Assessment of Heavy Metal Contamination in Vegetables Grown with Treated Wastewater in Ludas, Hisar, Haryana: A Comprehensive Study

SunitaLega

Assistant Professor
Department of Chemistry
Dayanand College
Hisar.

***Abstract*- Municipal wastewater is predominantly utilized for crop irrigation, particularly in periurban ecosystems, owing to its ready availability, disposal challenges, and the scarcity of fresh water. The use of wastewater in irrigation is known to significantly contribute to the presence of heavy metals in soil. These metals pose a substantial threat due to their non-biodegradable nature, prolonged biological half-lives, and their propensity to accumulate in various body tissues. The high solubility of heavy metals in water makes them highly toxic, even at low concentrations, as there is no efficient mechanism for their elimination from the body.The excessive build-up of heavy metals in agricultural soils through wastewater irrigation can lead to soil contamination. Leafy vegetables are particularly prone to accumulating heavy metals compared to grain or fruit crops. The absorption and accumulation of heavy metals by vegetables, both in their edible and inedible parts, can reach levels that pose clinical risks to both animals and humans consuming these metal-enriched plants. This study aims to compare the potential for heavy metal accumulation in some commonly grown vegetables in Ludas, Hisar. Given the widespread practice of crop irrigation with wastewater in India, the research also investigates the impact of wastewater irrigation on the concentration of accumulated metals to which humans may be exposed.**

***Keywords*: Non-biodegradable, Absorption, Accumulation, Heavy Metals.**

INTRODUCTION:

The issue of environmental pollution caused by toxic metals has become a growing concern in most major metropolitan areas. The introduction of toxic heavy metals into the ecosystem can result in geoaccumulation, bioaccumulation, and biomagnification. Essential heavy metals like Fe, Cu, Zn, Ni, and other trace elements play a crucial role in the proper functioning of biological systems. However, their deficiency or excess can lead to various disorders [1-2].

The contamination of the food chain by heavy metals has emerged as a pressing problem, primarily due to their potential accumulation in biosystems through polluted water, soil, and air [3-6]. Consequently, gaining a deeper understanding of heavy metal sources, their accumulation in the soil, and their impact on plant systems in water and soil has become a critical aspect of contemporary research on risk assessments [7-8].

The primary sources of heavy metals for vegetable crops are their growth media (soil, air, nutrient solutions), from which these metals are absorbed by the roots or foliage [9-10]. The gradual pollution of water resources is a widespread issue, resulting from the introduction of foreign materials from the surrounding environment. These materials include organic matter of plant and animal origin, runoff from land surfaces, and industrial and sewage effluents [11-12].

It has been observed that sewage effluents from municipal sources contain a significant amount of major essential plant nutrients, leading to a considerable improvement in soil fertility when used for crop field irrigation. However, treated sewage water also contains variable amounts of heavy metals such as Pb, Cd, and Cr, which have the potential to contaminate crops grown under such irrigation [5,13]. These heavy metals can induce acute and chronic symptoms, ranging from irritation to extensive metabolic disturbances [14]. The levels of toxic metals (Cd, Cr, and Pb) were analyzed in various vegetable foodstuffs [15-16].

MATERIALS AND METHODS

STUDY SITES AND SAMPLES

Vegetable samples were gathered from Ludas village in Hisar. To eliminate visible soil particles, the vegetables underwent a thorough cleaning process and were washed multiple times with tap water and double-distilled water.

Afterward, they were allowed to drain. Subsequently, the vegetables were incinerated at 180°C for a duration of 6 hours. The resulting dried plants were finely ground into particles using a clean, acid-washed mortar and pestle.

SAMPLE PREPARATION AND MEASUREMENTS

Atomic absorption spectroscopy is one of the various methods employed to determine the total contents and speciation analysis of heavy metals in environmental concentrations. This method is known for its simplicity and high selectivity. In this study, we utilize atomic absorption spectroscopy to determine the levels of heavy metals in vegetable samples.

All samples were meticulously prepared using analytical-grade chemicals and double-distilled water. To create stock solutions of 1000 ppm for cadmium (Cd), cobalt (Co), nickel (Ni), and zinc (Zn), 1 gram of each metal was dissolved in aqua regia (1:3 HCl& HNO_3) and made up to 1 liter in a volumetric flask. Similarly, a stock solution of lead (Pb) was prepared by dissolving 1.59 grams of $Pb(NO_3)_2$ in 1% HNO3. For chromium (Cr), a stock solution of 1000 ppm was prepared by dissolving 2.82 grams of $K_2Cr_2O_7$ in 1% HNO_3 and diluting it to 1 liter. Calibration curves were established for these standard metal ions using working standards of 2.5, 5, and 10 ppm.

In the analysis of vegetable samples, dried and powdered samples of each type were digested in a 100 ml Pyrex glass beaker by adding 1 gram to 10 ml of concentrated nitric acid. The initial cold digestion lasted for 24 hours, followed by heating at 50°C for an additional 4 hours. The solution was then boiled with a 1:5 mixture of concentrated acids HCl& HNO_3 to digest all organic matter, and the mixture was filtered after cooling. The final extract volume was adjusted to 25 ml using double-distilled water.

Concentrations of the vegetable samples were calculated based on the calibration curves for the standard metal ions.

APPARATUS

Heavy Metals analyses were carried out using Atomic Absorption Spectrophotometer at Department of soil sciences CCS Haryana Agriculture University, Hisar

RESULTS AND DISCUSSION

The majority of laboratory studies on the biosorption of heavy metals suggest that metal uptake is not attributed to a singular mechanism. Typically, two mechanisms are recognized: 'adsorption,' which involves the binding of materials onto the surface, and 'absorption,' which entails the penetration of metals into the inner matrix. The transportation of metals into the plant body may involve either one or both of these mechanisms.

Table 1. Cd, Cr (VI), and Pb in different vegetable samples

Sample No	***Vegetables***	**Cd** (ppm)	**Cr** (ppm)	**Pb**(ppm)
1	Spinach	6.52	1 2.65	8.44
2	Coriander	14.48	10.38	15.86
3	Pepper mint	13.69	3.80	3.80
4	Ladyfinger	0.95	1.26	1.34
5	Cauliflower	5.46	8.74	11.72
6	Brinjal	3.46	12.7	19.62
7	Bottle gourd	2.15	8.94	9.86
8	Chilies	4.02	ND	3.69
9	Raddish	3.28	8.66	6.19

The accumulation of these heavy metals in vegetables can be attributed to the utilization of municipal wastewater for their cultivation. The results from Table 1 indicate that the concentrations of Cd, Pb, and Cr exceed the permissible limits. The experimental uncertainty in individual measurements is found to vary within 1%. The accumulation is primarily attributed to the fact that Cd is readily absorbed by food crops, particularly leafy vegetables. Additionally, foliar absorption of atmospheric deposits on plant leaves may contribute to this accumulation. Different vegetable species exhibit varying metal accumulation based on environmental conditions, metal species, and the availability and forms of heavy metals in the soil. Studies have demonstrated that the uptake and accumulation of metals by different plant species depend on several factors, which various researchers have investigated. In general, the comparison of results suggests that metals in water have a more significant impact on vegetation.

CONCLUSION

Vegetable samples irrigated with municipal wastewater were subjected to heavy metal analysis. Almost all the samples exceeded the safe permissible levels set by the World Health Organization, namely Cd (0.05 ppm), Cr (0.1 ppm), and Pb (0.1-0.3 ppm). These results indicate that consumers are obtaining vegetables with elevated levels of heavy metals. It is crucial to educate and motivate farmers to implement effective countermeasures to reduce the accumulation of heavy metals in vegetables. Regular monitoring of the surrounding areas is recommended to prevent the potential consumption of contaminated vegetable foodstuffs.

REFERENCES:

1. Corn M. (1993). Handbook of Hazardous Materials, Academic Press, p.772. San Diego,CA .
2. Hu H., Aro A., Payton M., Korrick S., Sparrow D., Weiss S.T., Rotnitzky A. (1996). The relationship of bone and blood lead to hypertension: the normative aging study, J. Am. Med. Assoc. 275, 1171-6.
3. Cabrera C., Gallego C., Lopez M.C., Lorenzo M.L., Lillo M.E. (1994). Determination of levels of lead contamination in food and feed crops", J. AOAC Int.77, 1249-52.
4. Codex Alimentarious commission. Doc.No.Cx/FAC 96 /17.Joint FAO/WHO food standards programme. (1996). codex general standard for contaminates and toxin in foods.
5. Ikeda S., Murakami T. (1995). Zinc chemical form in some traditional soy food, J. Food Sci.60, 1151-6.
6. Mueller M., Anke M. (1994). Distribution of cadmium in the food chain (soil-plant-human), of a cadmium exposed area and the health risks of the general population, Sci. Total Environ. 156,151-8.
7. Bingham T.F., Page A. I., Hahler R.J., Ganje T.J. (1975). Growth. Cadmium accumulation of plants grown on soil treated with cadmium enriched sewage sludge. J. Environ. Qual.4, 207–210.
8. JECFA. Evaluation of certain food additives and contaminants. 41 report of the joint FAO/WHO, Expert Committee on food additives. (1993). World Health organization, Technical Report Series 837.
9. Ramraj, AthiyaAfshan, Halappa Gowda T.P., Karanth N.G.K. (2000). Sorption of copper(II) and lead(II) by microbial cultures duringgrowth. Indian J. Environ. Health. 42, 95–99.
10. Wiersma D., Van Goor B.J., VanderVeen N.G. (1986). Cadmium, lead, mercury and arsenic concentrations in crops and corresponding soils in the Netherlands, J. Agric. Food Chem. 34, 1067-74.
11. Tahvonen R., Kumpulainen J. (1995). Lead and cadmium in some berries and vegetables on the Finnish market in 1991-1993, Food Addit. Contam.12, 263-79.
12. Takács S., Tatár A. (1997). Trace elements in the environment and in human organs, Environ. Res. 42, 312-20.
13. Lark B.S., Mahajan R.K. and Walia T.P.S. (2002). Determination of metals of toxicological significance in sewage irrigation vegetables by atomic absorption spectroscopy and anode stripping voltammetry.Indian, J.Environ.Health, 44,164-167.
14. Olivares M., Uauy R. (1996). Limits of metabolic tolerance to copper and biological basis for present recommendations and regulations, Am. J. Clin. Nutr. 63,846S-52S.
15. Lester G. (1997). Fruit nutritional quality and health functionality, Cucumusmelo L, 7 ,222-7.
16. Mido Y., Satake M. (2003). Chemicals in the environment. In Toxic Metals (M.S Sethi, and S.A Iqbal, eds.), pp. 45–68 .Discovery Publishing House, New Delhi.