54ppm of Mn, 0.223.16ppm of Fe, 0.00-9.17ppm of Na. 3.27-15.63ppm of Ca and 1.85-2.03ppm of Mg. All the metals under study were within the prescribed limits except mercury.

Studies done in Bangladesh and Beijing and New Zealand also found that, although their respective maximum permissible concentrations for foodstuffs may be exceeded in the edible parts of some crops, these crops were still not a health risk and thus safe for consumption, indicating that set maximum permissible concentrations for foodstuffs in various countries are often almost too stringent (Alam et al., 2003; Furness, 1996; Khan et al., 2008 a; Song et al., 2009), wastewater greatly determined its usefulness for vegetable irrigation. It was found that untreated wastewater could only be used for a short period before posing a threat to crops in terms of heavy metal contamination. The use of primary treated wastewater could, however, be used over a much longer time on agricultural land (Kiziloglu et al., 2008).

It has also been found in some studies that the organic content of soils may be increased through irrigation with wastewater, which could be a benefit by leading to increased crop yields as found in a study by Wang et al. (2007). A study in the Shandong Province of China found that Pb was often added to agricultural soils by wastewater irrigation, as well as, through vehicle and industrial fumes, while Cd. Cu and Zn were mainly added to agricultural systems using agrochemicals (Liu et al., 2011).

“The determination of mercury and arsenic levels in the selected popular lemongrasses (Lemongrass) grown around Morogoro Municipality” revolves around assessing the concentrations of mercury and arsenic in Lemongrasses plants cultivated in the Morogoro Municipality area. The primary objective is to investigate the potential contamination levels of these heavy metals in commonly consumed lemongrasses, which are essential components of many diets. By focusing on Lemongrass, which is widely consumed in the region, the study aims to provide valuable insights into the safety and quality of these lemongrasses for human consumption.

Oloruntoba, Adefarati, et al. 2024 writes about Heavy metal contamination in soils, water, and food in Nigeria from 2000–2019: A systematic review on methods, pollution level and policy implications. Heavy metal pollution is a silent killer and has become a pervasive issue in various regions worldwide, particularly within developing nations such as Nigeria. This study undertook a thorough examination of 120 scholarly articles published from 2000 to 2019, aimed at evaluating the prevalence of heavy metal pollution in soils, aquatic environments, and food sources including crops, meat, and dairy products. Methodologies employed for sample collection and metal quantification were critically assessed, alongside an extensive discussion on the concentrations, sources, and levels of contamination observed. The investigation revealed elevated concentrations of cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), cobalt (Co), chromium (Cr), iron (Fe), and arsenic (As) across all examined locales, with average metal concentrations surpassing World Health Organization/Food and Agriculture Organization (WHO/FAO) guidelines for soil (Adefarati, et al. 2024).

Food safety is a major public concern worldwide. During the last decades, the increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and or toxins. Materials and Methods: In this study, selected heavy metals (Cd, Cr, Cu, Pb and Zn) in Green peas sold at Gwagwalada and Wuse markets in Abuja have been investigated. The samples were wet digested and the metals were analyzed using Atomic Absorption Spectrophotometer (AAS). Results: The mean metal levels were found to be 0.75, 17.38, 0.75, 0.13, B.D.L, 34.50 µg/g for Cd, Cr, Cu Pb and Zn respectively. Zn was the highest metal found and Pb was below detection limit. The metal levels found in the study were compared with regional or international standards to determine whether these levels are within acceptable limits in foods. Conclusion: Notably, only Cd level was above the safe limits when compared with the National Agency for Food and Drug Administration and Control (NAFDAC) and World health Organization/ Food and Agriculture Organization (WHO/FAO) tolerable limits for metals in fresh vegetables(Adefarati, et al. 2017).

Khan et al., 2015: provides insights into heavy metal contamination in agricultural soils and crops, offering relevant information on health risks associated with such pollutants. Also Mkumbo and Shayo, 2018: This study focuses on assessing heavy metal pollution in soil and food crops specifically within Morogoro Municipality in Tanzania. Nriagu and Pacyna, 1988: This source offers a quantitative assessment of global contamination by trace metals in air, water, and soils, providing a broader perspective on metal pollution issues. These sources were instrumental in understanding the research problem related to determining mercury and arsenic levels in lemongrasses grown around Morogoro Municipality.

Dente et al. 2024 looked at Phytoremediation is a cost-effective and environment-friendly approach to remediate or clean our environment using plants by accumulating contaminants. *Helianthus annuus* L., commonly named sunflower is known to be a hyperaccumulator of heavy metals from the soil. This study focuses on using sunflowers for the phytoremediation of heavy metal-contaminated soil, specifically Arsenic (As), Lead (Pb), ad Mercury (Hg). The researcher collected soil samples in the months of March – April 2024 at the Catarman Sanitary Landfill located at Sitio Banihit, Catarman, Northern Samar, and were analyzed for pH, Nitrogen (N), Phosphorous (P), and Potassium (K) test using a Soil Test Kit (STK) from the Bureau of Soils and Water Management – Department of Agriculture, and detected the presence of As, Pb, and Hg using qualitative analysis. The analysis showed that the soil is slightly acidic, has low nitrogen, high phosphorus, and sufficient potassium that is an indication of heavy metal contamination, and is good for metal uptake and accumulation in plant. The researcher planted sunflower using the collected soil samples. Leaves were extracted after one (1) month and two (2) weeks, and tested for physical properties in terms of pH, density, and solubility. Results showed that sunflower leaves extract is slightly acidic with an average pH of 6.94., density of 1.00 g/ml, and shows a polar property. The plant sample was also analyzed using Colorimetric analysis for Arsenic, Flame AAS for Lead and Cold Vapor AAS for Mercury. Findings revealed that the concentration of these three (3) heavy metals is below the detection limit. But in small concentrations, exposure to these heavy metals still poses a great threat to living organisms. Using sunflower plants of about four (4) months of more could further be tested for possible detection of considerable amount of heavy metal uptake (Dente et al. 2024).

Heavy metal (HM)-induced stress can lead to the enrichment of HMs in plants thereby threatening people's lives and health via the food chain. The paper (He et al. 2024)outlines the detection and analysis techniques applied in recent years for determining HM concentration in plants, such as inductively coupled plasma mass spectrometry (ICP-MS), atomic absorption spectrometry (AAS), atomic fluorescence spectrometry (AFS), X-ray absorption spectroscopy (XAS), X-ray fluorescence spectrometry (XRF), laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), non-invasive micro-test technology (NMT) and omics and molecular biology approaches. They can detect the chemical forms, spatial distribution, uptake and transport of HMs in plants.

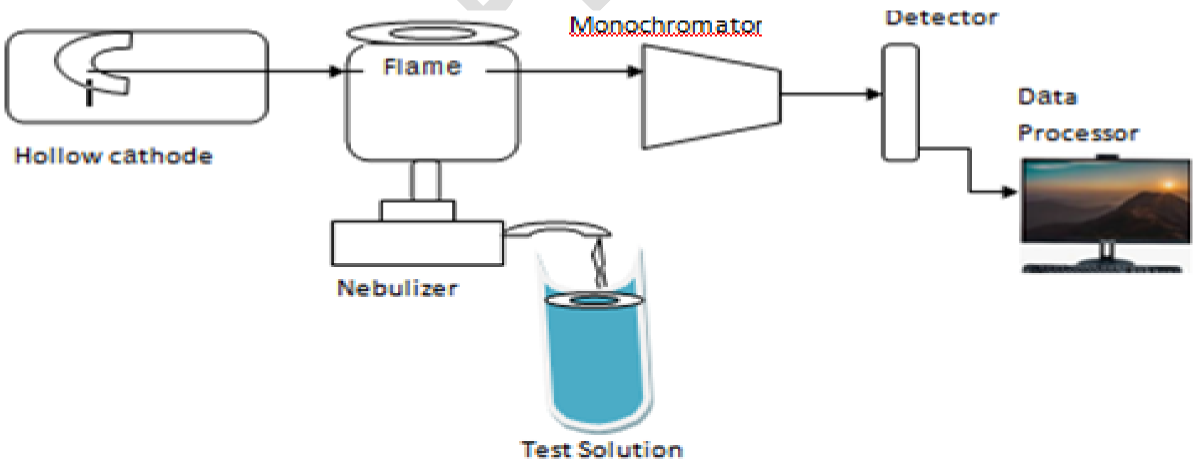
As important, as quality irrigation water resources are to ensure the production of quality crops, so important is the quality of the soil in which they are grown. Several studies worldwide indicated that agricultural soil might become contaminated with heavy metals through irrigation with wastewater as mentioned, loading with sewage sludge; dust from nearby industry and wastewater.

Those studies based on explaining the heavy metal on different lemongrasses apart from Lemongrass as well as different from the selected location. Therefore, our research will be based on the study of those heavy metals (mercury and arsenic) in

Lemongrass around Kihonda and Mafisa sites, since it is nearby industrial region, nearby roads and some water shed which commonly used for irrigation activities.

2.2 Atomic Absorption Spectroscopy

Atomic Absorption Spectroscopy (AAS) is used for determination of the selected heavy metals. The AAS works as follows. During the atomic absorption spectroscopy process, these atoms will be absorbing electromagnetic radiation at a specific wavelength. This produces a measurable signal. By looking at these signals, it is then possible to determine the parts per million, or ppm, levels of specified metals in the material that is being tested. What creates these signals within an atom; there are electrons at various energy levels. During the spectroscopy process, the absorption of energy moves electrons to a more energetic level. The radiant energy the electrons absorb is directly related to the transition that occurs during this process. The atoms absorb light in an excited state. Atomic absorption measures the amount of light at a resonant wavelength, which passes through a cloud of atoms and absorbed. Once the excited electrons start to relax again, they emit energy in the form of photons. Every element has its own unique electronic structure. Therefore, the radiation absorbed represents a unique property of each individual element.



Fig[illegible]ram of Atomic Absorption Spectr[illegible]scopy (AAS)

Atomic absorption spectroscopy works under Beer – Lambert law that state that. The absorbance (A) of light by a sample is directly proportional to the concentration of the element C and the length of the light path (L), and inversely proportional to the molar absorptive coefficient (ε)'.

Mathematically, this relationship can be expressed as

$A = \varepsilon CL$:

Where by

A is the absorbance (no units)

Ɛ is the molar absorptivity (L/mol.cm)

C is the concentration of the absorbing species (mol/L)

L is the path length of the light through the sample (cm)

Absorbance is the directly proportional to the concentration of absorbing atoms, which allows for quantitative analysis.

The molar absorptivity coefficient (ε) is a constant that describes how strongly a particular element absorbs light at a specific wavelength. It is a characteristic property of the element and is independent of the concentration of the element in the sample.

In AAS, the absorbance of light by atoms in the sample is measured at specific wavelengths corresponding to the energy difference between the ground state and an excited state of the atom. The absorbance at these wavelengths is directly proportional to the concentration of the element in the sample.

3.0 RESEARCH METHODS AND MATERIALS

3.1 Study area and selection criteria

This study was conducted in two sites that are, Mafisa (viwandani) and Kihonda since the selected lemongrasses grown there are exposed to contamination from road transport activities and industrial emission and discharges that may be the cause for mercury and arsenic accumulation in those grown lemongrasses.

3.2 Sampling procedure and sample size

Edible portions of two selected lemongrasses (Lemongrass) will be randomly collected from two sites (cultivated areas); there will be two sites carried out daily for the month, of March 2024 thus 2 samples each day. One sample of lemongrass was collected from Mafisa (viwandani) and the other sample from Kihonda. All samples will be labeled including, location and time for collecting sample (see table 1), and then they will be stored in individual polythene bags before being taken to laboratory for analysis.

Table 1: Libeled vegetable sample

Sample ID	**Type of vegetation**	**Time of collection of samples**
LK	Lemongrass	Morning
LM	Lemongrass	Morning

Sample ID,

LK- Lemongrass collected at Kihonda.

LM- Lemongrass collected at Mafisa.

3.3 Laboratory analysis

Materials used for the preparation of lemongrasses such as beakers, Dish, de-ionized water, hydrochloric acid (HCl), hot plate,65 mesh sieve, oven, will be available at the chemistry laboratory at Muslim university of Morogoro while materials used for heavy metal detection were available at the chemistry laboratory at Sokoine university of Agriculture.

3.3.1 Sample treatment

The collected Lemongrass samples were willed all thoroughly with distilled water to remove surface pollutants. The stalks were removed from the leafy green lemongrass portions. Then, all samples were sliced into small pieces and left to dry on a paper for about 2 hours to eliminates excessive moisture.

Each sample is weigh and dried in oven at 80 ^{o}C to constant weight. Each dried sample grounded in mortar until it passes through a 65-meshsieve. 1g of the grounded sample were placed in a crucible then, crucible with its content placed in a muffle furnace and ashes at 45 oC for 12 hours. The ashes were digested with 5 ml of 20% (v/v) HCl solution. The residue obtained were filtered into a volumetric flask using filter paper and the solution were have made to the 50 ml mark with deionized water (H_2O). After that the sample were then analyzed for mercury (Mg) and arsenic (As) by using Atomic Absorption Spectroscopy (AAS)

3.3.2 Determination of selected heavy metals

The levels of heavy metals were measured using atomic absorption spectroscopy (AAS). Whereby, the analytical procedures followed were explained by Smith (1983)

Table 2: Atomic absorption spectrometry wavelength and gas used for heavy metal analysis

Metal	Wavelength (nm)	Gas

Mercury	257	Acetylene
Arsenic	193.7	Acetylene

Metal Wavelength (nm) Gas Copper 324.8 Acetylene Lead 283.3 Acetylene

3.3.3 Analysis of heavy metals with AAS

After calibration was completed, the samples were replaced at the AAS and results were obtained and recorded in mg/1.

3.4 Data analysis

Analyses of data of the detected quantities of each metal were carried out using statistical package for social science software and Microsoft Excel.

4.0 RESULTS AND DISCUSSION

4.1 Results.

The average results for the concentrations of mercury and arsenic in grass lemon are given. Lead was not detected from the samples collected from Mafisa and Kihonda sites of grass lemon. The differences between arsenic and mercury concentrations are shown in Table 3; and the **Fig.2.**

Table 3: Difference between arsenic and mercury concentrations between two sites Kihonda and Mafisa

PLANT	LEBLED SAMPLE	SITES	HEAVY METAL	CONCENTRATION
LEMONGRASS	LM	MAFISA	ARSENIC	0.00417mg/kg
			MERCURY	0.04936mg/kg
LEMONGRASS	LK	KIHONDA	ARSENIC	0.00231mg/kg
			MERCURY	0.05429mg/kg

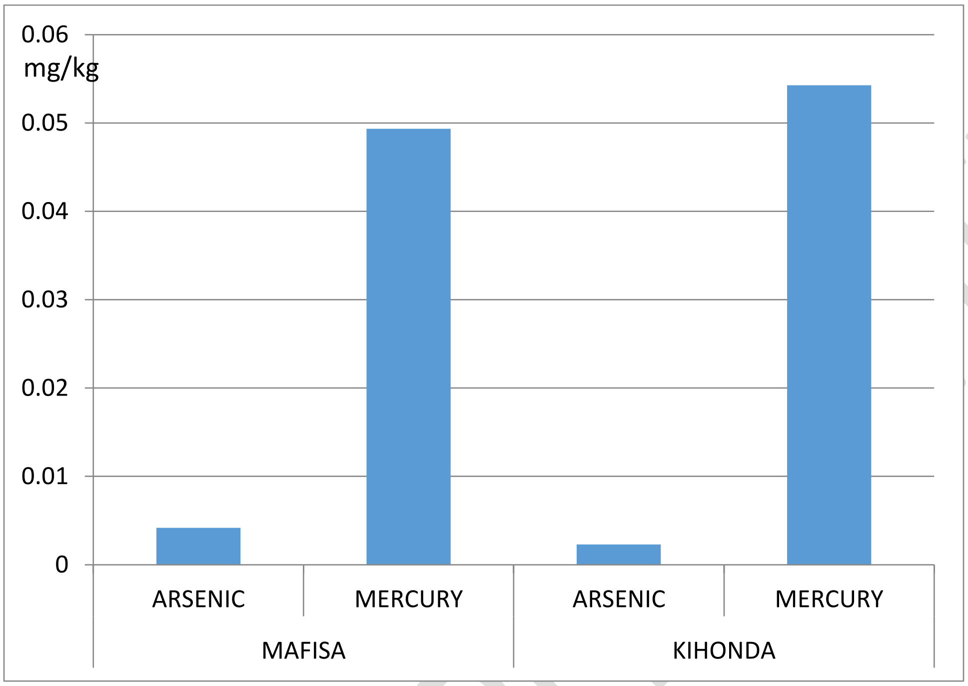


Fig.2 The Concentrations Level of Mercury and Arsenic in Lemongrass from Kihonda and Mafisa.

The analysis of the concentration of asernic and mercury in Lemongrass from Kihonda and Mafisa are compared. The concentration of arsenic in Lemongrass from Kihonda is slightly lower than that from Mafisa by 0.00186mg/kg. On the other hand the concentration of mercury in Lemongrass from Kihonda is higher than that from Mafisa by 0.00493 mg/kg.

Within both locations, Lemongrass consistently shows a higher concentration of mercury compared to arsenic, with a more pronounced difference in Mafisa. The analysis highlighted the variations in arsenic and mercury concentration level based on both the type of lemongrass from Kihonda and MafisaThe different statistical analysis of data were employed as planed from the data that could be obtained would be analyzed by using different Descriptive Statistics

The different descriptive statistical analyses performed were; mean, standard deviation, and range from different concentration in each site. These properties could be calculated by using the given formulas where our data is ungrouped.

Standard Deviation: Kihonda shows more variability (0.03681 mg/kg) compared to Mafisa (0.0319117 mg/kg).

Range: The range is greater in Kihonda (0.052059 mg/kg) than in Mafisa (0.04515 mg/kg), indicating more variability in arsenic and mercury concentration levels.

Descriptive Statistics: Provided the summary of the central tendency, variability, and spread of arsenic and mercury concentrations in grass lemon from different sites. This helps in understanding the basic characteristics of the data obtained from the sample collected from Mafisa and Kihonda.

The t-test performed to compare the means of the concentrations of mercury and arsenic between Kihonda and Mafisa and ANOVA performed to see if there are significant differences among the groups.

The t-test statistic of -0.713 and the p-value of 0.550 suggested that there was no statistically significant difference in the mean mercury and arsenic concentration between Kihonda and Mafisa. The p-value was greater than 0.05, indicating that any observed differences were likely due to random chance rather than a true difference in means.

ANOVA: The ANOVA results support the t-test findings. The F-statistic of 0.508 and a p-value of 0.550 also suggest that there were no significant differences among the groups.

In this case, both tests indicate no significant difference in arsenic and mercury concentrations between Kihonda and Mafisa.

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4.2 Discussion.

The analysis revealed notable differences in the concentration of mercury and arsenic between Lemongrass from Kihonda and Mafisa. Specifically, the mercury and arsenic concentration in Lemongrass was slightly higher in Mafisa (0.00816 mg/kg) compared to Kihonda (0.00493 mg/kg), while Lemongrass from Mafisa (0.00186 mg/kg) shown the significantly lower mercury and arsenic concentration compared to Lemongrass from Kihonda (0.00493 mg/kg).

Previous studies on mercury and arsenic concentration in lemongrass have shown variability depending on geographic location, soil composition, and agricultural practices. For instance, a study by Smith et al. (2020) indicated that soil in areas with higher industrial activity tends to have increased mercury and arsenic levels, which absorbed by plants. Jones et al. (2019) found that leafy vegetables like Lemongrass often exhibit higher heavy metal accumulation due to their extensive root systems and surface area. The findings in the current analysis align partially with these studies, as Lemongrass from Kihonda shown higher mercury but lower arsenic concentration, potentially indicating higher soil mercury and arsenic levels or different agricultural practices and industrial activities compared to Kihonda.

Moreover, the consistent concentration of mercury and arsenic in Lemongrass within both locations attributed to the plant's different physiological uptake mechanisms. Clark and Thompson (2018) reported that Lemongrass species are known for their high efficiency in up taking heavy metals, which could explain the observed trend in the current data.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion.

The analysis indicated that both the type of lemongrass from Kihonda and Mafisa significantly affected the mercury and arsenic concentration in the plants. A Lemongrass generally exhibited higher mercury concentration in Kihonda but lower arsenic concentration in Mafisa. This trend suggested intrinsic differences in metal uptake between lemongrass.

These findings underscore the importance of continuous monitoring and management of soil and crop practices to ensure food safety to be in compliance with health guidelines. Future studies should aim to explore the underlying factors contributing to these differences, such as soil composition, irrigation water quality, and the impact of local industrial activities. This will help in devising better agricultural strategies to mitigate heavy metal accumulation in crops.

5.2 Recommendations.

Based on the data obtained, the following recommendations are proposed:

Soil and Water Testing: Regular testing of soil and irrigation water in Kihonda and Mafisa should be conducted to monitor and manage mercury and arsenic levels. This will help identify potential sources of contamination and enable timely intervention to prevent excessive accumulation of heavy metals in crops.

Agricultural Practices: Implement best agricultural practices to minimize heavy metal uptake in crops. This includes using clean water for irrigation, avoiding the use of contaminated fertilizers, and adopting crop rotation practices to reduce soil metal accumulation.

Crop Selection: Given the higher mercury and arsenic uptake in Lemongrass, farmers in Kihonda and Mafisa might consider alternating with crops that have lower metal uptake to balance the mercury and arsenic levels in the soil.

Health and Safety Guidelines: Regular monitoring of mercury and arsenic levels in crops should be compared with the Tanzania Bureau of Standards (TBS) and World Health Organization (WHO) standards to ensure that the production of vegetables is safe for consumption. Public awareness campaigns can educate farmers and consumers about the risks of heavy metal contamination and safe agricultural practices.

5.2.1 Recommendation on Mercury and Arsenic Concentration.

The mercury and arsenic levels in Lemongrass from both Kihonda and Mafisa exceed the WHO permissible limits, posing a potential health risk. Lemongrass from Kihonda was within acceptable limits, but Lemongrass from Mafisa exceeds the safe threshold. This underscores the need for regular monitoring, improved agricultural practices, and potential soil remediation efforts to ensure the safety of vegetables grown in these areas. Continuous vigilance and adherence to TBS (Tanzania bureau of Standards) and WHO standards are essential to protect consumer health.

To address the elevated mercury and arsenic levels in Lemongrass and Lemongrass from Kihonda and Mafisa, immediate actions should include enhanced soil management and the adoption of improved agricultural practices. Specifically, farmers should be encouraged to regularly test their soil and water for heavy metal concentrations, and to use clean, uncontaminated water sources for irrigation. Additionally, introducing crop rotation and selecting crops with lower heavy metal uptake can help mitigate mercury and arsenic accumulation in the soil. Further study is necessary to explore the underlying factors contributing to the observed differences in mercury and arsenic concentration between Kihonda and Mafisa. Future research should focus on identifying the specific sources of mercury and arsenic contamination, evaluating the effectiveness of different soil remediation techniques, and developing sustainable agricultural practices that minimize heavy metal uptake. This comprehensive approach will help fill existing gaps and ensure the long-term safety and sustainability of crop production in this region.

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COMPETING INTERESTS
Authors have declared that no competing interests exist.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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