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Assessment of Lead (Pb) Accumulation in Vegetables Grown in and Around Kishangarh using Atomic Absorption Spectroscopy

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ABSTRACT

Due to increasing population, consumption of vegetables is also increasing know days and to increase production, fertilizers of different types are being used and fertilizers contain heavy metals which cause soil and water pollution. Water pollution and soil pollution are increasing due to industrialization and urbanization. Due to which the concentration of heavy metal (lead) in the environment, living organisms and vegetables is also increasing. Vegetables is used for nutrient values. But apart from nutrients, these vegetables also contain heavy metals which cause health issues in humans. The aim was to analyze the concentration of heavy metal (lead) in selected vegetables grown in the area around Kishangarh using wet acid digestion and analysis using Atomic Absorption Spectroscopy. We observed that the concentration of heavy metal (lead) in most of the vegetables was higher than the limits issued by WHO/EU/FSSAI. We should pay attention to this and think about the coming generation.

***Keywords**: Lead (Pb), Atomic Absorption Spectroscopy (AAS), Wet Acid Digestion, Soil and Water Pollution, Food Safety and Kishangarh (Ajmer).*

Introduction

Lead (Pb) is one of the major contributors to toxic heavy metal present in the environment and is has been identified as a major concern for its harmful effects on living organisms. Heavy metals are generally defined as metallic elements having a density greater than 5 gm/cm³, and lead falls within this category. Lead occurs naturally in the Earth’s crust; however, Sustained lead release into the environment causes long-lasting adverse ecological effects. The primary concern arises from anthropogenic activities, which have excessive lead concentrations in the environment, making it a global pollutant of major environmental and public health importance.

Lead has been used by human since ancient times because of its favorable physio-chemical properties. It is soft nature, malleable, and ductile metal that can be easily shaped and processed. Additionally, lead exhibits resistance to corrosion and poor electrical conductivity, characteristics that have supported its extensive application in various industrial sectors. Despite the rising awareness of its toxicity, lead continues to be used due to these advantageous properties, resulting in its extensive use since ancient times release into the environment. Industrial activities the major sources of lead contamination. Battery manufacturing and recycling units are considered the major widely prevalent contributors to environmental lead pollution worldwide. During production, handling, and recycling processes, excessive levels of lead-containing dust and waste are generated, which may contaminate air, soil, and water. Industrial smelting and refining operations further contribute to lead emissions through effluents and atmospheric deposition. Mining and metal-processing industries also play a substantial role in elevating lead concentrations in surrounding environments.

Infrastructure renovation activities are another important source of lead exposure. The use of lead-based paints, roofing materials, pipes, and soldering components in older buildings can result in the release of lead particles during demolition or maintenance. Similarly, plumbing and soldering practices involving lead-containing materials can contaminate drinking water systems, leading to long-term human exposure. Additional sources include shipbuilding and boat construction industries, printing processes, ammunition and armed industries, as well as pottery and ceramic manufacturing, where lead-based compounds are used for glazing and coating applications. Once released into the environment, lead exhibits a non-biodegradable and long-lasting nature. It does not undergo chemical breakdown and therefore accumulates in soil and sediments over extended periods. Lead can be transported through air in the form of particulate matter and deposited onto agricultural land and water bodies. From contaminated soil and water, lead may be taken up by plants, including vegetables, thereby entering the food chain. This transfer of lead from soil and water into biological systems represents a major route of exposure for both humans and animals. Lead is considered one of the most toxic heavy metals for plants and other living organisms. In plants, lead accumulation can harmfully affect physiological processes such as photosynthesis, respiration, enzyme activity, and nutrient uptake, ultimately leading to reduced growth and productivity. In agricultural systems, the presence of lead in edible portions of vegetables is of particular concern, as vegetables constitute a primary source of nutrition for large segments of the population. Continuous consumption of lead-contaminated vegetables can result in chronic exposure and bioaccumulation in the human body.

Human exposure to lead and its compounds is associated with a wide range of harmful impacts on human health. Lead can enter the body through uptake of contaminants via food consumption and water, inhalation of lead-containing dust and fumes, or contact with contaminated materials. After absorption, lead is distributed to major organs such as the brain, liver, kidneys, and bones. Chronic lead exposure has been linked to neurological damage, impairment of learning and memory, anemia, renal dysfunction, and reproductive disorders. Children are especially at risk of lead toxicity due to their developing nervous systems and higher absorption rates.

Although the industrial use of despite its toxicity, lead continues to be economically important, its extensive application over time has increased environmental contamination and toxicological risks. The regular release of lead into the environment, combined with its non-degradable nature and bioaccumulation in food chains, poses long-term threats to ecosystems and human populations. Therefore, systematic monitoring of lead levels in environmental and biological components of ecosystems is essential to evaluate contamination status and related health impacts. Understanding the sources, distribution, and toxic effects of lead is vital for environmental management and risk reduction aimed at reducing lead pollution and protecting environmental and human health protection.

Material and Method

- **Study Area and Sample Collection**

Vegetable samples were collected from selected area around Kishangarh (Ajmer). Mostly consumed vegetables were selected for analysis. The samples collected randomly from different areas in kishangarh. Fresh samples were collected in clean polythene bags and taken to the laboratory for further analysis.

- **Sample Cleaning and Drying**

Collected vegetable samples firstly washed distilled water to remove soil, dust, and other impurities and afterthey drying those samples at room temperature and the samples were drying in oven temperature around 65-75 degree Celsius.

- **Powder Preparation**

The oven-dried samples were cut into small pieces and ground using a clean mortar and pestle (or grinder) to obtain a fine powder. The powder samples stored in were no moisture present in polythene.

- **Wet Acid Digestion**

For heavy metal analysis, 2 g of each powdered vegetable sample was accurately weighed and after put samples in digestion flask. Wet acid digestion was carried out using a mixture of concentrated nitric acid (HNO_3) and hydrochloric acid (HCL) (1:3, HNO3 & HCL, aqua regia). The digestion samples were heated so that the organic material present in them would separate along with the vapour.

- **Dilution and Filtration**

After cooling to room temperature, the digested samples were diluted with distilled water and the final volume was made up to 25 ml. The solution was filtered using Whatman filter paper to remove any undigested matter. The clear filtrate was collected in clean volumetric flasks for instrumental analysis.

- **Instrumental Analysis by Atomic Absorption Spectroscopy (AAS)**

The prepared samples were analyzed for heavy metal concentration using Atomic Absorption Spectroscopy (AAS). Standard solutions of the respective metal were prepared for calibration. The absorbance of samples was measured under optimized instrumental conditions, and metal concentrations were calculated by comparing sample readings with the standard calibration curve.

Result and Discussion

Samples Taken around Kishangarh

Atomic Absorption spectroscopic determination of Lead (ppm)

- **Using** Wet Ashing **in vegetables**

S. No.	Vegetables Samples (Pb)	Concentration (ppm)
1.	***Abelmoschus esculentus***	0.337
2.	*Daucus carota*	0.625
3.	*Cyamopsis tetragonoloba*	0.45
4.	*Solanum tuberosum*	2.1
5.	*Capsicum annuum*	0.625
6.	***Cucumis sativus***	0.325
7.	*Lagenaria siceraria (Molina) Standl*	1.25
8.	*Solanum melongena*	1.95
9.	*Momordica charantia*	1.387
10.	***Brassica oleracea var. botrytis***	1.687

The concentration of Pb ranged (0.325-2.1 ppm). The maximum concentration of Pb was found in ***Solanum tuberosum*** (2.1 ppm) while the minimum concentration of Pb was found in ***Cucumis sativus***(0.325 ppm). The concentration was found to be more than FSSAI/EU/WHO limits (0.1, 0.05 & 0.1) in all the above sample.

Samples concentration and WHO/FSSAI/EU standard concentration comparison (Pb)

S.No.	Vegetables Samples	Pb concentration (ppm)	WHO limits (ppm)	FSSAI limits (ppm)	EU limits (ppm)	Status
1.	***Abelmoschus esculentus***	0.337	0.1	0.1	0.05	Exceed
2.	*Daucus carota*	0.625	0.1	0.1	0.05	Exceed
3.	*Cyamopsis tetragonoloba*	0.45	0.1	0.1	0.05	Exceed
4.	*Solanum tuberosum*	2.1	0.1	0.1	0.05	Exceed
5.	*Capsicum annuum*	0.625	0.1	0.1	0.05	Exceed
6.	***Cucumis sativus***	0.325	0.1	0.1	0.05	Exceed
7.	*Lagenaria siceraria (Molina) Standl*	1.25	0.1	0.1	0.05	Exceed
8.	*Solanum melongena*	1.95	0.1	0.1	0.05	Exceed
9.	*Momordica charantia*	1.387	0.1	0.1	0.05	Exceed
10.	***Brassica oleracea var. botrytis***	1.687	0.1	0.1	0.05	Exceed

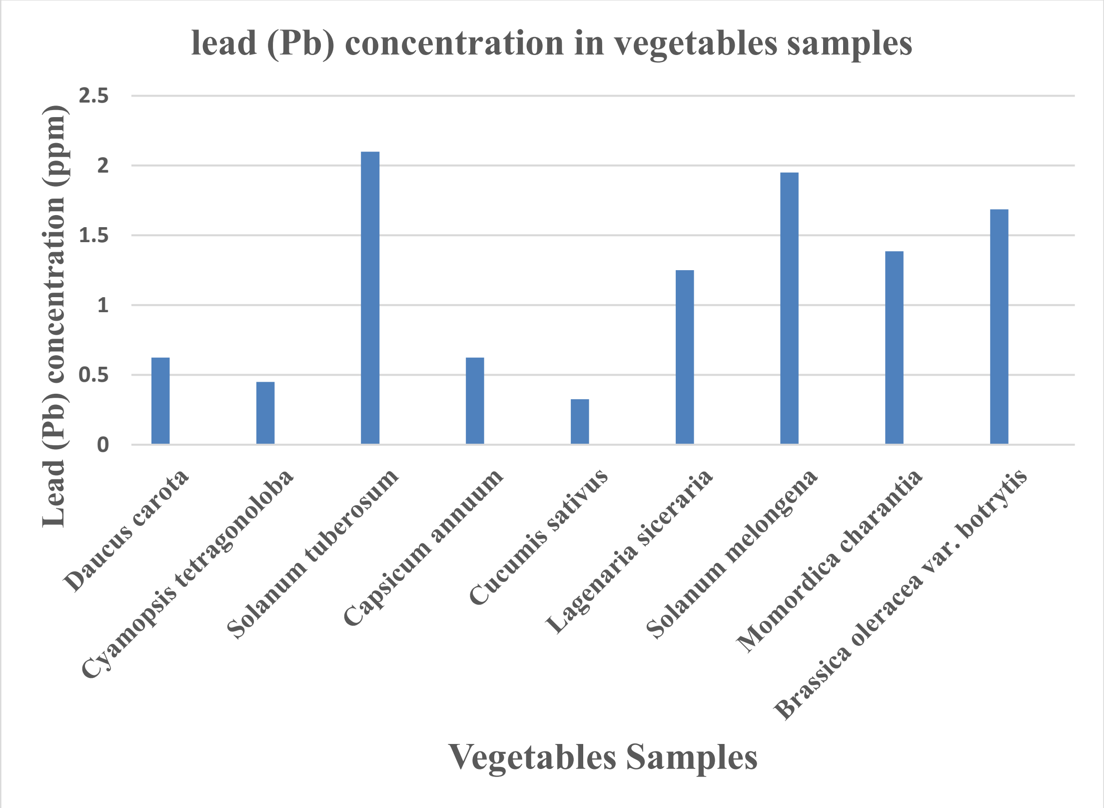
Lead (Pb) Concentration in Vegetables Samples

The concentration of lead (Pb) in vegetable samples collected from around kishangarhwas determined using by Atomic Absorption Spectroscopy after wet ashing digestion. The results indicated wide variation in Pb concentration among the analyzed vegetables.

The Pb concentration ranged from **0.325 to 2.10 ppm**. The **maximum concentration** of lead was reported in *Solanum tuberosum* (potato) with a value of **2.10 ppm**, followed by *Solanum melongena* (brinjal) (**1.95 ppm**) and *Brassica oleracea* var. *botrytis* (cauliflower) (**1.6875 ppm**). Average levels of Pb were observed in *Momordica charantia* (bitter gourd) (**1.3875 ppm**) and *Lagenaria siceraria* (bottle gourd) (**1.25 ppm**).

Comparatively lower concentrations were found in *Capsicum annuum* and *Daucus carota* (both **0.625 ppm**), *Cyamopsis tetragonoloba* (**0.45 ppm**), and *Abaelmoschus esculentus* (**0.3375 ppm**). The **minimum concentration** of Pb was report in *Cucumis sativus* (cucumber) with a value of **0.325 ppm**.

The bar graphthat **all vegetable samples exceeded the permissible limits** standard value given by **FSSAI (0.1 ppm), WHO (0.1 ppm), and EU (0.05 ppm)**. This indicates significant lead contamination in vegetables grown in the study area, which may be attributed to factors such as contaminated irrigation water, industrial activities, vehicles emissions, and excessive use of agricultural chemicals. Continuous consumption of such contaminated vegetables may pose potential health risks to the urban and rural population.



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