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CONCENTRATIONS OF LEAD IN SELECTED VEGETABLES GROWN & MARKETED ALONG MAJOR HIGHWAY IN KOLKATA (INDIA)

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ABSTRACT

Background: *Lead (Pb) exposure through contaminated environment has adverse health impacts that can affect almost every organ or system in the human body, including the bone and teeth, causing brittle bones and weakness. Pb stored in bones can re-enter the blood stream during periods of increased bone mineral recycling & can be redeposited in the soft tissues of the body causing musculoskeletal, renal, ocular, immunological, neurological, reproductive, and developmental abnormalities. Recent industrialization of developing countries have contributed to elevated levels of Pb in the urban environment, leading to emission of contaminated fumes that are deposited on vegetables during their production and transport. Prolonged consumption of such food may lead to the chronic accumulation of Pb in the system.* ***Objective:*** *To determine the extent of lead contamination in 10 common vegetables around Kolkata in India, and assess the implication of contamination on food safety.* ***Methods:*** *The present research was conducted to study Pb level concentrations in vegetables along a major highway with dense traffic. Concentration of lead after dry mineralization and organic phase extraction (APDC / MIBK) is determined using the atomic absorption spectrophotometry (AAS) in a Perkin Elmer AAS 2380 apparatus.* ***Results:*** *Mean ± SD of the concentration of Pb is analyzed in triplicates. Statistically significant difference is p < 0.0001. Vegetable samples obtained from roadside show 3-4 times higher lead concentration, carrot being the most Pb tolerant. Pb accumulation in the crops follows the order: carrot > radish > beet > cabbage > brinjal > cauliflower > spinach > tomato > chilly. It's concentration in various parts of plants shows: root > stems > leaves > other edible parts.* ***Conclusion:*** *samples analyzed were contaminated with abnormal levels of Pb sufficient enough to expose residents of Kolkata, India to adverse health effects of the metal.*

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Lead; pollution; food safety

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[I] INTRODUCTION

Lead (Pb) is very stable in soil and is highly toxic to human and animals. Pb contamination of vegetables cannot be under estimated as these food stuffs are important components of human diet [1]. Pb is a neurotoxin that can affect almost every organ or system in the human body. It can reduce cognitive development and intellectual performance in children and damage kidneys and reproductive system [2]. Most of the accumulated Pb is sequestered in the bone and teeth [3], causing brittle bones and weakness in the wrists and fingers. Pb that is stored in bones can re-enter the blood stream during periods of increased bone mineral recycling. Mobilized Pb can be redeposited in the soft tissues of the body and can cause musculoskeletal, renal, ocular, immunological, neurological, reproductive, and developmental effects [4].

Rapid and unorganized industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China [5] and India [6]. Emission of heavy metal contaminated fumes from the industries and vehicles may be deposited on the vegetable surfaces during their production, transport and marketing. Prolonged consumption of unsafe concentration of heavy metals through such food stuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans, causing disruption of numerous biochemical processes [7]. Monitoring and assessment of heavy metal concentrations in the vegetables from the market sites have been carried out in some developed and developing countries, but limited published data are available on heavy metal concentrations in the vegetables from the market sites in India [5, 6]

The objective of this study was to determine the extent of lead contamination in some vegetables around Kolkata in India, and assess the implication of such contamination on food safety.

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[II] MATERIALS AND METHODS

2.1 Materials

The present study was carried out in Kolkata, India, in a roadside market within and around 16 km of Science City, an industrial site with leather and industrial rubber manufacturing units. Fresh samples of Indian vegetables such as radish, beet, brinjal, cabbage, carrot, cauliflower, chilly, ladies finger, spinach and tomato (approximately 2 kg each) were collected over 2 years (2010 to 2012) from study area. Equal numbers of fresh vegetables for each group were collected from a local market, where the supply was obtained from the suburbs of South 24 Parghanas, an industrial pollution free zone, as a control group. They were then washed with tap water and double distilled water several times & allowed to drain, frozen and kept at -20°C until analyzed.

2.2 Methods

Concentration of lead after dry mineralization of biological materials (30 gm of homogenized samples) and organic phase extraction (APDC / MIBK) has been determined using atomic absorption spectrophotometry (AAS) in a Perkin Elmer AAS 2380 apparatus [8]

Appropriate quality assurance procedures and precautions were taken to ensure the reliability of the results. Reagent blank determinations were used to correct the instrument readings. For validation of the analytical procedure, repeated analysis of the samples against internationally certified plant standard reference material (SRM 1570) was used and the results were found within ±2% of the certified values.

Differences in the levels of the metals between particular vegetables were tested by the use of one way analysis of variance (ANOVA). Statistical significance was assessed using student's t-test [9]. Results were deemed statistically significant where $p < 0.005$. Also, statistical analysis was conducted using SAS software [10].

[III] RESULTS

Analytical data of Pb contents in vegetables, the number of vegetables studied per group & the statistical significance between study & control group are summarized in **Table- 1**.

Pb present in the air in the form of Pb dust and automobile exhausts are known to contribute significantly to atmospheric Pb [11]. Results from our study revealed that, the amount of Pb in vegetables appears to be greater in places with dense vehicle traffic.

Comparison of the values of Pb contents in the edible parts of ten types of vegetables showed that the maximum allowable limits for Pb was exceeded in the majority of samples.

In root vegetables, especially radish and carrots, maximum allowable limits of Pb were exceeded by up to 3 times. These remarkably high Pb contents of radish and carrots collected from study area are probably related to their own physiological milieu.

Unlike most vegetables, the accumulation of Pb in fruits and in vegetables like cabbage and cauliflower is high because a large portion of Pb absorbed by trees is stored from air deposition. The Pb content in these vegetables are seen to be almost 4 times the maximum allowable limit.

The higher concentration of Pb in these vegetables may be attributed to their location and proximity to the highway. The vegetable samples obtained from the highway side had significantly higher ($p<0.0001$) Pb concentration than those obtained from a local market, where the source of vegetable supply is the suburbs of South 24 Parghanas, a region free from industrial pollution.

The average content of Pb in leaves of spinach were reported to be slightly higher than the maximum allowable limit, but 2-times higher when compared with the control group. Chilly, ladies finger and tomato showed low Pb level, suggesting a resistance towards Pb accumulation. The distributions of lead in various parts of the vegetables are shown in **Table- 2**.

Among the vegetables tested for the study, the highest lead concentration was found in carrot (13.92 ± 0.75), while chilly, ladies finger and tomato showed low Pb level, suggesting a resistance towards lead accumulation in them.

By CAP132V standards for HK & SEAR countries, 6 mg/kg9 [12] is the maximum allowable limit for lead.

Table. 1: Lead content in vegetable samples (in mg/kg of dry vegetable sample or ppm)

Vegetables	No. of sample	Study Group	Control Group	Significance
Radish	24	12.90 ± 0.89	4.06 ± 0.98	<0.0001
Carrot	22	13.92 ± 1.42	4.89 ± 0.58	<0.0001
Beet	32	12.99 ± 1.72	4.16 ± 0.95	<0.0001
Cabbage	26	12.42 ± 0.85	4.01 ± 0.86	<0.0001
Cauliflower	28	9.13 ± 0.62	2.98 ± 0.66	<0.0001
Brinjal	26	10.61 ± 0.72	3.98 ± 0.23	<0.0001
Spinach	22	6.98 ± 0.68	2.99 ± 0.58	<0.0001
Ladies finger	42	3.96 ± 0.60	2.65 ± 0.57	<0.0001
Tomato	28	3.76 ± 0.85	2.56 ± 0.68	<0.0001
Chilly	52	2.59 ± 0.32	1.01 ± 0.48	<0.0001

Table. 2: Pb concentrationIn different parts of dry vegetables (mg/kg of dry vegetable sample or ppm)

Sample	Root	Stem	Leaves	Edible part
Beet	12.60 ± 0.82			
Radish	12.90 ± 0.89			
Carrot	13.92 ± 0.75			
Cabbage		12.39 ± 1.76		
Spinach			6.96 ± 0.40	
Brinjal				10.72 ± 0.52
Cauliflower		9.73 ± 0.72		
Ladies finger				3.98 ± 0.78
Tomato				3.86 ± 0.86
Chilly				2.61 ± 0.32

[IV] DISCUSSION

Heavy metals are of great significance in ecochemistry and ecotoxicology because of their toxicity at low levels and tendency to accumulate in human organs [1].

Pb is toxic and can be harmful to plants, though the plants usually show ability to accumulate large amount of Pb without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several times the threshold of maximum level permissible for human [13]. From our study, high value of Pb was observed for radish and carrot. Due to its proximity with the highway, emitted Pb from vehicular exhausts gets deposited on the exposed vegetables. Pb pollution has been shown to be commensurate with population and vehicular density, and this somehow explains why residents consuming Pb infested vegetables are prone to toxicity.

Consumption of such vegetables will certainly result in health problems. Most of the accumulated Pb is sequestered in the bone and teeth [3]. This can cause brittle bones and weakness in the wrists and fingers. Pb that is stored in bones can re-enter the blood stream during periods of increased bone mineral recycling (i.e., pregnancy, lactation, menopause, advancing age, etc.). Mobilized Pb can be re deposited in the soft tissues of the body and can cause musculoskeletal, renal, ocular, immunological, neurological, reproductive, and developmental effects [4].

Observations from this study showed elevation of Pb in all the vegetables. Based on the values of Pb in ten different vegetables, it can be assumed that if 80 gm of any of these is presumably consumed every day, the weekly intake would exceed the tolerable limits of 6 mg/kg recommended by CAP 132V standards.[12]

The results of the study revealed that continuous consumption of these vegetables will inevitably result in hazardous consequences. There should be a rule for regular evaluation of Pb load in vegetables from toxicity prone areas & based on metal loads, studied plants can be used for environmental monitoring.

[V] CONCLUSION

To conclude, it is recommended that awareness is needed to avoid trading of edible fruits and vegetables in & around places that have a heavier atmospheric lead concentration (i.e. industrial surroundings or heavily traffic congested roads). Also there should be a rule for regular evaluation of Pb load in vegetables from toxicity prone areas & based on metal loads, studied plants can be used for environmental monitoring & its capacity to cause hazardous consequences.

CONFLICT OF INTERESTS

There is no conflict of interest with any author regarding publication of this article.

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