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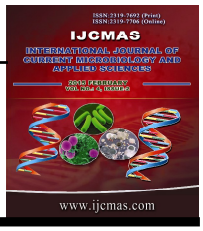


**Original Research Article**

# Cadmium Contamination in Green Leaves Grown in Madurai District, India

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**Keywords**

Cadmium, *Amaranthus dubius*, *Basella alba*, *Alternanthera sessilis*

**A B S T R A C T**

Three green leaves (*Amaranthus dubius, Basella alba, Alternanthera sessilis*) collected from five sites near Vaigai river at Madurai District were analyzed for cadmium contamination using Atomic absorption spectrophotometer. This study explains the level of cadmium contamination during summer and rainy season in Madurai District. Results showed that cadmium concentration in all three green leaves at site-1 and site-2 crossed permissible limit recommended by Indian Standard (Awashthi 2000) during rainy season. Nevertheless, cadmium concentration in all samples at the selected sites was high in rainy season than the summer season. However, *Amaranthus dubius* leaf contains high level of cadmium in sites during summer and rainy season. This extent of contamination in green leaves may be due to excessive discharge from automobile, industry and agricultural practices in Vaigai river. Hence proper monitoring of metals in green leafy vegetables grown very near to Vaigai river is mandatory. This could prevent excessive metal accumulation in food chain. Also, the cultivators shall be given proper awareness to cultivate the crop in healthy sites.

## Introduction

Currently malnutrition related nutrient deficient syndromes are detectable in human beings. In South Asia alone approximately 11 million children die before their five years old (FAO, 2005). Nutrient deficiencies of vitamin A, iron and zinc are pervasive all over the world (FAO, 2001). Africa and South-East Asia having the maximum vitamin A deficiency of 44.4% and 49.9% respectively, globally estimated 33.3% or 190 million children younger than 5 years are at threat of vitamin A deficiency (WHO, 2009). According to the World Health Organization (2008) iron deficiency is the most general and widespread nutritional disorder in the world. Ruel *et al.* (2005) observed that the consumption of fruits and vegetables in 10 sub-Saharan African countries never reached the WHO/ FAO recommended minimum daily intake. The study also stated that the mean consumption did not even reach half of the recommended intake. Variety of leafy vegetables used in balanced diet (116g/day) as they are rich in minerals and vitamins. Leaf vegetables are naturally low in calories and fat, high in protein per calorie, dietary fiber, iron and calcium, and phytochemicals such as vitamin c, carotenoids, lutein, folate,

magnesium and vitamin K. However heavy metal contamination in leaf is of great distress. Consumption of heavy metals loaded food can considerably deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho-social behavior, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al.,* 2008).

Utilization of untreated sewage water for agricultural purpose plays a pivotal role in extensively rising heavy metals in soil and crops (Mapanda *et al.,* 2005) and increases individual metal in soil by 2% to 80% and in crops by 14% to 90% (Sarabjeet Singh Ahluwalia and Dinesh Goyal, 2007). Heavy metals are very easily accumulated in the edible parts of leafy vegetables than the grain or fruit crops (Mapanda, Mangwayana, Nyamangara and Giller, 2005). Particularly cadmium has been considered as a one of the most hazardous trace elements in food and in the environment, not only for its high toxicity, but also for its persistence (Battaglia *et al.,* 2005). Once it is absorbed, it accumulates in the body even throughout the life (Bernard, 2008). Hence the present investigation was aimed to assess the cadmium contamination in three green leaves samples such as *Amaranthus dubius* (Fig-1), *Basella alba* (Fig-2) and *Alternanthera sessilis* (Fig-3) in the selected sites near Vaigai river at Madurai District.

## Materials and Method

### Collection and preparation of green leaves samples for analysis of cadmium:

Three green leaves *Amaranthus dubius* (Fig-1), *Basella alba* (Fig-2) and *Alternanthera sessilis* (Fig-3) samples collected randomly near Vaigai river at Madurai District during March to May 2013 (Summer season) and October to December 2013 (Rainy season) were washed thoroughly with tap water followed by distilled water to remove adsorbed elements. Samples were cut into small pieces, air dried for one week in a shady place at room temperature.

For extraction of selected metals, dry ashing of green leaves samples was done by taking specific weight of each sample in a pre-weighed china dish and was placed in furnace. The furnace temperature was gradually increased from room temperature to 500ºC in 1 hr. The sample was ashed for about 5h until a grey or white ash residue was obtained. The contents of china dish were cooled to room temperature in desiccators and 10mL of 20% HCL was added, the mixture was heated to dissolve its content. The solution was then filtered through whatman (42) filter paper into 50mL flask and diluted to the mark (Khan *et al.,* 2007). The solutions were then stored in clean and dry plastic bottles and run for the determination of cadmium by using Atomic absorption spectrophotometer (Parkin Elmer 400) under standard conditions.

## Results and Discussion

The level of heavy metals in green leaves samples of different regions of Madurai District during summer and rainy season of 2013 was shown in Table-1. Cadmium contamination was very high in rainy season than the summer season in all three green leaves samples (*Amaranthus dubius, Basella alba and Alternanthera sessilis*) in near Vaigai river at Madurai District. During summer season the highest level of cadmium were recorded in *Amaranthus dubius* at Sellur 1.591ppm and Munichalai 1.513ppm, it was above the permissible limit recommended by Indian Standard (Awashthi 2000). In rainy season the cadmium

concentration in Sellur and Munichalai were beyond the permissible limit of Indian Standard (Awashthi 2000) in all the three green leaves samples (*Amaranthus dubius, Basella alba and Alternanthera sessilis*) but in Theppakulam the level of cadmium beyond the safe limit in *Amaranthus dubius* only. The maximum cadmium concentration was observed in Sellur 1.877ppm in *Amaranthus dubius*. In Iravathanallur and Vandiyur site the cadmium were present within the safe limit in both the seasons of all three green leaves samples (*Amaranthus dubius, Basella alba and Alternanthera sessilis*).

Particularly, *Amaranthus dubius* accumulated highest level cadmium concentration in all the sampling sites followed by *Alternanthera sessilis* and *Basella alba*. Heavy metal concentrations varied among vegetable to vegetable, which may be attributed for the type of heavy metal (Zurera *et al.,* 1989). Variations in transfer factor among different vegetables may be attributed to differences in the concentration of heavy metals in the soil and differences in heavy metal uptake by different vegetables (Cui *et al.,* 2004; Zheng *et al.,* 2007). As well as number of factors involved in the uptake of heavy metals by vegetables such as climate, atmospheric deposition, the concentrations of heavy metals in soil, the nature of soil on which vegetables are grown and the degree of maturity of plant affect bio concentration of heavy metals in vegetables (Lake *et al.,* 1984). Recent studies have compared heavy metal contents among species and varieties under similar environmental conditions. These studies showed that there are differences in the crops ability to absorb or accumulate heavy metals. Such differences can occur between different parts of the crops (Jinadasa *et al.,* 1997; Angelova *et al.,* 2004). Muhammad Farooq *et al.,* (2008) revealed that, based on plant species, their physical and chemical properties, plants can readily absorb cadmium from soil where upon ingestion will enter into human food chain. In the present investigation also the cadmium accumulation was different in all three green leaves in the same site, these may be due to the varied accumulation ability of green leaves in similar environmental condition. Actually, cadmium presence is a dangerous proposition and is a wakeup call for our ecosystem and human beings in general. Compare to other heavy metals cadmium is the most toxic metal because it bio-accumulates and may cause health disorders even at low concentration (Nagajyoti *et al.,* 2010). Randwan and Salama (2006) conducted a market based survey for heavy metals in Egyptian fruits and vegetables and they found lowest cadmium concentration in coriander and palak leafy vegetables.

Madurai is situated in the bank of the river Vaigai. It runs across many villages, small towns and large cities of five districts. In Madurai district there are 9 large scale enterprises is present. They are mostly engaged in manufacturing sugar, solar power generation, calcium sennoside, tyre and tube, rubber and automobile component, textile, non ferrous metal power and milk products, concrete sleepers etc (Brief Industrial Profile of Madurai District 2012-13). Past few years, the Vaigai river is treated like an open drain for the discharge of raw sewage, domestic and industrial waste etc. The people living nearby Vaigai river, cultivating their green leaves in Vaigai river. Day by day these agricultural activity leads to the accumulation of heavy metals in green leaves and the metal entered in to the body through food chain. Use of contaminated water for irrigation, fertilizers, sewage and compost can remarkably increase the cadmium uptake into plant

tissues (Jackson and Alloway, 1991).

The present study provides data on cadmium pollution in green leaves near Vaigai river at Madurai District. The cadmium level during rainy season is beyond the permissible level in Selur and Munichalai. This investigation can also help in risk assessment of consumer exposure to the expected heavy metal levels. It is therefore suggested that regular survey of heavy metals like cadmium should be done on all food commodities in order to evaluate whether any health risks from heavy metal exposure do exist, to assure food safety and to protect the end user from food that might affect their health. The present study also suggested that cadmium contamination is increasing in the environments especially in the urban areas near river, so proper monitoring of cadmium level in green leaves is necessary to avoid the health hazards in animals and in human beings at Madurai District.

**Table.1** Cadmium concentrations (ppm) in the green leaves samples of Madurai District during summer and rainy season 2013

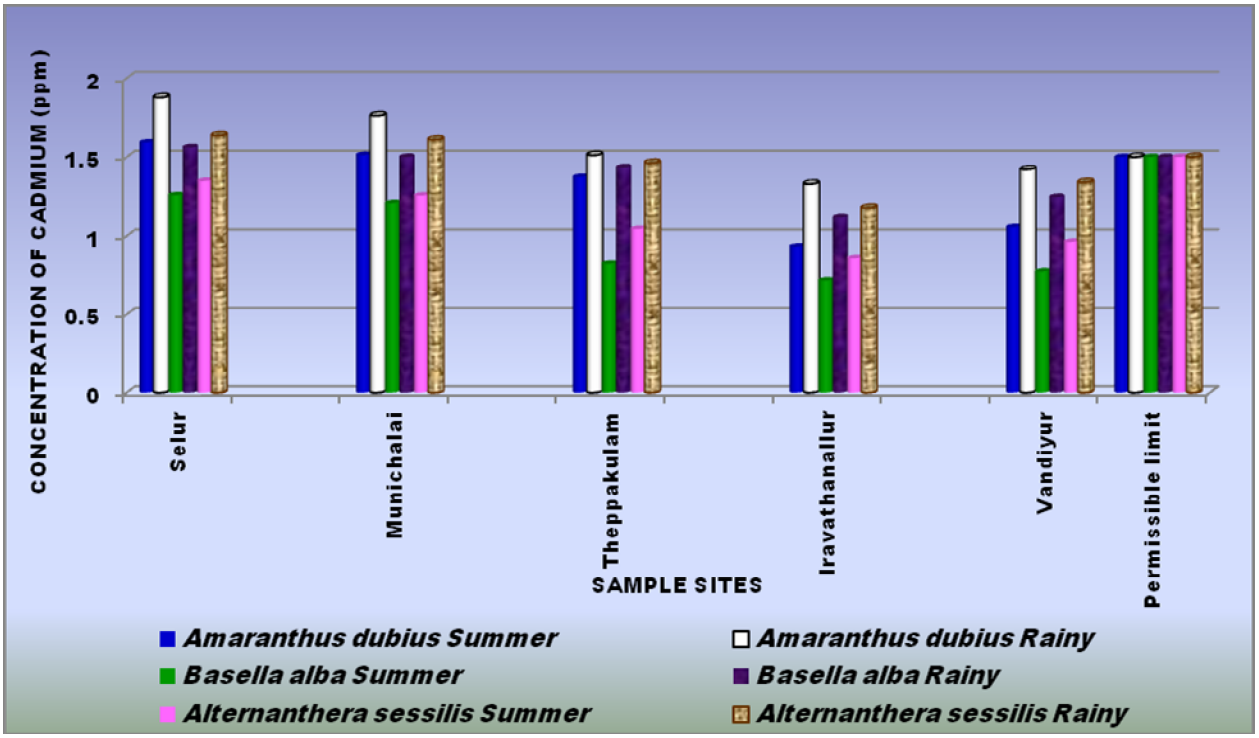
| S.No | SITES | *Amaranthus dubius* | | *Basella alba* | | *Alternanthera sessilis* | |
|---|---|---|---|---|---|---|---|
| | | *Summer* | *Rainy* | *Summer* | *Rainy* | *Summer* | *Rainy* |
| 1. | Sellur | 1.591 | 1.877 | 1.258 | 1.561 | 1.347 | 1.634 |
| 2. | Munichalai | 1.513 | 1.763 | 1.209 | 1.501 | 1.256 | 1.608 |
| 3. | Theppakulam | 1.372 | 1.512 | 0.822 | 1.435 | 1.043 | 1.462 |
| 4. | Iravathanallur | 0.933 | 1.329 | 0.718 | 1.116 | 0.856 | 1.179 |
| 5. | Vandiyur | 1.055 | 1.421 | 0.774 | 1.247 | 0.963 | 1.339 |
| Permissible limit Indian standard (Awashthi 2000) | | 1.5ppm | 1.5ppm | 1.5ppm | 1.5ppm | 1.5ppm | 1.5ppm |

**Fig.1** *Amaranthus dubius*

**Fig.2** *Basella alba*

**Fig.3** *Alternanthera sessilis*

**Fig.4** Cadmium concentrations (ppm) in the green leaves samples of Madurai District during summer and rainy season 2013

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