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Original Article

GREY WATER FARMING OF LADIES FINGER AND CLUSTER BEANS-INDUCES DIETARY TOXICITY?

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ABSTRACT

Objective: A large number of farmers are growing different vegetables and supplying them to the Solapur market. The majority of these farms are located on the banks of the "nullah", whose water is used for irrigation. From, a farm field in Degaon, a village on the Solapur–Mangalvedha road and on the bank of 'nullah' two fruit vegetables viz., Ladies Finger (Bhendi) and Cluster Beans (Gawar) are evaluated in the study. The purpose of this study was to analyse the presence of selected toxic non-essential heavy metals i.e. Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb) and Mercury (Hg) in the two vegetables.

Methods: Atomic Absorption Spectrophotometer (AAS) was used for determining the concentration of heavy metals. Optimised wet acid digestion procedure was employed to solubilize the metals from the vegetable samples.

Results: The following concentrations (mg/kg) of the non-essential heavy metals were found in the edible parts of the *Ladies Finger* and *Cluster Beans*, respectively: *Ladies Finger*: As (16.07), Hg (16.77), Pb (1.148), Cr (17.14), Cd (0.704 mg/kg) and *Cluster Beans*: As (18.76), Hg (21.86), Pb (1.675), Cr (17.14), Cd (0.888 mg/kg). The study revealed the presence of all the chosen NEHMs in the vegetables. Cadmium levels in both Cluster Beans and Ladies Finger were below the maximum acceptable limit and hence fit for human consumption as per FSSAI standards As (1.1), Pb (1.0), Cd (1.5), Hg (1.0 ppm). Though unsafe as per WHO/FAO standards As (0.1), Pb (0.5), Cd (0.2), Cr (1.2), Hg (0.05 ppm).

Conclusion: The other three NEHMs levels were approximately 15 times more than the permitted levels and hence might pose danger on human consumption.

Keywords: AAS, Cluster Beans, Grey water, Ladies Finger, Non-essential heavy metals, WHO/FAO, FSSAI

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INTRODUCTION

Grey water is 'Wash water' or 'Stormwater" or 'Wastewater' or "Sewage water". It is all waste water apart from toilet wastes and food wastes. There are a significant difference between greywater and toilet waste water; it is also called as 'Blackwater' [1-3].

Fig. 1: A view of 'nullah' with grey waste water from Solapur city on Solapur–Mangalvedha road

Role of vegetables on health

Vegetables are the fresh and edible portions of herbaceous plants. They are essential food and highly beneficial for the maintenance of health and prevention of diseases. They contain valuable food ingredients like high carbohydrate, vitamin, mineral, fibre, antioxidants, metabolites and act as buffering agents for acidic substances which can be successfully utilized to build up and repair the body [4, 5]. The recent Joint FAO/WHO expert consultation on diet, nutrition and the prevention of chronic diseases, recommended the intake of a minimum of 400 g of fruit and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as heart diseases, cancer, diabetes [6].

Heavy metals in vegetables and their toxicity

The process of absorption of inorganic substances depends on the pH and type of soil. It has been observed that the conc. of minerals vary from place to place and from plant to plant and on the source of water also [8, 9]. Non-essential heavy metals Cr, Cd, Pb, As, and Hg can get accumulated in commonly used vegetables i.e. Ladies Finger and Cluster Beans through the soil [10, 11].

Table 1: Permissible limits of heavy metals in vegetables as per WHO/FAO, FSSAI [7]

Heavy metal	WHO/FAO permissible values (mg/kg)	Food safety and standards authority of India (FSSAI) parts per million (ppm) metal
As	0.1	1.1
Pb	0.5	1.0
Cd	0.2	1.5
Cr	1.2	-
Hg	0.05	1.0

Table 2: Symptoms due to different heavy metals toxicity [12]

Heavy metals	Toxicity
Arsenic	Acute poisoning, Cancer of lungs, GI damage–severe vomiting, diarrhea
Mercury	Malfunctioning of: nerves, kidneys and muscles, Neuromuscular changes (weakness, muscle atrophy, twitching), Emotional changes (mood swings, irritability, nervousness, etc.)
Cadmium	Nephrotoxicity, stomach irritation resulting in vomiting and diarrhea
Chromium	Damage to DNA and proteins
Lead	Loss of appetite, head-ache, hypertension, abdominal pain, renal dysfunction, fatigue, sleeplessness, arthritis, hallucinations, vertigo.

Ladies finger (LF) (Okra) (Bhendi)

'LF' contains vitamins and minerals as chief nutrients. It also contains a large amount of fiber, and has a unique profile of proteins. Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander [13].

Cluster beans (CB) (Guar) (gawar)

Cluster beans lower LDL, or bad cholesterol, levels thereby improving your heart health and lowering the risk of a heart attack. The iron in these beans increases body's hemoglobin production and allows blood to carry more oxygen around the body. Cluster beans have Vitamins A, B and K, in addition to minerals like calcium, iron, folate and potassium [14].

MATERIALS AND METHODS

Materials collection and location

Ladies Finger and Cluster beans were collected from a farm near Degaon (Degaon-Kegaon road) village at around 10 kms near Solapur on Solapur–Mangalvedha road. (17.6721086 °N, 75.8489531 °E) [15].

Fig. 2: Location of nullah (Degaon-Kegaon road)

Firstly, vegetable samples were washed with water to remove mud and dust and then finally rinsed with distilled water. Both the vegetable samples were sliced with the help a of knife into small pieces. The samples were dried in air under the sun for a few days. They were ground by an electric grinder to small particle size and directly stored in fresh plastic containers for further analysis.

Methods

Wet acid digestion method as described by AOAC in 1990 was used in the study: 1.0 gm each of dried sample was added to 10 ml of conc. HNO_3 in 50 ml beaker and placed on the electric hot plate for 1 hour to get semi dried sample. Again 10 ml of conc. HNO_3 and 4 ml of H_2O_2 were added and again kept on a hot plate and heated vigorously. The addition of HNO_3 and H_2O_2 were continued till a colourless solution obtained. And its volume reduced up to 2-3 ml. It was cooled and filtered with the help of what man filter paper. The filtrate was stored in 10 ml sample bottles or vials. It was diluted up to 25 ml by de-ionized water before taking to Atomic Absorption Spectrometer. Metal contents in the prepared samples were analyzed using Atomic Absorption Spectrophotometer (iCE 3000, Thermo Scientific, USA) following the conditions described in AOAC (1990). Selected metals included Cadmium (Cd), Chromium (Cr), Arsenic (As), Lead (Pb), and Mercury (Hg). Calibrated standards were prepared from the commercially available stock solution in the form of an aqueous solution (1000 ppm). Highly purified de-ionized water was used for the preparation of working standards. All the glass apparatus used throughout the process of analytical work were immersed in 8N HNO3 overnight and washed with several changes of deionized water prior to use.

Fig. 3: Atomic absorption spectrophotometer (iCE 3000, thermo scientific, USA) (Solapur University, Solapur)

RESULTS

Table 3: Comparative conc. Vs absorbance data for Cr in the standard and CB samples

Sample ID	Absorbance	Rsd %	Conc. mg/l or µg/ml
Cr Blank	0.001	43.6	0.0000
Cr Standard 1	0.070	2.2	10.0000
Cr-1	0.005	7.4	0.5868
Cr-2	0.004	1.9	0.4500
Cr-3	0.004	16.4	0.4243
Cr-4	0.006	6.9	0.6799
Cr-5	0.005	3.0	0.5931
Cr-6	0.005	7.7	0.5692

Table 4: Comparative conc. Vs absorbance data for Cr in the standard and LF samples

Cr-1	0.006	8.2	0.6823
Cr-2	0.006	5.1	0.7763
Cr-3	0.007	7.7	0.8323
Cr-4	0.004	9.8	0.5214
Cr-5	0.003	14.5	0.3659
Cr-6	0.003	13.9	0.2970

Permissible limits		**Actual conc. of HM in sample**	
As per WHO/FAO (mg/kg)	As per FSSAI (mg/kg)	CB	LF
1.2	-	17.142 mg/kg	17.142 mg/kg

Table 5: Comparative conc. Vs absorbance data for As in the standard and CB samples

Sample ID	**Absorbance**	**Rsd %**	**Conc. mg/l or μg/ml**
As Blank	0.001	27.8	0.0000
As Standard 1	0.373	0.8	40.0000
As-1	0.010	10.6	1.1986
As-2	0.008	4.3	0.9201
As-3	0.007	8.0	0.8892
As-4	0.008	5.4	0.9811
As-5	0.005	2.2	0.6647
As-6	0.005	26.4	0.6254

Table 6: Comparative conc. Vs absorbance data for As in the standard and LF samples

As-1	0.002	53.7	0.3381
As-2	0.007	7.3	0.8572
As-3	0.009	3.2	1.0312
As-4	0.009	3.0	1.0270
As-5	0.007	3.0	0.8239
As-6	0.007	6.2	0.8793

Permissible limits		**Actual conc. of HM in the sample**	
As per WHO/FAO (mg/kg)	As per FSSAI (mg/kg)	CB	LF
0.1	1.1	18.766 mg/kg	16.07 mg/kg

Table 7: Comparative conc. Vs absorbance data for Cd in the standard and CB samples

Sample ID	**Absorbance**	**Rsd %**	**Conc. mg/l or μg/ml**
Cd Blank	0.005	27.6	0.0000
Cd Standard 1	1.360	0.2	10.0000
Cd-1	0.006	12.8	0.0050
Cd-2	0.005	12.9	0.0024
Cd-3	0.004	14.5	0.0048
Cd-4	0.005	5.0	0.0034
Cd-5	0.005	7.2	0.0015
Cd-6	0.004	6.7	0.0088

Table 8: Comparative conc. Vs absorbance data for Cd in the standard and LF samples

Cd-1	0.004	10.3	0.0066
Cd-2	0.004	2.3	0.0062
Cd-3	0.003	5.8	0.0147
Cd-4	0.001	13.1	0.0276
Cd-5	0.000	12.2	0.0403
Cd-6	0.011	>99	0.1155

Permissible limits		**Actual conc. of HM in the sample**	
As per WHO/FAO (mg/kg)	As per FSSAI (mg/kg)	CB	LF
0.2	1.5	0.888 mg/kg	0.704 mg/kg

Table 9: Comparative conc. Vs absorbance data for Pb in the standard and CB samples

Sample ID	Absorbance	Rsd %	Conc. mg/l or µg/ml
Pb Blank	0.000	>99	0.0000
Pb Standard 1	0.544	0.3	10.0000
Pb-1	0.003	5.9	0.0556
Pb-2	0.007	2.3	0.1366
Pb-3	0.003	8.8	0.0575
Pb-4	0.005	2.0	0.1028
Pb-5	0.003	7.1	0.0543
Pb-6	0.001	21.9	0.0307

Table 10: Comparative conc. Vs absorbance data for Pb in the standard and LF samples

Pb-1	0.001	5.6	0.0091
Pb-2	0.003	9.3	0.0614
Pb-3	0.003	13.2	0.0604
Pb-4	0.004	3.2	0.0832
Pb-5	0.002	13.6	0.0451
Pb-6	0.002	5.0	0.0469

Permissible limits		Actual conc. of HM in the sample	
As per WHO/FAO (mg/kg)	As per FSSAI (mg/kg)	CB	LF
0.5	1.0	1.675 mg/kg	1.148 mg/kg

Table 11: Comparative conc. Vs absorbance data for Hg in the standard and CB samples

Sample ID	Absorbance	Rsd %	Conc. mg/l or µg/ml
Hg Blank	0.107	>99	0.0000
Hg Standard 1	0.678	0.5	300.0000
Hg-1	0.006	5.8	2.6232
Hg-2	0.002	2.6	0.9867
Hg-3	0.000	53.8	0.2661
Hg-4	0.000	36.6	0.3035
Hg-5	0.001	1.1	0.2302
Hg-6	0.008	6.1	51.9592

Table 12: Comparative conc. Vs absorbance data for Hg in the standard and LF samples

Hg-1	0.005	2.7	53.4478
Hg-2	0.003	1.8	54.0988
Hg-3	0.003	7.0	54.0740
Hg-4	0.004	6.3	54.0163
Hg-5	0.003	8.1	54.4573
Hg-6	0.002	8.9	54.6968

Permissible limits		Actual conc. of HM in sample	
As per WHO/FAO (mg/kg)	As per FSSAI (mg/kg)	CB	LF
0.05	1.0	21.865 mg/kg	16.775 mg/kg

Table 13: Consolidated list of conc. of HMs in CB and LF

Metals	Heavy metals conc. in CB (Gawar) (mg/kg)	Metals	Heavy metals conc. in LF (Bhendi) (mg/kg)
As	18.77	As	16.07
Cd	0.89	Cd	0.70
Cr	17.14	Cr	17.14
Pb	1.68	Pb	1.15
Hg	21.87	Hg	16.78

DISCUSSION

The AOAC method (1990) of estimation of heavy metals in organic samples using AAS yielded the results as presented the above fig. and tables. From the results, following information could be derived

Heavy metals conc. in cluster beans

Of the five NEHMs evaluated in *CB* all the five metals could be detected in the samples chosen. However, of the five, three heavy metals viz., As, Cr, and Hg were seen in exceedingly high conc. of 18.77, 17.14 and 21.87 mg/kg conc. respectively. Though, Cd (0.89 mg/kg) and Pb (1.68 mg/kg) were in relatively low conc. these two also were above their permissible limits of 0.2 and 1.0 mg/kg of the sample.

Heavy metal conc. in ladies finger

Of the five NEHMs evaluated in *LF* all the five metals could be detected in the samples chosen. However, of the five, three heavy metals viz., As, Cr, and Hg were seen in exceedingly high conc. of 16.07, 17.14 and 16.78 mg/kg conc. respectively. Though Cd (0.70 mg/kg) and Pb (1.15

mg/kg) were in relatively low conc., these two also were above their permissible limits of 0.2 and 1.0 mg/kg of the sample.

CONCLUSION

The results indicate that all the non-essential heavy metals are chosen in this study viz., As, Cd, Cr, Hg and Pb were found to exist in both the vegetable samples. The concentration of As, Hg and Cr were found in excessively high amounts whereas, Cd and Pb were just above the permitted limits. This may be pointing towards possible contamination of 'nullah water' with wastes from automotive garages which might lead to elevated lead and mercury levels. But, it is interesting to see that the lead and cadmium conc. in both the vegetables were low indicating either inability of the plant to accumulate these NEHMs or their absence in soil/water. It is also interesting to note that the absorption pattern of all the five metals was similar in both CB and LF. This means the existence of an unfavourable set of conditions for the cultivation of these two vegetable crops. Further, consumption of CB and LF might also potentially exhibit toxicity symptoms of As, Cr and Hg on short-term treatment and Cd and Pb toxicity on long-term treatment. It might also indicate that the conditions of cultivation i.e., soil nature, water source are both unsuitable for the cultivation of the two plants. So, it might be better to substitute these two plants from others which don't accumulate the NEHMs under study. Alternatively, it would also be possible to follow remediation of soil to avoid the uptake of HMs by either changing their oxidation status or by changing soil pH.

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CONFLICT OF INTERESTS

Declare none

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