International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

A Study on the Contamination of Heavy Metals in Arakeerai *(Amaranthus dubius)* Cultivated in Different Sites of Coimbatore in India

Antisha[1], Dr. V. Premala Priyadharsini[2]

[1]Research Scholar, Department of Food Service Management and Dietetics,
Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore

[2]Associate Professor, Department of Food Service Management and Dietetics
Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore

Abstract: ***Green leafy vegetables form a part of everybody's diet specially the vulnerable group which includes children, adolescents, pregnant, nursing and aged people where in their requirements for vitamins and minerals are higher. Contamination of heavy metal in greens due to agricultural practices, environmental changes pollution and use of pesticides result in the contamination posing serious health issues. The heavy metal contamination of Arakeerai (Amaranthus dubius) cultivated from three different sites of Coimbatore (agricultural field, near contaminated water beds and organic farm) was tested for Chromium, Zinc and lead contamination using standard procedure. Result revealed a contamination of chromium and zinc irrespective of the site of cultivation. Presence of lead was found to be below the deductible levels***

Keywords: Heavy metal contamination, arakeerai ***(Amaranthus dubius)***, toxic, heavy metals

1. Introduction

Leafy vegetables hold an important place in well-balanced diets. Green leafy vegetables are the cheapest of all the vegetables within the reach of poor man, being richest in their nutritional value. The lack of knowledge especially on the nutritive value of these green leafy vegetables among the public in general is the main drawback in their lower consumption. **(Oyenuga, 1975)**

The **World Health Organization (WHO**) recommends a daily intake of more than 400g of vegetables per person. **Aruna Narayanan (2017)** opines that green leafy vegetables found in South India, used as a source of food have many health benefits like protection from eye problems, iron deficiency and oxidative damage.

Very important factor to be considered is that the greens are least expensive and are easily grown and can be made available throughout the year from small plot of land. Leafy vegetables are appreciated because they not only supply the protective nutrients and add variety to a monotonous diet, but also have an alternative taste, pleasing appearance and aroma. Hence, green leafy vegetables form a part of everybody's diet specially the vulnerable group which includes children, adolescents, pregnant, nursing and aged people where in their requirements for vitamins and minerals are higher(**Laxmaiah A, 2010)**

Metals are found naturally in the earth's crust and their compositions vary among different localities, resulting in spatial variations of surrounding concentrations. Heavy metals like chromium, lead have many adverse health effects and last for a long period of time, heavy metal exposure continues and is increasing in many parts of the world. Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons. Heavy metals enter the surroundings by natural means and through human activities. Various sources of heavy metals include soil erosion, natural weathering of the earth's crust, mining, industrial effluents, urban runoff, sewage discharge, insect or disease control agents applied to crops, and many others (*Adefila et al*,2010)

Heavy metals are thus commonly defined as those having a specific density of more than 5 g/cm3. Metallic elements are intrinsic components of the environment.

Their presence is considered unique in the sense that it is difficult to remove them completely from the environment once they enter in it. Heavy metal constitutes an important class of toxic substance which are encountered in numerous occupational and environmental circumstances. The impact of these toxic agents on human health is currently an area of intense interest due to the ubiquity of exposure. With the increasing use of a wide verity of metals in industry and in our daily life, problems arising from toxic metal pollution of the environment have assumed serious dimensions **(**Akpanabiatu M.I., 2009)

Both essential and toxic elements are present in vegetables over a wide range of concentrations as they are said to be good absorber of metals from the soil.Some heavy metals such as Cr, Mn, Ni, Zn, Cu, and Fe are considered essential components for biological activities in the body; however, their presence in elevated levels is reported to cause problem to human. On the other hand, Pb, Cd, Hg and As are non-essential and play toxic role to living organism and hence are considered as toxic elements. (**Ramesh H.L and Yogananda V.N Murthy 2012)**

Since very few studies have been conducted on heavy metal contamination of green leafy vegetables in the regions of Coimbatore the present study is to throw light on the heavy

metal contamination of green leafy vegetables in different sites of cultivation. Thus the study titled "Analysis of heavy metal contamination of selected green leafy vegetables on different sites of cultivation" is carried out with **the objective** to analyses the heavy metal contamination in **Arakeerai *(Amaranthus dubius)*** cultivate in Coimbatore at different site namely in the agricultural fields, on the contaminated waterbeds of sewages and sludge's and in organic farms.

2. Methodology

Phase I: Assessment of Mean Daily Intake of Green Leafy Vegetables

Selection of Area - Green Leafy Vegetables are principally known for their high nutritional content and are often consumed for their health and dietary benefits. Humans consuming green leafy vegetables are exposed to heavy metals by ingestion (drinking or eating foods that are grown in the polluted fields or on water beds) or inhalation (breathing). Working in or living near an industrial site which utilizes heavy metals like Cr, Pb, Zn, Cd, Cu, Ni and Mn and their compounds increases ones risk of exposure, as does living near a site where these metals have been improperly disposed. Subsistence lifestyles can also impose higher risks of exposure to these heavy metals.

Coimbatore a city which is known for its dual role in agriculture and industrial activities is selected for the conduct of the study since the region has more chances of pollution of heavy metal. Green leafy vegetables that are grown in and around nearby contaminated banks of sewages and sludges which are sold in popular markets of Ukkadam, the one which grows in proper agricultural field is sold in the Saibaba Colony market and the one which is organically farmed is sold in Organic store situated in Murugan Mills which was purposively selected using purposive sampling. Hence, these areas are selected for conducted the study, since agricultural practices and use of fertilizers also plays an important role in the retention of heavy metals in vegetables and green cultivated.

Selection of sample- To assess the mean daily intake of green leafy vegetables a total of 75 women between the age group of 30-35years weighing between 50-55kgs comprising 25 women each who purchased green leafy vegetables exclusively from the above three identified parts of Coimbatore namely Ukkadam, Saibaba Colony and Murugan Mills were selected through purposively sampling.

Selection of tools and collection of data- A well-structured questionnaire was constructed to collect background information like age, weight, economic status, occupational status, family size and type. Using the questionnaire the investigator also collected information on the consumption pattern of green leafy vegetables and the knowledge of heavy metals contamination.

Measurement of Weight- Since weight was one of the criteria for selection of subject, it was taken for all the 75 respondents from the three selected regions. Weight is taken using an electronic weighing balance and the subject was asked to stand erect in the weighing balance with minimum clothing and without shoes. Before taking the readings, the weighing machine was calibrated to the nearest zero and the weight was recorded to the nearest value.

Consumption pattern of Green Leafy Vegetables- Using a well-structured interview scheduled , the investigator collected the information pertaining to the place of purchase of green leafy vegetables, the consumption pattern of commonly consumed green leafy vegetables, their frequency of consumption and also the various forms in which they were consumed. The investigator also collected information from all the 75 respondents on the knowledge of heavy metal contamination and home remedies if any that they follow to get rid of the heavy metal contamination.

Mean Daily Intake of Green Leafy Vegetables- Based on the data collected on the consumption pattern of green leafy vegetables, the mean daily intake of green leafy vegetables was calculated for all the three regions. The quantum of consumption of cooked volume of green leafy vegetables was elicited in household measurements and was converted into raw equivalent.A total of 18 green leafy vegetables available in the market were listed in the frequency chart. The respondents were asked to tick the commonly and most frequently consumed green leafy vegetables. The current investigation aim at analyzing the heavy metal contamination of a Arakeerai *(Amaranthus dubius)*, the commonest greens consumed in all of the three regions Coimbatore.

Inclusion Criteria

- Women 30-35years
- Weight ranging between 50-55kg
- Women who purchase green from Saibaba Colony, Ukkadam, Organic store market
- Women who are willing to participate in the study

Exclusion Criteria

- Women under/more than 30-35 years
- Women weighing more than 55kgs
- Women who do not purchase green from Saibaba Colony, Ukkadam, Organic store market.

An informed consent was obtained from all the respondents and it was approved by the Institutional Human Ethical Clearance AUW/IHEC/FSMD-16-17/XMT-07 dated 3rd. February 2017.

Phase II: Analysis of Heavy Metals Contamination in Selected Green Leafy Vegetables

Procurement of green leafy vegetables- Two bunches of Arakeerai *(Amaranthus dubius)*, was purchased from three main markets in Coimbatore namely Saibaba Colony, Ukkadam and an Organic Store in Murugan Mills.

Cleaning - The greens were washed with tap water followed by distilled water and were thoroughly rinsed to remove all the sand, dirt and impurities. The edible portion of the green was then taken for further processing.

Drying and Dehydration- Edible portion of the selected green leafy vegetables were cut into smaller pieces and were shade dried for two days to remove all moisture thoroughly. The dried greens samples were then kept in a hot air oven at 150ºC for 4hours and dehydrated thoroughly to obtain a moisture free sample till a constant weight is obtained.

Powdering- Using a clean blender, the dried samples were made into fine powder. The greens sample powders were then passed through a sieve of 1mm width to obtain a very fine powder.

Analysis of heavy metal- One gram of the greens sample (1 g) was digested by adding 15 ml of tri-acid mixture **(**Nitric acid (HNO3), Sulphuric acid (H2SO4), and Hydrochloric acid (HClO4) in the ratio of 5:1:1 at 80 °C until a mixture gives out white fumes and forms transparent solution. The digested sample was filtered using Whatman No. 42 filter paper after cooling and the filtrate was finally made up to 50 ml with distilled water. The samples were analysed by atomic absorption spectrophotometer using an air-acetylene flame for Cr, Pb and Zn. The instrument was fitted with specific lamp of particular metal. The instrument was calibrated using manually prepared standard solution of respective heavy metals as well as drift blanks using standard procedure **.**The reading were noted at wavelength of 425.4nm for chromium 405.4nm for lead and 213.9nm for zinc with a slide width of 0.1nm

Calculation of Mean Intake of heavy metals- The mean intake of heavy metals by the subject for all the three selected regions namely Saibaba Colony, Ukkadam and an Organic store from Murugan Mills was calculated using the formula:

$$\textbf{Mean Intake of Heavy metals} = \frac{\text{Heavy metals concentration in green leafy vegetables x Daily intake of green leafy vegetables}}{\text{Average body weight}}$$

The mean intake of heavy metal was then compared with the recommended intake of heavy metal proposed with WHO/FAO (2001) standard. The results were statistically analyzed.

3. Results

The salient findings of the study are, Background information

The mean age of the selected women was 33years and the mean weight was found to be 53kg a weight range meeting the standards of a reference woman.The families which earned more than Rs10000/ month purchased organic greens (23) compared to those who earned between Rs5000-10000 and less than Rs5000. None of the families with less than Rs5000 purchase organic vegetables as they were expensive compared to the ones available in the market and on streets. Out of 75 women, 43 of them were found to be employed. Also it is clear that more number of business women (8) and professional (6) had organic greens as their choice of purchase. Forty seven out of 75 women lived in nuclear family and only 18 women had more than five member in the family.

Table 1: Commonly Purchased Green Leafy Vegetables (N=75)

Types of Greens	S (N=25)	U (N=25)	M (N=25)		Types of Greens	S (N=25)	U (N=25)	M (N=25)
Ara keerai	19	10	18		Murungai keerai	2	8	6
Siru keerai	15	15	15		Curryvapilai	15	7	15
Thandu keerai	16	10	13		Pudina	9	6	12
Mullai keerai	14	12	15		Manathakkalli keerai	5	5	10
Palak keerai	18	15	19		Agathi keerai	2	6	9
Kothamalli	12	10	12		Vellari keerai	5	5	8

Vendayam	5	6	8		Modakathan keerai	1	9	5
Ponnanganni	8	8	9		Mukarrate keerai	1	8	3
Paruppu keerai	1	9	2		Kuppameni	5	5	6

***Multiple response**, **Note**- S- Saibaba Colony, U- Ukkadam, M-Murugan Mills

Majority of the consumers from ukkadam (15) and Saibaba Colony (12) bought the green leafy vegetables from road side followed from street vendor. It was also evident that all the 25 member selected from Murugan Mills purchased greens only from organic stores.The commonly purchased green were Arakeerai (19) which was the most commonly consumed greens followed by palakkeerai (18), thandukeerai (16), serukeerai (15) and mullaikeerai (14) respectively by the selected women surveyed from Saibaba Colony.(table I).

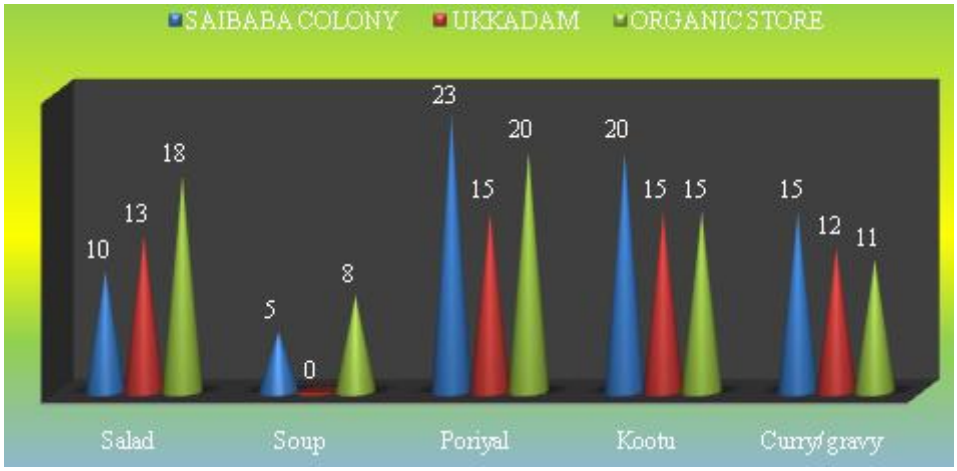

Figure 1: Different Forms of Consumption of Green Leafy Vegetables

From the figure 1 it is evident that irrespective of regions, more than 15 out of 25 subjects consumed greens in the form of poriyal and kootu, a popular recipe of Tamil Nadu prepared by combining greens with red gram or Bengal gram dhal.

Mean intake of green leafy vegetables

The quantum of consumption of cooked volume of green leafy vegetables was elicited in household measurements and was converted into its raw equivalent. The mean intake of consumption was then calculated and presented in table II

Table 2: Mean intake of green leafy vegetables

	MEAN INTAKE	S	U	M	
	Arakeerai *(Amaranthus dubius)*	83	79	65	
	Sirukeerai *(Amaranthus polygonoides)*	70	68	80	
	Thandukeerai *(Amaranthus caudatus)*	67	69	69	
	Mullaikeerai *(Amaranthus gangeticus)*	83	74	70	
	Palakkeerai *(Spinacea oleracea)*	68	75	64	

Note- S- Saibaba Colony, U- Ukkadam, M- Murugan Mills

From the above table, it can be inferred that the mean intake of all the selected commonly consumed greens ranged between 65 to 85 gm per person.

Knowledge and Attitude of Women on Heavy Metals Contamination

Sixty five out of 75 women were aware of the risk of contamination of heavy metals in green leafy vegetables and this is strongly felt as a reason as to why 25 women purchased organic green than the one sold in the markets. Most respondents believed that organically farmed greens are safe for consumption when compared to the one available in the general market and 64 women opined that organic greens are free of heavy metal contamination and are safe to consum since they are grown without any additional pesticides and chemicals. Out of 75 women, the practice of washing green leafy vegetables (32) followed by cooking (30), blanching (8) and few adopt usage of soaking in salty water (5) to get rid of heavy metals.

Heavy Metals Contamination of Arakeerai - The contamination of heavy metals for chromium, lead and zinc in Arakeerai is tabulated in table VII and is discussed below:

Table 3: Contamination of Heavy Metals in Arakeerai *(Amaranthus dubius)*

	Heavy metals Contamination	Area			
		Saibaba Colony	Ukkadam	Murugan Mills	
	Chromium (ppm)	130.9	279.3	52.5	
	Lead (ppm)	BDL	BDL	BDL	
	Zinc (ppm)	83.87	82.43	78.65	

***BDL- Below Detectable Level.**

From the above table it is evident that the contamination of heavy metals in Arakeerai was comparatively less in organically farmed greens(chromium-52.5, zinc-78.65) than the one procured from local markets of Ukkadam and Saibaba Colony. Further it was observed that the chromium contamination was found to be highest in green procured from Ukkadam market, which can be attributed to the fact that the Ukkadam area is generally polluted with sewage, and sludges where the green are normally grown and heavy metals contamination depends on the exposure of soil to chemical, biological pollutants and fertilizers. Further it was also observed that in all the three samples the presence of lead was below detectable level. Hence, the Null Hypothesis I - There is no contamination of chromium, lead and zinc in Arakeerai cultivated at different site of Coimbatore namely Saibaba Colony, Ukkadam and Murugan Millswas rejected.

Table 4: The Mean Intake of Heavy Metals From Aarakeerai

Regions	Chromium	Zinc	Permissible limit	t- test
Saibaba colony	208.93	133.86	Cr-0.46 mg Zn-15.73mg	Cr-.007 %** Zn-.014 %**
Ukkadam	438.67	122.86		
Murugan mills	64.62	97.93		

From the table it is evident that the heavy metal intake for chromium and zinc by the consumption of aarakeerai alone was found to be very high compared to the permissible level (chromium-0.4mg, zinc-15.7mg) recommended by WHO for green leafy vegetables.

The difference between the mean intake of heavy metals and permissible intake was found to be significant at 1% level of significance. The lead content of Aarakeerai was found to be belowdeductible level.

4. Summary and Conclusion

In general the level of contamination of heavy metal in aarakeerai was comparatively lesser in Organic farmed vegetable compared to ones cultivate in the agricultural fields and in the banks of sewages and sludge's and was found to be significant at 1% level. Thus the above findings of the study throws a major challenge before the scientific fraternity to explore the user friendly remedial measures to reduce the level of heavy metals contamination not only in greens but also for all fruits and vegetables in future.

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