Journal homepage: www.fia.usv.ro/fiajournal
Journal of Faculty of Food Engineering,
Ştefan cel Mare University of Suceava, Romania
Volume XVII, Issue 1- 2018, pag. 53 - 58

FOOD AND ENVIRONMENT SAFETY

COMPARATIVE STUDY OF TOXIC METALS AND MICRONUTRIENTS IN VEGETABLES IRRIGATED BY SEWAGE/FRESH WATER

Muhammad HAROON[1], *Muhammad VAQAS[2]
[1] *Department of Chemistry, Minhajuniversity Lahore, Lahore, Pakistan*
[2]*Health, Safety, Enviornment and Quality Department, Attock Refinery Limited, Rawalpindi, Pakistan,*
muhammad_vaqas@yahoo.com
*Corresponding author
Muhammad VAQAS
Received November 22th 2017, 23th March 2018

Abstract: *The purpose of this study was to compare the concentrations of micronutrients (Maganese, Zinc, Copper, Iron and Chromium) and toxic metals (Lead and Cadmium) in edible part of ten different species of vegetables, irrigated by sewage/fresh (tube well) water. It was found that the irrigation source changes the concentration of micronutrients and toxic metals in the edible part of vegetables leading to risks for humans' health.*

Keywords: *micronutrients, edible part of vegetables, humans' health risk, effect of irrigation source*

1. Introduction

Irrigation is an artificial application of water to soil. It is used to assist the growth of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas, during periods of inadequate rainfall; irrigation also includes protecting plants against frost [1].
Vegetables are important protective food, highly beneficial for the maintenance of health and prevention of disease. Increasing fruit and vegetable consumption up to 600g per day (baseline) could reduce the total worldwide burden of disease by 1.8% and reduce the burden of ischaemic heart disease by 31% and ischaemic stroke by 19%. For stomach, oesophageal, lung and colorectal cancer, the potential reductions were 19%, 20%, 12% and 2% respectively [2].
Manganese is essential for development, metabolism and the antioxidant system. Nevertheless, excessive exposure or intake may lead to neurodegenerative disorder cause dopaminergic neuronal death [3].
Zinc is typically the second most abundant transition metal in organisms after iron and it is the only metal which appears in all enzyme classes [4].
Excess zinc can be harmful. Excessive absorption of zinc suppresses copper and iron absorption. Copper deficiency leads to tissue injury while high intake may increase the chances of cancer especial liver cancer. The patients with hemochromatosis have high risk of liver cancer and malignancies [5].
Iron is involved in numerous biological processes and excess Iron typically damages cells in the heart, liver and elsewhere, causing adverse effects that include coma, metabolic acidosis, shock, liver failure, coagulopathy, adult respiratory distress syndrome, long-term organ damage, and even death [6].
In the form trivalent chromium Cr^{3+}, chromium is identified as an essential

nutrient. Its role is important in the action of insulin [7]. In contrast, hexavalent chromium Cr^{6+} is highly toxic and mutagenic when inhaled [8].

Lead is a toxic metal and primary cause of lead's toxicity is its interference with a variety of enzymes because it binds to sulfhydryl groups found on many enzymes [9].

Cadmium intake through diet associates to higher risk of endometrial, breast and prostate cancer as well as to osteoporosis in humans [10-12].

The main objective of this survey was to determine the concentration of micronutrients and toxic metals in the edible part of vegetables so all the samples were collected from Gujrawala, Punjab Pakistan.

2. Matherials and methods

The collected samples were the edible part of the vegetables irrigated either by fresh water (tube well) or sewage water. All the samples were collected in sunny days, temperature range 25-30ºC in paper bags with complete labeling of name, date and location.

The vegetables with some soil and dust were washed with tap water first and then with distilled water. All the samples were primarily dried in open air covered with filter papers and further dried in an oven at temperature 70 - 80ºC. All the dried samples were grinded in wooden mortar in such a way that mortar was cleaned thoroughly each time after use to avoid the intermixing of the samples. Sieving of the grinded samples was done in a stainless steel sieve of 5 mm mesh. The grinded samples were kept in air tight polythene bags labeled with sample number, in a dark and cool place [13, 14].

The samples were digested by taking one gram of the dried sample in a 100 ml beaker and added 20 ml nitric acid (conc.). The beaker was covered with a watch glass and was allowed to stand for two hours then placed on a hot plate inside a fuming chamber until the solid particles nearly disappeared then removed from hot plate and allowed to cool. After that 10 ml of 72% perchloric acid was added and again placed on the hot plate. Heated gently first and then vigorously until solution in beaker became clear and volume reduced to about 5-6 ml then cooled and added 3ml of 50% hydrochloric acid, again heated on hot plate until volume of the solution is reduced to 5 ml at the end it was allowed to cool and added some distilled water.

The solution was transferred carefully to 100 ml measuring flask and made the volume up to mark with distilled water, shacked well and allowed to stand overnight, filtered, and collected in labeled plastic bottles. All the samples prepared likewise and stored in dark. A blank test solution was also prepared by adopting the same procedure without taking vegetable sample [15].

All the vegetable samples were analyzed by atomic absorption spectrometer [Perkin Elemer PinAAcleTM 900T] and calculations were performed by following formula [16].

Metal in vegetable sample:

$$\mathbf{(mg/kg) = (S\text{-}B)*dt*V / W}$$

S = Sample Reading; B = Blank Reading; dt = Dilution factor; V = Volume of first dilution; W = Weight of sample.

3. Results and discussion

Manganese (Mn): The highest concentration of manganese was found 94,53mg/kg in the Spinach (*Spinacia oleracea*) grew near drain nala in the village of Kot Mand Gujranwala and irrigated with sewage water which comes out from industries and houses. The concentration of manganese was observed in the range of 10,34 – 94,53 mg/kg in the vegetable samples irrigated with sewage water. The level of manganese was found to be 8,75 – 78,78 mg/kg in the vegetables irrigated with fresh water. In the nine vegetable species, the manganese found higher in the vegetables irrigated with sewage water and lower in the vegetables irrigated with fresh water (Fig. 1).

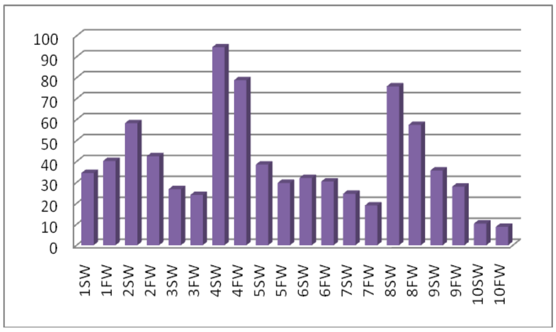

Fig. 1. Manganese (mg/Kg)

Zinc (Zn): The level of zinc in the vegetables irrigated with sewage water was ranged from 8,82 – 23,26 mg/kg. In the nine vegetable species, the level of zinc was found higher in the vegetables irrigated with sewage water and lower in the vegetables irrigated with fresh water. The level of zinc in the vegetables irrigated with fresh water was found in the range of 4,28 – 14,28 mg/kg. Similar concentration of zinc was observed in the vegetable specie Radish (*Raphanus Sativus*) irrigated with both type of irrigation waters (Fig. 2).

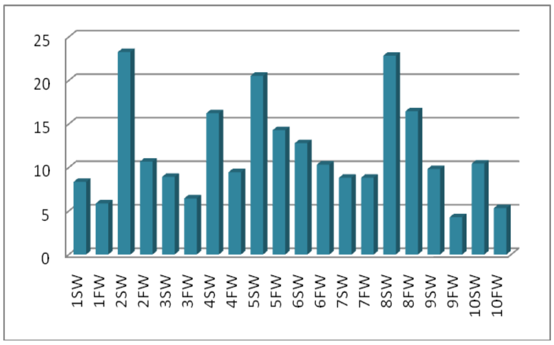

Fig. 2. Zinc (mg/Kg)

Copper (Cu): The level of copper in the vegetables irrigated with sewage water was found in the range of 8,86 – 26,57 mg/kg. The concentration of copper in the vegetables irrigated with fresh water was determined to be 16,84 – 5,80 mg/kg. The highest amount of copper was found 26,57mg/kg in the fenu-greek (*Trigonella foenum - graecum*) grew near drain nala in the village of Qila Deso Singh Gujranwala and irrigated with sewage water (Fig. 3).

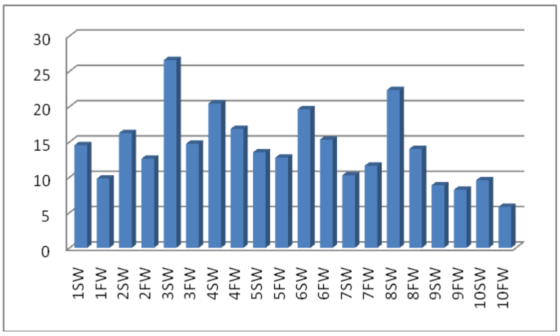

Fig. 3. Copper (mg/Kg)

Iron (Fe): The concentration of iron in the vegetables irrigated with sewage water was found to be 48 - 584 mg/kg. In the eight vegetable species, the amount of iron was found higher in the vegetables irrigated with sewage water and lower in the vegetables irrigated with fresh water. The concentration of iron in the vegetables irrigated with fresh water was determined to be 30 – 412 mg/kg. The highest amount of iron was found 584 mg/kg in the Spinach (*Spinacia oleracea*) grew near drain nala in the village of Kot Mand Gujranwala and irrigated with sewage water which comes out from industries and houses (Fig. 4).

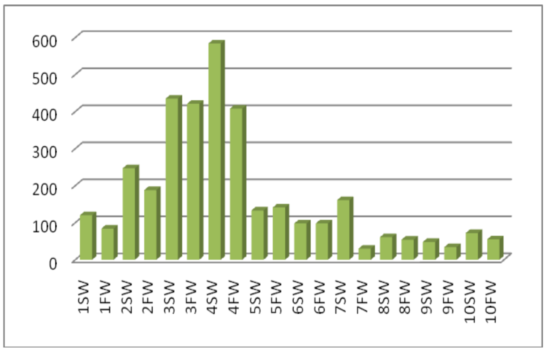

Fig. 4. Iron (mg/Kg)

Chromium (Cr): It was examined that most of the vegetables irrigated with sewage water contained the higher concentrations of chromium as compared to the vegetables irrigated with fresh water. The concentration of chromium in the vegetables irrigated with fresh water was evaluated in the range of 0.17 - 1.34mg/kg. The chromium concentration in the vegetables irrigated with sewage water was determined to be 0.09 - 2.30 mg/kg. The concentrations of chromium were not found in the vegetables Lady's finger (*Hibiscus rsculentis*) and Radish (*Raphanus sativus*) irrigated with fresh water (Fig. 5).

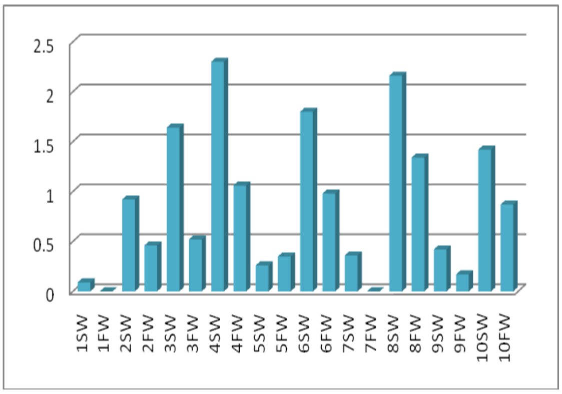

Fig. 5. Chromium (mg/Kg)

Lead (Pb): The level of Pb concentrations in the vegetables irrigated with sewage water was found in the range of 0.48 - 4.23mg/kg. The concentration of lead was observed in the range of 0.27 - 2.87 mg/kg in the vegetable samples irrigated with fresh water. The concentration of lead was determined higher in the fenu-greek (*Trigonella foenum - graecum*) irrigated with fresh water as compared to that irrigated with sewage water because it was grown near the road side (Fig. 6).

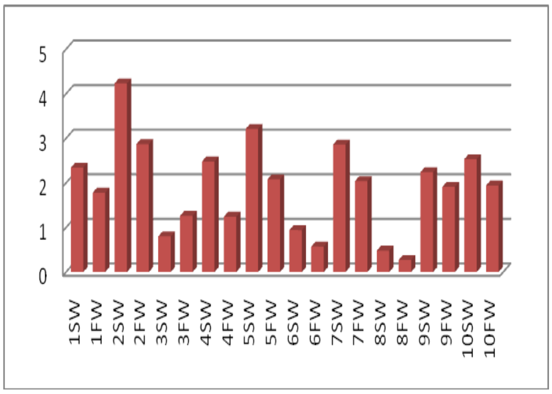

Fig. 6. Lead (mg/Kg)

Cadmium (Cd): It was noted that most of the vegetables contained higher concentrations of cadmium in the vegetables irrigated with sewage water than those irrigated with fresh water. The level of cadmium in the vegetables irrigated with sewage water was found in the range of 0.04 - 1.86 mg/kg. The highest concentration of cadmium was determined 1.86 mg/kg in the Couliflower (*Brassica oleracea*) irrigated sewage water grew in the field of Francisabad, Gujranwala near the drain stream containing industrial and domestic effluents. The concentrations of cadmium were determined to be 0.01 - 0.34 mg/kg in the vegetables irrigated with fresh water (Fig. 7).

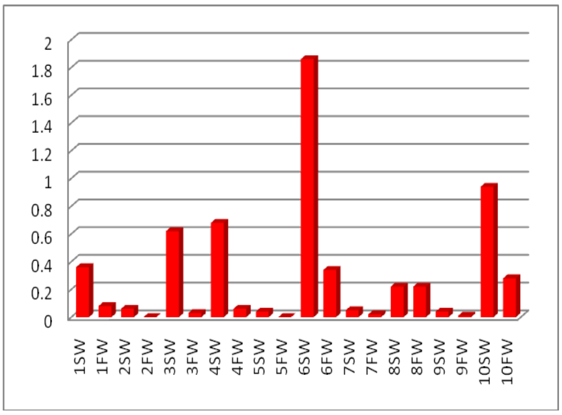

Fig. 7. Cadmium (mg/Kg)

Table1.
Concentration of metals in edible part of vegetables irrigated by sewage/ fresh (tube well) water

S. No.	Sample No.	Vegetable name	Botanical name	Mn mg/Kg	Zn mg/Kg	Cu mg/Kg	Fe mg/Kg	Cr mg/Kg	Pb mg/Kg	Cd mg/Kg
1	1SW	Lady's finger	*Hibiscus esculentis*	34.46	8.34	14.53	120	0.09	2.34	0.36
2	1FW	Lady's finger	*Hibiscus esculentis*	40.24	5.86	9.8	84	ND*	1.78	0.08
3	2SW	Mint	*Mentha Spicata*	58.26	23.26	16.25	247	0.92	4.23	0.06
4	2FW	Mint	*Mentha Spicata*	42.48	10.67	12.61	188	0.46	2.87	ND*
5	3SW	Fenu-Greek	*Trigonella foenum-graecum*	26.73	8.92	26.57	435	1.64	0.8	0.62
6	3FW	Fenu-Greek	*Trigonella foenum-graecum*	23.98	6.44	14.73	421	0.52	1.26	0.03
7	4SW	Spinach	*Spinacia oleracea*	94.53	16.23	20.44	584	2.3	2.48	0.68
8	4FW	Spinach	*Spinacia oleracea*	78.78	9.45	16.84	408	1.06	1.24	0.06
9	5SW	Bell pepper	*Capsicum annuum*	38.51	20.53	13.52	133	0.26	3.21	0.04
10	5FW	Bell pepper	*Capsicum annuum*	29.76	14.28	12.78	141	0.35	2.08	ND*
11	6SW	Cauliflower	*Brassica oleracea*	32.13	12.79	19.63	98	1.8	0.94	1.86
12	6FW	Cauliflower	*Brassica oleracea*	30.42	10.33	15.32	98	0.98	0.57	0.34
13	7SW	Radish	*Raphanus sativus*	24.55	8.82	10.27	161	0.36	2.86	0.05
14	7FW	Radish	*Raphanus sativus*	18.98	8.82	11.62	30	ND*	2.04	0.02
15	8SW	Bitter Gourd	*Momordica charantia*	75.84	22.84	22.34	61	2.16	0.48	0.22
16	8FW	Bitter Gourd	*Momordica charantia*	57.47	16.45	14	54	1.34	0.27	0.22
17	9SW	Vegetable Marrow	*Cucurbita pepo*	35.65	9.82	8.86	48	0.42	2.24	0.04
18	9FW	Vegetable Marrow	*Cucurbita pepo*	27.94	4.28	8.22	34	0.17	1.91	0.01
19	10SW	Apple Gourd	*Praecitrullus fistulosus*	10.34	10.44	9.58	72	1.42	2.53	0.94
20	10FW	Apple Gourd	*Praecitrullus fistulosus*	8.75	5.33	5.8	55	0.87	1.94	0.28

ND*= Not Dectected

4. Conclusion

Sewage water irrigation is practicing in various developing countries like Pakistan and normally considers a source of good production. This study shows that concentrations of micronutrients (Mn, Zn, Cu, Fe and Cr) and toxic metals (Pb and Cd) in edible parts of the vegetables were higher in vegetables irrigated by sewage water so using the sewage water as irrigation source is hazardous to humans health.

5. Acknowledgments

We are thankful to Dr. Izhar ul Haq (Minhaj University Lahore) and Dr. Muhammad Adnan Iqbal (University of Agriculture Faisalabad) for their support and guidance.

6. References

[1]. SNYDER R. L. and MELO-ABREU J. P., Frost protection fundamentals practice and economics, Vol. 1, *Food and Agriculture Organization of the United Nations*, (2005).
[2]. SIEBERT S., JIPPE H., PETRA D., JEAN-MARC F., SEBASTIAN F., and KAREN F., The Digital Global Map of Irrigation Areas– Development and Validation of Map Version 4, *Tropentag, Conference on International Agricultural Research for Development. University of Bonn*, (2006).
[3]. EMSLEY J., Manganese, Nature's Building Blocks: An A-Z Guide to the Elements. Oxford, UK: *Oxford University Press*, 249-253 (2001).
[4]. BROADLEY M. R., WHITE P. J., HAMMOND J. P., ZELKO I., LUX A., Zinc in plants. *New Phytologist*, 173(4): 677-702, (2007).
[5]. FABRIS N., MOCCHEGIANI E., Zinc-human diseases and aging. *Aging clinical and Experimental Research*, 7: 77-93, (1995).
[6]. CHENEY K., GUMBINER C., BENSON B., TENENBEIN M., Survival after a severe iron poisoning treated with intermittent infusions of deferoxamine. *Journal of Toxicology: Clinical Toxicology*. 33(1): 61-6, (1995).
[7]. ANDERSON R. A., Chromium as an Essential Nutrient for Humans. *Regulatory Toxicology and Pharmacology*, 26 (1 Pt 2): S35-S41, (1997).
[8]. WISE S. S., WISE JP. SR., Chromium and Genomic stability. *Mutation Research /Fundamental and Molecular Mechanisms of Mutagenesis*, 733(1-2): 78-82, (2012).
[9]. ABRAHAM M. R., COLIN D. R., MARGARET K. H., GEORGE E. L., NORMAN J. S., Lead. *Rudolph's Pediatrics* (21st ed.) *McGraw-Hill Professional*, 369 (2003).
[10]. JULIN B., WOLK A., JOHANSSON J. E., ANDERSSON S. O., ANDREN O., AKESSON A., Dietary cadmium exposure and prostate cancer incidence: A population-based prospective cohort study. *British Journal of Cancer*, 107(5): 895-900, (2012).
[11]. ENGSTROM A., MICHAELSSON K., VANTER M., JULIN B., WOLK A., AKESSON A., Associations between dietary cadmium exposure and bone mineral density and risk of osteoporosis and fractures among women. *Bone*. 50(6): 1372-1378, (2012).
[12]. JULIN B., WOLK A., BERGKVIST L., BOTTAI M., AKESSON A., Dietary cadmium exposure and risk of postmenopausal breast cancer: A population-based prospective cohort study. *Cancer Research*. 72(6): 1459-1466, (2012).
[13]. Agency for toxic substances and disease registry. Toxicological profile for chromium. *U.S. Public health service, Department of Health and Human Services, Atlanta, US*, (1998).
[14]. AMMA M. K., Plant and Soil Analysis. *Rubber Research Institute, Rubber Board, Kottayam-686009, Keral*, (1990).
[15]. JONES J., Benton, Plant tissue analysis for micronutrients, In J. J. Mortvedt et al., (ed) Micronutrients in Agriculture. *Soil Science Society America*, Madison, Wisconsin, U.S.A., 319-348, (1972).
[16]. RECHARDS L. A., Diagnosis and Improvement of Saline and Alkali soils. (ed) 1954, *Oxford and IBH Publishing Company, New Delhi*, (1968).