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The comparative analysis of heavy metal presence in the leafy vegetable in Agra city

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Abstract:
Heavy metal contamination in vegetables is a significant concern in Agra city, as these vegetables are an important source of essential nutrients for human consumption. Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and chromium (Cr) are among the most common heavy metals found in vegetables. The sources of heavy metal contamination in vegetables can vary, including industrial activities, urbanization, vehicular emissions, agricultural activities, and solid waste disposal. These sources can lead to heavy metal accumulation in soil, which can result in contamination of crops and vegetables.
The health effects of heavy metal exposure from contaminated vegetables can vary depending on the type and level of exposure. Short-term exposure to high levels of heavy metals can lead to acute health effects such as nausea, vomiting, and respiratory problems, while long-term exposure to lower levels can cause chronic health effects such as kidney damage, neurological disorders, and cancer. To address the issue of heavy metal contamination in vegetables in Agra city, several measures can be taken. These include the implementation of strict regulations and guidelines for industrial and agricultural activities to reduce heavy metal emissions, proper waste management practices to prevent soil contamination, and regular monitoring of heavy metal levels in vegetables.

I. Introduction

Heavy metal presence in leafy vegetables is a significant concern, as these metals can accumulate in the plant tissues and pose a health risk to humans who consume them[1-5]. Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and chromium (Cr) are among the most common heavy metals found in leafy vegetables. The presence of these heavy metals in leafy vegetables can occur due to various reasons, including soil contamination, irrigation water, air pollution, use of contaminated fertilizers, and industrial activities. Once these heavy metals enter the plant tissues, they can accumulate in edible parts of the plant, such as leaves and stems[6,7].

Consuming leafy vegetables contaminated with heavy metals can cause several health problems, including kidney damage, neurological disorders, cancer, and reproductive disorders. Pregnant women, children, and the elderly are particularly vulnerable to the adverse effects of heavy metals[8-10]. To minimize the risk of consuming contaminated leafy vegetables, it is essential to follow good agricultural practices, such as using clean water for irrigation, avoiding the use of contaminated fertilizers, and avoiding growing crops in contaminated soil. Additionally, it is important to wash and cook leafy vegetables thoroughly before consuming them, as this can help to remove some of the heavy metals[9].

Regular monitoring of heavy metal levels in leafy vegetables is also crucial to ensure the safety of food products. Governments and food safety authorities can set permissible limits for heavy metals in leafy vegetables, and regular testing of food products can help to ensure compliance with these limits. If high levels of heavy metals are detected, appropriate measures can be taken to prevent the sale and consumption of contaminated food products[11].

The comparative analysis of heavy metal presence in the leafy vegetables in Agra city is an important research topic as it can provide valuable information on the potential health risks associated with the consumption of these vegetables[7]. Leafy vegetables are an important source of essential nutrients such as vitamins, minerals, and dietary fibers. However, they are also susceptible to contamination by heavy metals such as lead (Pb), cadmium (Cd), and mercury (Hg) that can accumulate in the soil and be taken up by the plants. These heavy metals are toxic to humans and can cause various health problems such as kidney damage, neurological disorders, and cancer[12].

The study can be conducted by collecting samples of commonly consumed leafy vegetables such as spinach, lettuce, and coriander from different parts of Agra city. The samples can then be analyzed for heavy metal concentrations using analytical techniques such as atomic absorption spectroscopy (AAS) or inductively coupled plasma mass spectrometry (ICP-MS)[13-15]. The comparative analysis can be done by comparing the heavy metal concentrations in the leafy vegetables from different parts of the city and with the permissible limits set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). The data obtained can be analyzed statistically to determine if there are significant differences in heavy metal concentrations between the samples[16-18].

The findings of the study can be used to raise awareness about the potential health risks associated with the consumption of leafy vegetables contaminated with heavy metals. The study can also help in identifying the sources of heavy metal contamination and in developing strategies to mitigate the risks associated with heavy metal contamination in leafy vegetables.

Experimental setup:

The study was done in the Agra district which was known for the one of seven wonder in world the TAJ, thus a great tourism spot, the high tourism rate will influence the high hotels and food restaurants which were effectively presents their cuisine to all the national and foreign delegates to welcome in TAJ city. The sources of heavy metal contamination in soil and water of Agra city can vary, including industrial activities, urbanization, vehicular emissions, agricultural activities, and solid waste disposal. These sources can lead to heavy metal accumulation in soil and water, which can result in contamination of crops and drinking water. Furthermore the four main daily consumable leafy vegetables spinach, Fenugreek, Chenopodium, coriander were choose for the study of heavy metal accumulation in the plants because these were daily consumed as main source of nutrients throughout the year, and irrigated by the river water and normal soil. Which were found highly contaminated and examined in earlier study. We also take the 3 main vegetable growing point of the district and a huge production of these leafy vegetables from where it will distributed in market throughout the district and labeled as A B and C.

Estimation of heavy metal:

Soil, water and plant samples (1g) were digested by adding tri-acid mixture (HNO_3, H_2SO_4, and $HClO_4$ in 5:1:1 ratio) at 80ºC open vessel method was used. 10 ml of concentrated Nitric acid was added to 10 g of the concerned drug in a conical flask. This solution was then heated for three hours. After three hours of digestion, the solution was cooled to room temperature and 5 ml of concentrated Perchloric acid was added to it. The sample was then heated up to 150˚C for three hours to ensure its complete digestion. At 80ºC open vessel method was used. 10 ml of concentrated Nitric acid was added to 10 g of the concerned drug in a conical flask. This solution was then heated for three hours. After three hours of digestion, the solution was cooled to room temperature and 5 ml of concentrated Perchloric acid was added to it. The sample was then heated up to 150˚C for three hours to ensure its complete digestion. Digestion was continued with subsequent addition of Perchloric acid till a white powder or ash was obtained. If the sample was dark brown in colour, a few ml of Nitric acid and Perchloric acid were added and the sample was re-digested to get the white powder. The final white powder or ash was dissolved in small amount of warm distilled water and then filtered through Whattman filter paper No.1. Volume of the filtrate obtained was made up to 10 ml and this was then subjected to metal analysis by Volume of the filtrate obtained was made up to 10 ml and this was then subjected to metal analysis by Atomic Absorption Spectrophotomete[16-20]. Metal analysis was performed on a Perkin Elmer Model Analyst 100 double beam atomic absorption spectrophotometer fitted with high intensity hollow cathode lamps. Compressed air and acetylene gas were used to ignite the flame. Standard curves were constructed with solution of known concentrations. The unknown samples were analyzed against the standard curve for measuring the concentration of the desired metal. The concentrations were expressed in microgram/gram of the sample[20-28].

II. Result and discussion

The heavy metals present in leafy vegetable across the district, and year are shown in Table 1 a and b. Across the study the value (µg g^{-1}) of Cu, Cd, Cr, Ni, Pb, Zn, Fe and Mn varied from 54 to 101, 8.10 to 28.22, 23 to 66, 14 to 72, 11 to 40, 51 to 142, 840 to 2583 and 25 to 63, respectively, as shown in Table 1 a and b.

Table 1a: *Heavy Metals (µg g^{-1}) in leafy vegetable Spinatch and Chenopodium across the three study point.*

Heavy Metals	Spinach			Chenopodium		
	A	B	C	A	B	C
Cu	87.07	77.03	74.20	91.43	87.83	70.67
	(1.89)	(5.26)	(3.94)	(5.54)	(3.25)	(1.91)
Cd	15.00	8.10	14.80	20.01	15.31	18.70
	(3.60)	(1.11)	(2.31)	(1.30)	(2.72)	(3.11)
Cr	35.67	36.23	23.47	45.67	38.87	26.00
	(3.13)	(0.91)	(1.9)	(3.68)	(2.91)	(2.72)
Ni	14.27	26.33	22.00	25.67	49.77	38.50
	(1.05)	(5.6)	(3.18)	(4.29)	(1.36)	(1.15)
Pb	14.33	10.67	13.23	23.30	13.27	24.47

	(0.81)	(1.36)	(2.05)	(2.01)	(1.76)	(4.39)
Zn	122.43	88.63	70.90	142.03	90.83	82.50
	(19.3)	(3.07)	(8.27)	(18.96)	(3.82)	(7.36)
Fe	2583	1818	1264	2052	1527	853
	(92.1)	(105)	(15)	(108)	(54.9)	(29.69)
Mn	45.00	52.93	33.37	54.37	62.93	36.53
	(3.18)	(1.42)	(2.51)	(4.57)	(2.12)	(2.87)

A, B, and C are tree leafy vegetable production points across the district, respectively. The values in the parentheses are ±SD.

Table 1b: *Heavy Metals (μg g^{-1}) in leafy vegetable Fenugreek and Coriander across the three study point.*

Heavy Metals	**Fenugreek**			**Coriander**		
	A	**B**	**C**	**A**	**B**	**C**
Cu	74.17	66.80	53.50	100.70	88.57	78.27
	(2.81)	(1.59)	(2.4)	(7.39)	(3.33)	(5.1)
Cd	23.62	14.73	24.60	28.22	25.32	25.41
	(1. 51)	(1.50)	(3.02)	(1.81)	(1.30)	(4.11)
Cr	53.97	50.10	34.77	65.77	46.70	43.00
	(1.95)	(1.83)	(3.71)	(3.05)	(6.05)	(2.2)
Ni	35.30	53.30	47.50	43.63	71.80	56.23
	(1.15)	(2.91)	(2.61)	(2.78)	(3.22)	(2.6)
Pb	30.03	22.10	29.70	39.80	26.40	36.07
	(3.1)	(2.95)	(1.45)	(3.4)	(1.9)	(4.8)
Zn	80.43	64.90	51.00	124.47	87.53	65.23
	(5.71)	(3.4)	(1.28)	(16.4)	(2.21)	(3.3)
Fe	1919	1509	1047	1377	1245	840
	(86.16)	(41.53)	(20.59)	(46.66)	(35.85)	(24.2)
Mn	36.73	25.67	25.40	29.27	35.37	32.43
	(3.72)	(2.55)	(3.72)	(3.51)	(4.06)	(4.05)

A, B, and C are tree leafy vegetable production points across the district, respectively. The values in the parentheses are ±SD.

season also exhibited notable differences in the values of heavy metals due to age, except for Cd, Pb and Fe. Further, the analysis suggested that the Fe and Mn varied statistically due to two way and three way interactions of age, propagation and watering condition (Table 2).

Table 2: *Summary of Repeated Measure ANOVA on the Heavy Metals of study material plant and study points.* *$^{ns}P > 0.05$; $^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.*

Parameter	**Study points (A)$F(1,8)$**	**Plants (P) $F(1,8)$**	**Season (S) $F(1,8)$**	**A×P $F(1,8)$**	**S×P $F(1,8)$**	**A×S $F(1,8)$**	**A×P×S $F(1,8)$**
Cu	209.8***	6.17*	64.41***	3.19^{ns}	3.33^{ns}	33.88**	1.34^{ns}
Cd	0.34^{ns}	206.3***	84.94***	0.009^{ns}	0.75^{ns}	0.00^{ns}	0.23^{ns}
Cr	275.01***	209.72***	27.13*	5.14*	6.14*	0.05^{ns}	0.76^{ns}
Ni	81.44***	368.29***	161.49***	0.70^{ns}	1.19^{ns}	5.31*	0.87^{ns}
Pb	0.62^{ns}	278.67***	72.37***	0.66^{ns}	0.05^{ns}	0.21^{ns}	1.25^{ns}
Zn	203.7***	26.84**	22.89**	2.56^{ns}	7.29*	3.94*	2.42^{ns}
Fe	1.30^{ns}	478.86***	518.78***	103.8***	17.43**	4.95*	3.84*
Mn	45.91***	721.76***	72.6***	14.70*	2.23^{ns}	12.63**	13.89**

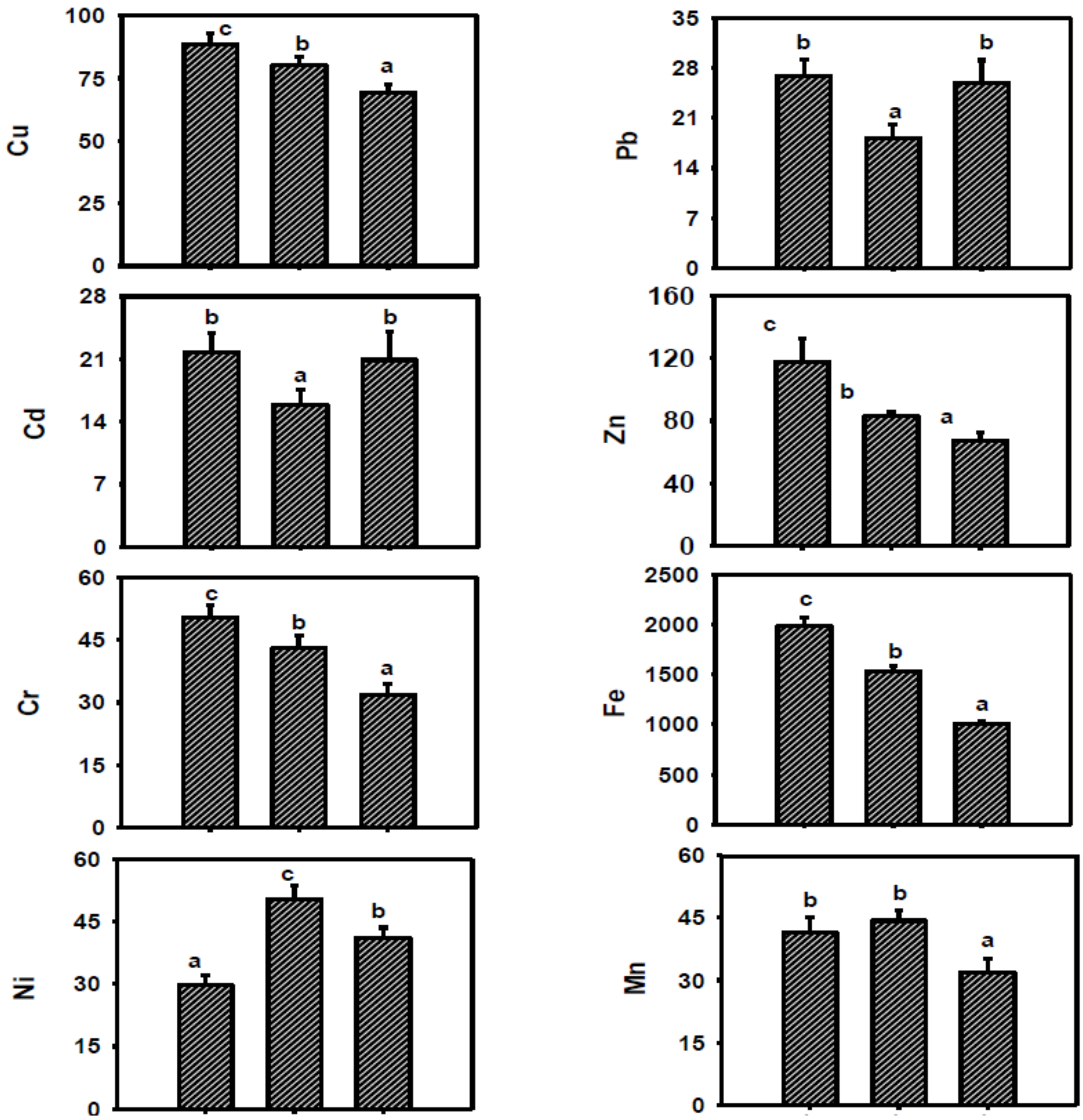

Fig 1: Heavy Metals (µg g-1) Variation in leafy vegetables across district in three consecutive season. Different Letters within a Diagram are Significantly Different at P ≤0.05.

III. Discussion and conclusion:

Heavy metals inhibit physiological processes such as respiration, photosynthesis, cell elongation, plant-water relationship, N-metabolism and mineral nutrition[20]. Metals can be transported via an apoplastic system and immobilized in cell walls[22]. Toxic metals become a real threat to plants mainly when they reach to the cytosol of the cell. Therefore, the ability of root cells to control the transport of heavy metals via membranes determines tolerance by plants[25]. They can be immediately complexed, inactivated and transformed into a physiologically tolerable form via action of phytochelatins and sequestred in cell vacuoles[28]. Ni accumulation damages the cellular parts of the leaves, alters its water metabolism, pigment and reserve material synthesis and finally inhibits the yield production[22,18]. Decreased Fe concentration has been associated with reduction of chlorophyll content. Reduction in Fe concentration is also associated with decrease in the activities of the Fe enzymes, catalase and peroxidase, and thus, reduced availability of Fe for chlorophyll–heme biosynthesis[21].
The toxic metal accumulation were found in all leafy vegetables and does not lies in the dietary standards so none of the leafy vegetables were recommended for the consumption for the localpeople as it worsen the condition of the health and also generated the cancerous property with long consumption.

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