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Assessment of Heavy Metal Contamination in Vegetables Grown in and Around Nashik City, Maharashtra State, India

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Abstract: *The study was conducted to find out the content of lead (Pb), cadmium (Cd), arsenic (As) and copper (Cu) in some selected vegetables grown in and around Nashik city, Maharashtra state (India). Vegetable samples from four different sites were collected and digested by using tri-acid digestion method. Concentrations of heavy metals were analyzed by using atomic absorption spectrophotometer. The results of this study showed that there was wide variation in the concentration of these metals in vegetables collected from different sites. Vegetables grown in the vicinity of an industrial area were most contaminated while vegetables grown in rural area were least contaminated. Analytical results indicated that the concentration of lead in 35% vegetable samples collected from industrial area were more than maximum permitted limit. The high concentration of cadmium was found in onion and coriander, while lead content was recorded high in spinach and cauliflower. Arsenic concentration in 25% samples collected from industrial area was more than maximum permitted limit. Copper concentration in most of the vegetable sample was within permissible limit; only two out of forty samples have high concentration of copper. The results of the study showed that consumers are at greater risk of purchasing these fresh vegetables with high levels of heavy metals beyond permissible limits as defined by the Indian Prevention of Food Adulteration Act, 1954.*

Keywords*: Heavy Metals, Vegetables, Contamination, Nashik*

I. Introduction

Nashik city is situated at the bank of Godavari River in Maharashtra state. Around Nashik there are numbers of villages having large farming communities. Vegetables and fruits are very important part of the human diet as they contain proteins, carbohydrates, vitamins, minerals and trace elements. They contain both essential and toxic elements in various concentrations. Many researchers have shown that some common vegetables have ability of accumulating high level of metals from the soil. Distribution of heavy metals in plant body depends upon their concentration in soil and water as well as plant species and its population. [1, 2] Heavy metals play very important role in the metabolism and growth of plants and animals. These metals can alter the metabolism and functions of some essential trace elements, like iron, copper, zinc, calcium selenium and manganese by competing for the ligands in biological system. [3] Heavy metals are very harmful because of their non-biodegradable nature and their potential to accumulate in different body parts. [4] Excessive accumulation of heavy metals can develop systematic health problem in human body. Accumulation of heavy metals in agricultural soils result in increased metal uptake by crops, this can affect food quality and safety. According to toxicity studies, these metals can directly damage human beings by affecting mental and neurological function. [5] Sewage and irrigation with contaminated water is responsible for increased concentration of metals in the soil and vegetation [6]. Irrigation of crops with industrial and municipal wastewater is a common practice in periurban area due to its easy availability, disposal problems and scarcity of fresh water. [4]

Polluted environment in urban agriculture, contaminated food transport and poor sanitary condition are responsible for food contamination in urban areas. [7] Industrial activities such as metal finishing, paint pigment, battery manufacturing and traffic emissions are mainly responsible for environmental pollution. Human activities like urban compost and municipal waste water sludge depositions, use of pesticides and phosphate fertilizers also contribute in heavy metal pollution [8, 9] Major categories of soil pollutants include nutrients (fertilizers, sewage sludge), acids, heavy metals, radioactive elements and organic chemicals (herbicides, insecticides, fungicides and other pesticides). Many of these pollutants are continuously discharged into the soils through land waste disposal, inputs from the atmosphere and irrigation by municipal waste water on a daily basis [10, 11]. Use of polluted water in the immediate surroundings of big cities for growing of vegetables is a common practice. Although this water has rich source of organic matter and plant nutrients, it also contains sufficient amounts of soluble heavy metal salts. When such water is used for cultivation of crops for a long period, these heavy metals may accumulate in soil and deterioration it. [12]The present study was conducted with an aim to compare the heavy metals (lead, cadmium arsenic and copper) level of some commonly available vegetables from Nashik, Maharashtra State, India

Study area

The study area for the research work is Nashik, Maharashtra State (India). This is one of the fast growing cities having large farming community. Location of city is between 18.33 degree and 20.53 degree North latitude and between 73.16 degrees and 75.16 degree East Longitude. Nashik is known as Mini Maharashtra, as the climate and soil conditions in some parts of Nashik resembles with of Konkan, Western Maharashtra and Vidarbha Region. Many important rivers including Godavari originate from the Nashik district. Godavari is popularly known as Ganga of South India. The climate of the Nashik is very pleasant and comparable with Bangalore and Pune In recent years, increase in temperature and decrease in rainfall is observed due to industrialization, urbanization, deforestation and global warming. Vegetables and fruits like grape are very important crops of the Nashik district

For the present study four different sites were selected from the Nashik, Maharashtra. (India)

Site-1 Nashik (Satpur and Ambad) industrial area.
Site-2 Sinnar industrial area.
Site-3 Nandur village (near municipal waste water disposal centre)
Site-4 Dindori (away from industrial and city area)

II. Materials and methods

Sample collection

Fresh vegetable samples were collected in triplicate from four different sites. The sample collected includes Coriander (*Coriandrum sativum)*, Spinach (*Spinacia oleracea)*, Onion (*Allium cepa*), Cauliflower (*Brassica oleracea botrytis*), Brinjal (*Solanum melongena*), Cabbage (*Brassica oleracea*), Tomato *(Solanum lycopersicum*), Cucumber (*Cucumis sativus*), Potato (*Solanum tuberosum*) and Carrot (*Daucus carota*).

Sample preparation and treatment

Vegetable samples were brought to the laboratory and washed under clean tap water followed by double distilled water to eliminate soil and air-born pollutants. The moisture and water droplets were removed with the help of blotting papers.100 gram of edible portion of all three samples was homogenized, and immediately oven dried at 110°C until the constant weight was achieved. Fully dry samples were then ground to fine powder in a manual grinder and kept in clean, dry, stopper glass containers at room temperature. A working solution of H2SO4 (65%), HClO4 (65%) and HNO3 (70%) with ratio of 1:1:5 was prepared and used for digestion of the samples. For heavy metal analysis, one gram of dry powder of each sample was digested in 100 ml Pyrex glass beaker by adding 15 ml of aforementioned three-acid mixture and then heated at 80^{o}C till the solution became transparent. The resulting solution was cooled and filtered with whatman filter paper. Finally volume of the extract was made up to 50 ml using double distilled water [13-15]. Analysis of heavy metals was carried out by using Shimadzu Atomic Absorption Spectrophotometer, Model AA 6300.

III. Results and discussion

Concentration of lead, cadmium, arsenic and copper from randomly collected samples of coriander (*Coriandrum sativum)*, spinach (*Spinacia oleracea)*, onion (*Allium cepa*), cauliflower(*Brassica oleracea botrytis*), brinjal (*Solanum melongena*), cabbage(*Brassica oleracea*), tomato *(Solanum lycopersicum*), cucumber(*Cucumis sativus*) , potato(*Solanum tuberosum*) and carrot(*Daucus carota*) form four different sites in Nashik district were analysed. The study showed that the concentration of metals greatly varied in sample collected from different sites.

Lead

Table 1. shows the lead (Pb) concentration in vegetable samples collected from different sites from Nashik district. Lead concentration in 35 % vegetable sample collected from industrial area recorded higher than the permissible limits of Indian Prevention of Food Adulteration Act (PFA), 1954. Lead concentration ranges from 1.60 to 9.70 ppm for Nashik industrial area and 1.90 to 7.10 ppm for Sinnar industrial area. High concentration of lead in vegetables was due to high content of metals in the soil, and may be due to irrigation by metal contaminated water released from nearby industries. Maximum vegetable sample (80%) collected from Nandur and the entire samples collected from Dindori have lead concentration within permissible limit. Fig.1. shows comparison of lead (Pb) level in different vegetables collected from different sites. From fig. it is clear that site 1 is most polluted while site 4 is least polluted. Highest level of lead was found in spinach and cauliflower while lowest level of lead was found in cucumber.

Cadmium

Table 2. shows the cadmium (Cd) concentration in vegetable samples collected from above mentioned four sites. Cadmium concentrations in the entire sample collected from Dindori were within the permissible

limits of Indian Prevention of Food Adulteration Act (PFA), 1954. Cadmium concentration in two out of ten samples collected from Nandur has recorded higher than the permissible limits of 1.5 µg /g**.** 30% vegetable sample collected from Nashik and Sinnar industrial area recorded cadmium concentration higher than the permissible limit. Concentration ranges from 0.60 to 3.30 ppm for Nashik industrial area and 0.80 to 2.20 ppm for Sinnar industrial area. Graphical representation of cadmium level in different vegetables collected from different sites is shown in fig.2 Three out of four sample of coriander and onion shows high level of cadmium than permissible limits.

Arsenic

Arsenic concentration in 5 out of 20 samples collected from industrial area has higher than the permissible limits of Indian Prevention of Food Adulteration Act (PFA), 1954. Arsenic concentration in all sample collected from Dindori and 90% sample collected from Nandur were within safe limit (Table 3 and fig.3)

Copper

Table 4 shows concentration of copper (Cu) in vegetable samples collected from different sites in ppm while fig. 4 shows its comparative representation. Copper concentration of most of vegetable sample was within permissible limit. Only two out of 40 samples shows copper concentration above permissible limit. Concentration ranges from 4.90 to 30.80 ppm for Nashik industrial area, 6.30 to 14.20 ppm for Sinnar industrial area, 3.10 to 15.20 ppm for Nandur village and 2.20 to 7.10 ppm for Dindori.

IV. Conclusions and Recommendation

The main source of heavy metal pollution is urbanization and industrialization. The Heavy metal concentration in the different vegetable sample was found higher than the permissible limits according to Indian Prevention of Food Adulteration Act (PFA), 1954. Nearly 35 % samples collected from industrial area showed higher levels of lead than the permissible limit of 2.5 mg/kg. Nearly 75 % of onion and coriander samples showed higher levels of cadmium than the permissible limit of 1.5 mg/kg; rest of the samples including spinach and cabbage had cadmium within the safe limits. The high concentration of arsenic and copper was recorded in carrot and cauliflower respectively. Result of the study showed that vegetables grown in the vicinity of an industrial area were most contaminated. This is due to high content of metals in the soil and may be due to use of contaminated water released from industries for irrigation. Vegetables grown away from the industrial area and city (Dindori) were least contaminated and safe.

By controlling industrial and vehicular pollution of water, soil and air can prevent cadmium and lead contamination. Limiting the use of wastewater for irrigation and minimizing the use of sewage sludge, municipal compost and certain pesticides can help in controlling heavy metal pollution. Farmers need to be made aware of side effects associated with certain pesticides, fertilizers and irrigation water sources during cultivation. Washing of vegetables at farm should be done with clean water. Care should be taken during the transport and sale of vegetables. The results of the present study showed that consumers are at greater risk of purchasing fresh vegetables with high levels of heavy metals beyond permissible limits as defined by the Indian Prevention of Food Adulteration Act, 1954.

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Table-1

Concentration of Lead in vegetable samples collected from different sites. (µg /g dry wt.)

Sr. No.	Vegetables	Site-1	Site-2	Site-3	Site-4
1	Coriander (*Coriandrum sativum)*	6.10	5.10	2.10	1.20
2	Spinach (*Spinacia oleracea)*	9.20	4.80	4.20	1.40
3	Onion (*Allium cepa*),	2.20	2.40	1.60	1.60
4	Cauliflower (*Brassica botrytis*)	8.10	7.10	2.10	N.D.
5	Brinjal (*Solanum melongena*)	2.30	2.40	2.40	1.20
6	Cabbage (*Brassica oleracea*)	2.10	1.90	5.10	N.D.
7	Tomato *(Solanum lycopersicum*)	2.20	2.20	1.20	0.50
8	Cucumber (*Cucumis sativus*)	1.60	1.60	2.10	1.40
9	Potato (*Solanum tuberosum*)	2.40	2.30	N.D.	N.D.
10	Carrot (*Daucus carota*)	9.70	2.10	2.10	N.D.

N.D. = Not Detected

Table-2

Concentration of Cadmium in vegetable samples collected from different sites. (µg /g dry wt.)

Sr. No.	Vegetables	Site-1	Site-2	Site-3	Site-4
1	Coriander (*Coriandrum sativum)*	2.80	2.10	1.60	1.40
2	Spinach (*Spinacia oleracea)*	1.20	1.40	1.00	N.D.
3	Onion (*Allium cepa*),	3.30	1.80	1.80	1.00
4	Cauliflower (*Brassica botrytis*)	1.00	1.70	N.D.	0.50
5	Brinjal (*Solanum melongena*)	0.70	0.90	1.20	0.70
6	Cabbage (*Brassica oleracea*)	0.90	1.40	1.40	1.10
7	Tomato *(Solanum lycopersicum*)	0.90	0.80	N.D.	N.D.
8	Cucumber (*Cucumis sativus*)	1.10	1.40	1.00	1.20
9	Potato (*Solanum tuberosum*)	0.60	1.30	1.40	N.D.
10	Carrot (*Daucus carota*)	1.60	1.00	N.D.	N.D.

N.D. = Not Detected

Table-3

Concentration of Arsenic in vegetable samples collected from different sites. (µg /g dry wt.)

Sr. No.	Vegetables	Site-1	Site-2	Site-3	Site-4
1	Coriander (*Coriandrum sativum)*	1.20	1.10	1.00	0.60
2	Spinach (*Spinacia oleracea)*	0.90	1.30	0.80	N.D.
3	Onion (*Allium cepa*),	1.40	0.60	N.D.	N.D.
4	Cauliflower (*Brassica botrytis*)	0.90	0.80	0.90	0.60
5	Brinjal (*Solanum melongena*)	0.40	0.90	0.90	0.50
6	Cabbage (*Brassica oleracea*)	0.70	N.D.	1.10	0.60
7	Tomato *(Solanum lycopersicum*)	0.60	1.00	0.90	N.D.
8	Cucumber (*Cucumis sativus*)	1.00	0.90	N.D.	0.70
9	Potato (*Solanum tuberosum*)	0.80	N.D.	0.50	N.D.
10	Carrot (*Daucus carota*)	2.30	1.30	0.60	N.D.

N.D. = Not Detected

Table-4

Concentration of Copper in vegetable samples collected from different sites. (µg /g dry wt.)

Sr. No.	Vegetables	Site-1	Site-2	Site-3	Site-4
1	Coriander (*Coriandrum sativum)*	11.20	11.30	4.20	5.10
2	Spinach (*Spinacia oleracea)*	8.10	8.30	15.20	3.10
3	Onion (*Allium cepa*),	7.80	6.50	4.10	2.20
4	Cauliflower (*Brassica botrytis*)	30.80	13.50	9.10	6.50
5	Brinjal (*Solanum melongena*)	5.60	10.40	4.40	3.20
6	Cabbage (*Brassica oleracea*)	6.50	8.40	5.11	7.10
7	Tomato *(Solanum lycopersicum*)	7.40	8.20	3.10	4.40
8	Cucumber (*Cucumis sativus*)	30.40	7.20	6.20	2.80
9	Potato (*Solanum tuberosum*)	9.60	14.20	8.10	5.50
10	Carrot (*Daucus carota*)	4.90	6.30	5.50	3.30

N.D. = Not Detected

Figure1. Comparative representation of lead (Pb) concentration in different vegetables.

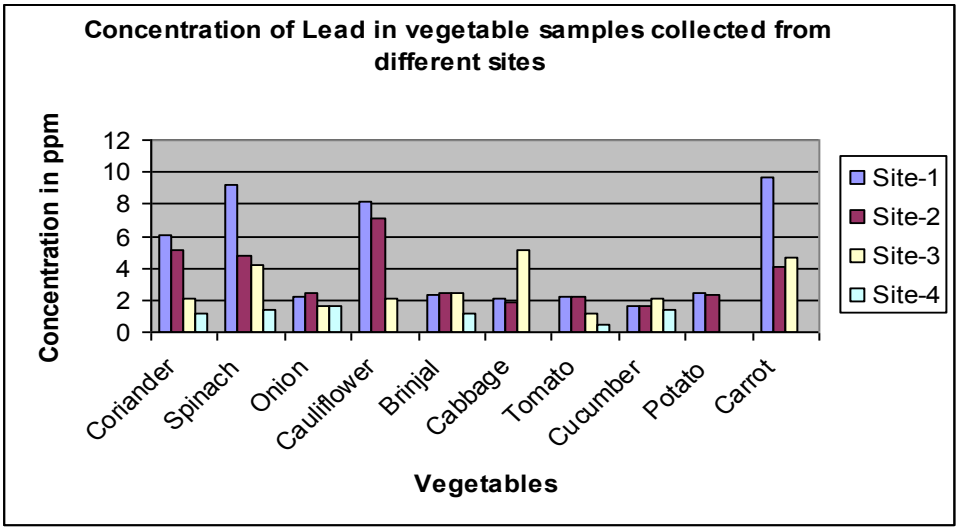


Figure2. Comparative representation of Cadmium (Cd) concentration in different vegetables.

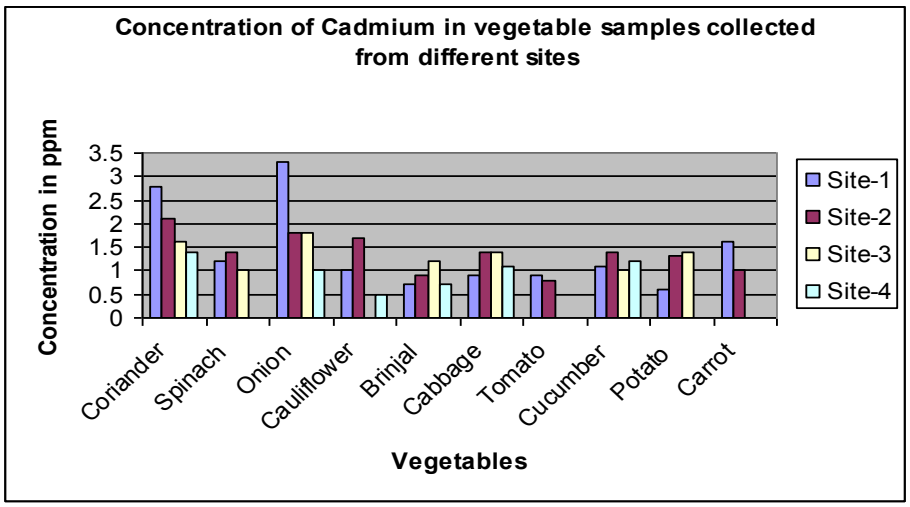


Figure3. Comparative representation of Arsenic (As) concentration in different vegetables

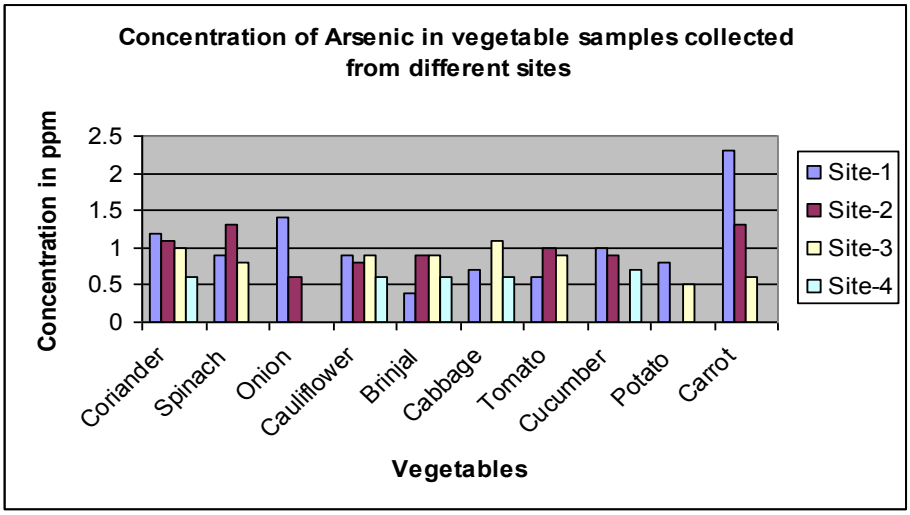
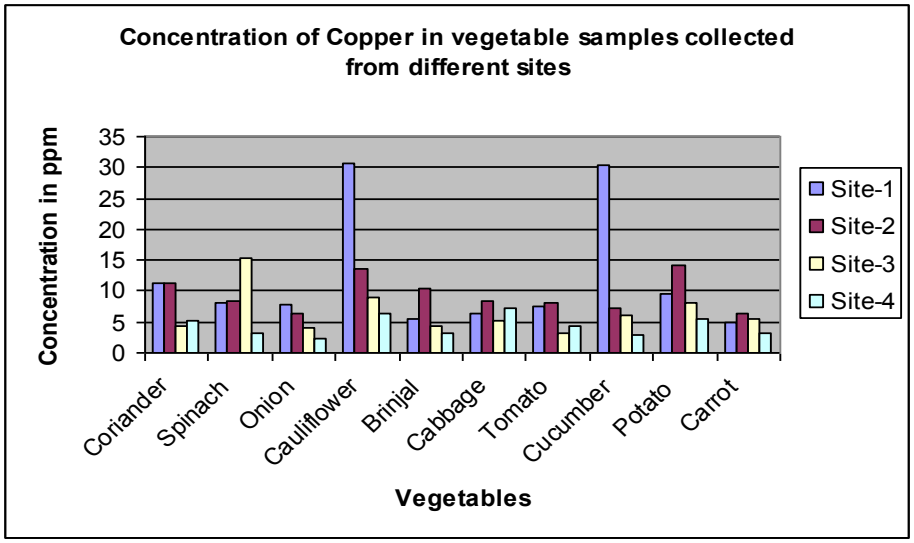


Figure4. Comparative representation of Copper (Cu) concentration in different vegetable



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