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Heavy Metal Accumulation in Selected Vegetables Irrigated with Untreated Sewage Waste Water in Allahabad City

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Abstract: ***The present study was conducted to assess the heavy metals (Cu, Cd, Pb, Ni) concentration of vegetables (Spinach, Cucumber, Ladyfinger, Ridge guard) irrigated with waste water in around yamna river of Allahabad district. Lead was several fold higher in all vegetables irrigated with waste water in both sites (Mahewa Path and Arail Ghat), the study showed that the concentration of lead varied greatly in all vegetables (Table 1, 2). Spinach was having the higher average mean concentration of lead (18.764 mg/L), followed by Ladyfinger (15.227 mg/L), Ridge gourd (5.117 mg/L) and Cucumber (2.602 mg/L) and Cu (1.372 mg/L) was higher in spinach followed by cucumber (0.369 mg/L), Ladyfinger (0.182 mg/L) and Ridge gourd (0.170 mg/L), in site one (Mahewa path). The average mean concentration of Pb in Spinach, Cucumber, Ladyfinger and Ridge gourd were (4.333 mg/L), (5.079 mg/L), (10.407 mg/L) and (10.779 mg/L) respectively, in case of Cu Ridge gourd (0.269 mg/L) got the highest amount followed by Spinach (0.237 mg/L), Cucumber (0.227 mg/L) and Ladyfinger (0.218 mg/L) in Arail Ghat. The study suggests that wastewater irrigation led to accumulation of heavy metals in food stuff causing potential health risk to consumers.***

Keywords: Heavy metals, waste water, vegetables.

1. Introduction

The growing problem of water scarcity has significant negative influence on economic development, human livelihoods, and environmental quality throughout the world. Rapid urbanization and industrialization releases enormous volumes of wastewater, which is increasingly utilized as a valuable resource for irrigation in urban and peri-urban agriculture. It drives significant economic activity, supports countless livelihoods particularly those of poor farmers, and substantially changes the water quality of natural water bodies (Marshall *et al.*, 2007). (12)

Sewage waste water irrigation leads to accumulation of heavy metals in the soil. Sewage waste has been implicated as a potential source of heavy metals such as Copper (Cu), Cadmium (Cd), Zinc (Zn), Lead (Pb), Nickel (Ni) and Iron (Fe) in the edible and non-edible parts of vegetables. Food safety issues and potential health risks make this as one of the most serious environment concern. There is evident to indicate that agriculture soil also has increased levels of heavy metals as a result of increased in anthropogenic activities. Waste water carries appreciable amount of trace toxic metals which often leads to degradation of soil, health and contamination of food chain mainly through the vegetable grown on such soils. The toxic elements accumulated in organic matter in soil are taken up by growing plants and lastly exposing humans to this contamination. (1).

Vegetables are major components of human diet, being sources of essential nutrients, antioxidants and metabolites in food items. In the present study the concentration of heavy metals in locally produced vegetables quantified in around Yamuna river Allahabad city of India.(3)

2. Materials and Methods

Study Area

The present work entitled was conducted in research laboratory of Warner School of Food and Dairy Technology, Department of soil science SHIATS, and Faculty of food analysis and research laboratory Center for Food Technology in Allahabad University, from September 2014 to April 2015. The sample of vegetables and soil was collected from waste water irrigated Yamuna banks where crops are irrigated with wastewater which is coming directly from the municipality. Our study area is situated in the left side of the Yamuna River around 10 km south of Allahabad city. The common vegetables grown in this area is cucumber, spinach, ladyfinger, ridge gourd and etc. which are supplied to the all vegetables market in Allahabad and the rest entire the common market. In this study we investigated the concentration of Pb, Ni, Cd, and Cu in soil and vegetables grown in this agricultural land area having long term uses of the treated and untreated wastewater for irrigation.

Soil and plant analysis:

20 samples were selected from each site. Four selected vegetables samples were of cucumber, spinach, ladyfinger and ridge gourd. The samples were collected by hand using vinyl gloves carefully packed into polyethylene bags and the whole plant body was brought to the laboratory, During the month from September 2014 to April 2015 in clean, pre-sterilized sampling bags in order to estimate the total heavy metal content (Cu, Cd, Pb and Ni). First vegetable sample sliced and air dried in a piece of paper and subsequently oven-dried on a constant weight at 65 ºC for 48 hours, ground with a ceramic-coated grinder (Liuetal. 2006) and

stored in a dry place for further analysis of heavy metals. Plant and soil samples were digested in 15 ml of HNO_3, H_2SO_4 and $HClO_4$ mixture (5:1:1) at 80 ºC until a transparent solution will obtained **(Allen *et al.*1986).** These transparent solutions were then filtered through Whatman filter paper number 42 and diluted to 50 ml with distilled water. The concentrations of heavy metals in the filtrate were determined by using Atomic Absorption Spectrophotometer (Per Kin Elmer Analyst 400).

3. Results and Discussion

Vegetables samples of spinach (Beta vulgaris L), Cucumber (*Cucumis sativus*), ladyfinger (***Abelmoschus esculentus Moench***) and Ridge gourd (Cucurbitaceae), were collected from Mahewa path and Arail Ghat sites around yamuna river of Allahabad city, to study the heavy metal (Cu,Cd, Pb, Ni) concentration. Leafy vegetables were preferred for sampling since past research indicates that they accumulate heavy metals at a greater capacity than other vegetables (Jinadasa *et al.,* 1997). The study showed that the concentration of Pb varied greatly in all vegetables (Table 1,2). Spinach got the higher average mean concentration of Pb (18.764 mg/L), followed by ladyfinger (15.227 mg/L), Ridge gourd (5.117 mg/L) and cucumber (2.602 mg/L) and Cu (1.372 mg/L) was higher in spinach followed by cucumber (0.369 mg/L), ladyfinger (0.182 mg/L) and Ridge gourd (0.170 mg/L), in site one (Mahewa path). The average mean concentration of Pb in spinach, cucumber, ladyfinger and Ridge gourd were (4.333 mg/L), (5.079 mg/L), (10.407 mg/L) and (10.779 mg/L) respectively, in case of Cu Ridge gourd (0.269 mg/L) got the highest amount followed by spinach (0.237 mg/L), cucumber (0.227 mg/L) and ladyfinger (0.218 mg/L) in site two (Arail Ghat) .

Heavy metal concentration showed variation among different vegetables collected from both sites, four elements examined in four vegetables irrigated with waste water in two selected sites of Allahabad areas. The average concentration of heavy metals Cu, Cd, Pb and Ni were (1.372 mg/L), (0.017 mg/L), (18.764 mg/L) and (0.030 mg/L) respectively in spinach from site one. Meanwhile the concentration of Cu, Cd, Pb and Ni in cucumber were (0.369 mg/L), (0.007 mg/L), (2.602 mg/L) and (0.020 mg/L) respectively from site one (Mahewa Path). Whereas in ladyfinger the average concentration of heavy metals Cu, Cd, Pb and Ni were (0.182 mg/L), (0.008 mg/L), (15.227 mg/L) and (0.015 mg/L) respectively in site one (Mahewa Path). Last vegetable in site one (Mahewa path) was Ridge gourd which was having (0.170 mg/L), (0.005 mg/L), (5.117 mg/L) and (0.015 mg/L) respectively for the elements Cu, Cd, Pb and. In comparison with the standard guideline for vegetables (WHO, 2007) it was found that mean value of Pb concentration in vegetables exceeded the recommended level. In comparison with site two (Arail Ghat) the mean concentration of Pb (10.428 mg/L) and Cu (0.523 mg/L) were high in all vegetables, whereas the mean concentration of Cd (0.009 mg/L) and Ni (0.020 mg/L) were almost in same quantity. In individual comparison spinach has the highest mean concentration of Pb and Cu followed by lady finger in site one itself.

The average value of Cu was highest (1.372 mg/L) in spinach followed by in cucumber (0.369) and the minimum was recorded in ridge guard. The order of average values of Cu was obtained as spinach (1.372 mg/L) > cucumber (0.369 mg/L) > ladyfinger (0.182 mg/L) > Ridge gourd (0.170 mg/L). Similarly, the average value of Cd was highest (0.017 mg/L) in spinach followed by in lady finger (0.008 mg/L) and the minimum was recorded in Ridge gourd (0.005 mg/L) . The order of average values of Cd was obtained as spinach (0.017 mg/L) > ladyfinger (0.008 mg/L) > cucumber (0.182 mg/L) > Ridge gourd (0.170 mg/L). Moreover, the average value of Pb was highest (18.764) in spinach followed by in ladyfinger (15.227 mg/L) and Ridge gourd (5.117 mg/L) and the minimum was recorded in cucumber (2.602 mg/L). The order of average values of Cu was obtained as spinach (18.764 mg/L) > ladyfinger (15.227 mg/L) > Ridge gourd (5.117 mg/L) > cucumber (2.602 mg/L). In case of nickel the average value of Ni was highest (0.030 mg/L) in spinach followed by in cucumber (0.020 mg/L) and the minimum was recorded in ridge guard. The order of average values of Ni was obtained as spinach (0.030 mg/L) > cucumber (0.020 mg/L) > ladyfinger (0.015 mg/L) > Ridge gourd (0.015 mg/L).

The average mean concentration of heavy metals (mg/kg dry weight) were 0.237 for Cu, 0.014 for Cd, 4.333 for Pb and 0.019 for Ni in spinach from site two, whereas average mean concentration of Cu, Cd, Pb and Ni in cucumber were 0.227, 0.006, 5.079 and 0.020 respectively, heavy metal concentration (Cu, Cd, Pb and Ni) in lady finger were 0.218, 0.010, 10.407 and 0.016 respectively, Meanwhile the mean concentration of heavy metals like Cu, Cd, Pb and Ni in Ridge gourd were 0.269, 0.005, 10.779 and 0.023 respectively. Here also the average mean concentration of Pb were the highest among all vegetables following by Cu. Individually Ridge gourd was having the highest level of Pb followed by ladyfinger, cucumber and spinach. In comparison with site one the mean concentration of all elements were less, but In comparison with the standard guideline for vegetables (WHO, 2007) it was found that mean value of Pb concentration in all vegetables exceeded the recommended level. Heavy metal concentration showed variation among different vegetables collected from site one and two (fig.1,2).

The average value of Cu was highest (0.269) in Ridge gourd followed by in spinach (0.237) and the minimum was recorded in ladyfinger (0.218). The order of average values of Cu was obtained as (0.269) Ridge gourd > spinach (0.237) > cucumber (0.227) > ladyfinger (0.218). Similarly, The average value of Cd was highest (0.014) in spinach followed by in lady finger (0.010) and cucumber (0.006) and the minimum was recorded in Ridge gourd (0.005) . The order of average values of Cd was obtained as spinach (0.014) > ladyfinger (0.010) > cucumber (0.006) > Ridge gourd (0.005). Moreover, the average value of Pb was highest (10.779) in Ridge gourd followed by in ladyfinger (10.407) and ridge cucumber (5.079) and the minimum was recorded in spinach (4.333). The order of average values of Cu was obtained as ridge gourd (10.779) > ladyfinger (10.407) > cucumber (5.079) > spinach (4.333). In case of nickel the average value of Ni was highest (0.023) in Ridge gourd followed by in cucumber (0.020) and spinach (0.019)

the minimum was recorded in lady finger (0.016). The order of average values of Ni was obtained as Ridge gourd (0.023) > cucumber (0.020) > spinach (0.019) > ladyfinger (0.016). Results of one way ANOVA shows that variation in the heavy metal concentration was significant due to treatment in Cd and the remaining all elements were non-significant. The variation in heavy metal concentration in vegetables of same site may be described to the differences in their morphology and physiology for heavy metal uptake, exclusion, accumulation and retention (carlton-smith and Davis, 1983; Kumar et al., 2009). Several fold higher concentration of Pb was observed in all vegetables in both sites. Among all vegetables in site one spinach had the highest level of Pb (18.764) followed by Cu (1.372). For other vegetables ladyfinger had highest level of Pb (15.27) in site one and Ridge gourd (10.779) in site two.

The maximum concentration of Pb was exhibited by spinach (18.764) in site one and Ridge gourd (10.779) in site two followed by ladyfinger in site one (15.27) and ladyfinger in site two (10.44) which exceeded the acceptable tolerance level of WHO for Pb by three and three times, respectively. Pb concentration in edible portions of all the vegetables examined in the present study were above the permissible levels recommended by WHO, India (Awashthi 2000) The mean Pb content in vegetables (9.0385) was lower than the values reported in Titagarh, west Bengal, (21.9-57.63 mg/kg) (Gupta et al.2008) but comparatively higher than the Pb level reported in China (0.18-7.75 mg/kg) (liu et al.2006), (1.97-381 mg/kg) (Liu et al.2005) and in varnsi, India (3.09-15.74 mg/kg) (Sharma et al.2007). However it was significantly lower than the mean concentration of Pb (409 mg/kg) reported in vegetables from Turkey by Turkdogan et al.(2002). The higher concentration of Pb in all vegetables in both sites may be the result of fuel combustion from the rapid increase in traffic and city waste (Maleki and Zarasvand, 2008). (Nabulo et al. 2006) reported atmospheric deposition to be the dominant pathway for Pb to leafy vegetables.

Table 1: Heavy metals concentration (mg/L) in selected vegetables irrigated with untreated sewage water in Mahewa Path.

Treatments	uC	dC	bP	iN
Spinach	1.372	0.017	18.764	0.030
Cucumber	0.369	0.007	2.602	0.020
Ladyfinger	0.182	0.008	15.227	0.015
Ridge guard	0.170	0.005	5.117	0.015
Mean	**0.523**	**0.009**	**10.428**	**0.020**
F- test	NS	S	NS	NS
S. Ed. (±)	0.455	0.002	10.155	0.006
C. D. (P = 0.05)		0.004		

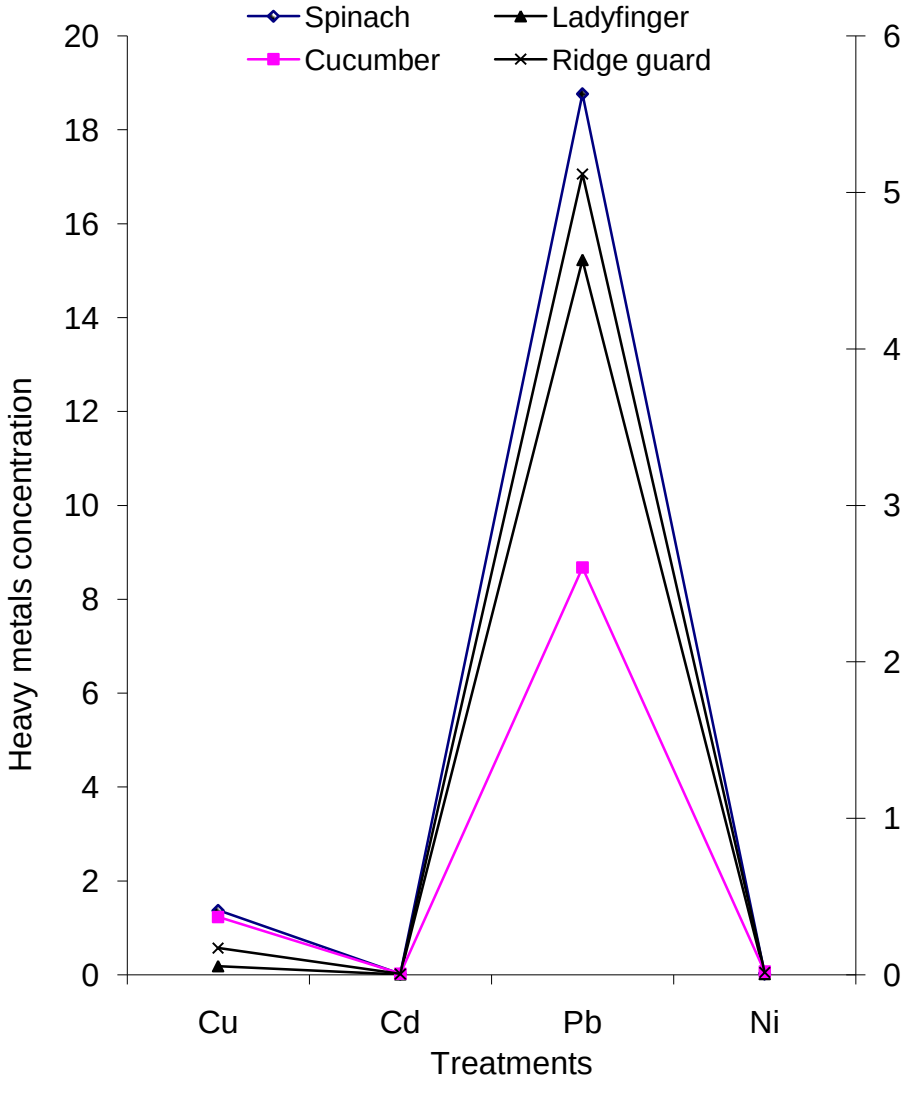
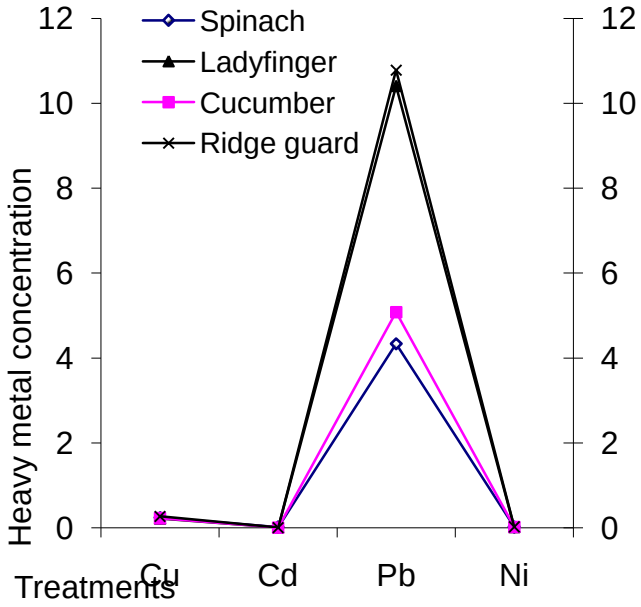


Figure 1

Table 2: Heavy metals concentration (mg/L) in selected vegetables irrigated with untreated sewage waste water in Arail Ghat.

Treatments	**uC**	**dC**	**bP**	**iN**
Spinach	0.237	0.014	4.333	0.019
Cucumber	0.227	0.006	5.079	0.020
Ladyfinger	0.218	0.010	10.407	0.016
Ridge guard	0.269	0.005	10.779	0.023
Mean	**0.238**	**0.009**	**7.649**	**0.019**
F- test	NS	S	NS	NS
S. Ed. (±)	0.108	0.001	7.538	0.005
C. D. (P = 0.05)		0.002		



4. Conclusion

The long term waste water irrigation led to the accumulation of heavy metals in soil and consequently into the vegetables. Heavy metal concentration varied among the test vegetables, which reflect the differences in their uptak capabilities and their further translocation to edible portion of the plants. Pb and Cu were above the national and international permissible limits in all the vegetables. Target hazard quation of heavy metals also suggests that Pb and Cu concentration in most of the test vegetables had potential for human health risk due to consumption of plants grown in the area having long term uses of untreated waste water for irrigation. Long term consumption of these metal-contaminated vegetables can cause different disease like Brain and Kidney damage, cancer in human body, dermatitis. Responsible agencies should carry out public health education within the consumption area to sensitive the general public on the potential effects of indiscriminate disposal of waste and the potential health hazards associated with the consumption of vegetables cultivated with wastewater.

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