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Short Communication

ACCUMULATION OF LEAD IN VEGETABLE CROPS ALONG MAJOR HIGHWAYS IN KOLKATA, INDIA

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ABSTRACT
The present research was conducted to study Pb level concentrations in vegetables along a major highway with traffic density. 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. The concentration of Pb is analyzed in triplicates. Statistically significant difference is $p < 0.005$. Vegetable samples obtained from roadside show significantly higher lead concentration, carrot being the most Pb tolerant species. Pb accumulation in the crops follows the order: carrot > beet > cabbage > brinjal > cauliflower > spinach > tomato > chilly. It's concentration in various parts of plants shows: root > stems > leaves > other edible parts. There is a considerable risk of Pb poisoning from vegetables produced & marketed around industrial sites. Also concentration of Pb even after washing exceeds permissible limit recommended by WHO/FAO.

KEY WORDS: Lead, pollution, food safety.

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 physiologic and neurological toxin 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]. Rapid and unorganized industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China [3] and India [4]. 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, leading to cardiovascular, nervous, kidney and bone diseases [5]. 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 [3,4]. The objective of this study was to determine the extent of lead contamination in food around Kolkata in India, and assess the implication of such contamination on food safety.

MATERIALS AND METHODS

The present study was carried out in Kolkata, India (roadside market within 4 km of Science City, as well as in plantations around Science City within 15 km). Fresh samples of Indian vegetables such as 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. They were then washed with tap water and double distilled water several times & allowed to drain, frozen and kept at -20°C until analyzed. 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 [6]. 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 [7]. Results were deemed statistically significant where $p < 0.005$. Also, statistical analysis was conducted using SAS software [8].

RESULTS

Concentration of Pb found in tested samples for the present study was summarized in Table 1. The vegetable samples obtained from the roadside had significantly higher lead concentration. This is an indication that motor vehicle emission is a source of higher lead accumulation in such vegetables. The results showed that carrot and beet were the most Pb tolerant species, while the others were Pb sensitive to varying degrees. The Pb accumulation in the crops is as follows: carrot > beet > cabbage > brinjal > cauliflower > spinach > tomato > chilly (in decreasing order). Taking into consideration the Pb allocation in various parts of plants, the order is root > stems > leaves > edible parts. 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 WHO standards, 0.3 mg/kg is the maximum allowable limit of lead in edible parts of vegetables, beyond which health is affected [9].

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 [10].Pb, present in the air in the form of Pb dust and automobile exhausts are known to contribute significantly to atmospheric concentration of Pb [11]. Results from this study revealed that, the amount of lead in vegetables appears to be greater in places with higher traffic congestion, thereby suggesting accumulation of atmospheric lead particles in them. The variation in concentration of heavy metals in vegetables observed during the present study may be attributed to: the physical and chemical nature of soil in the production sites, absorption capacity of heavy metals by different vegetables, atmospheric deposition of heavy metals. These may be influenced by innumerable environmental factors such as temperature, moisture and wind velocity, the nature of the vegetables, ie, leafy, root, fruit, and lastly the texture of the exposed surface areas of vegetables, whether rough, hairy or smooth [12].The highest Pb concentration is found in the roots in all the crops studied. Carrots accumulate the highest amount, followed by beet, cabbage, brinjal, cauliflower, spinach, ladies finger, tomato and chilly. This finding corroborates the characteristic tendency of Pb to accumulate preferentially in the roots. The metal moves in the root through the apoplast, crossing the cortex, and accumulates close to the endodermis, which acts as a partial barrier preventing Pb from migrating to the plant parts above ground. The high Pb concentration in roots can also be due to the immobilization of this element by insoluble organic polymers present in the root tissue [13].However, seasonal variation does not influence the levels of Pb in any sample. The introduction of Pb into the food chain may affect human health and thus, studies' concerning Pb accumulation in vegetables is gaining more importance [1],as environmental pollution is increasing day by day. Overall, the vegetables that were tested in the present study were found to be contaminated by Pb, posing health hazards for the consumer. In conclusion, it is recommended that awareness is needed to avoid cultivation of vegetables in farms and fields irrigated by urban and industrial waste water or water contaminated by heavy metals. Also 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) should be avoided to prevent harmful accumulation of lead in human body.

TABLE 1: Lead content in vegetable samples (in mg/kg or ppm) at selected site.

Sample	Results	Range
Beet	12.60 ± 0.82	12.38 – 13.11
Brinjal	10.72 ± 0.52	9.61 – 11.99
Cabbage	12.39 ± 1.76	11.61 – 13.92
Carrot	13.92 ± 0.75	12.96 – 14.10
cauliflower	9.73 ± 0.72	8.99 – 10.61
Chilly	2.61 ± 0.32	1.96 – 3.94
Ladies finger	3.98 ± 0.78	2.94 – 4.11
Spinach	6.96 ± 0.40	5.12 – 7.16
Tomato	3.86 ± 0.86	2.91 – 4.26

Each value is a mean ± SD of these analyses done in triplicates. Statistically significant difference at $p < 0.005$.

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