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Heavy Metal Accumulation in Vegetables Irrigated with Sewage and Its Impact on Health

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Abstract

Ever increasing population, urbanization and industrialization have led to generation and indiscriminate discharge of large volume of water from domestic, commercial, industrial uses from which natural water sources become unfit for human usage. The use of sewage water for irrigation is a matter of major concern due to the presence of toxic metals and other pollutants, which ultimately contaminate the soil. Unscientific management practices of pollutants lead to ecological Imbalance. The use of sewage for irrigation is a common practice in majority of peri-urbans. An investigation made on the impact of sewage irrigation on soil and the potentiality of vegetables in the accumulation of the metal pollutants from the soil. The potential of vegetables for the accumulation of heavy metals from the sewage irrigated soil, cleans up the environment. Consumption of vegetables has positive impact on the health of man.

Keywords: Heavy metals, sewage, accumulation, toxicity, health.

Introduction

The rapid development of urbanization and industrialization, together with the shortage of availability of fresh water to be used for irrigation has led to raising use of sewage for agricultural land irrigation. While the sewage provides water and valuable plant nutrients, it leads to the potential accumulation of heavy metals in agricultural soils [1]. When the contents of heavy metals exceed the permitted threshold, they will impact the normal growth of crops or even might enter the food chain to threat human health and animal health [2,3]. In the semiarid regions factors forces us to use sewage effluent for crop production are: i. Scarcity of alternative water for irrigation ii. High cost of fertilizers. The unscientific disposal of untreated effluent has resulted in the accumulation of heavy metals in land, water bodies and the plants growing in the sewage [4]. The vegetable cultivation with the sewage water now a days is a common practice in and around cities. Heavy metal toxicity has sever effect on our health, nervous system, kidneys, lungs and other organ functions. Surface water bodies get polluted due to urban sewage discharge[5,6,7,8].

The vegetables which were grown by sewage water irrigation are found to contain heavy metals. The use of sewage has significant health implications for both consumers and farmers. It has been well established that bacteria, viruses, protozoa, nematodes and fungi are capable of causing diseases can be found in foods contaminated with sewage water[9]. Therefore, for more satisfactory results, waste water should be treated to remove harmful substances and micro-organisms before it is used for irrigation. When the vegetables / crops irrigated with sewage water, contains poisonous elements and microorganisms in a great amount [10]. Special attention has been paid to those vegetables that are eaten raw. Since the micro-organisms that settle over them are able to survive for several weeks and when these vegetables are consumed, they produced diarrhea, Salmonellosis, Shigellosis[11]. The indiscriminate use of sewage causes clogging of soil pores resulting in decreased permeability. Lack of aeration in sewage produces toxic gases which were found to create unhygienic conditions[12].

Perishable vegetables are grown around urban areas, which are more prone to heavy metals contamination due to variety of urban and industrial activities including vehicular pollution. Continuous use of waste water for irrigation leads to accumulation of heavy metals in vegetables[13,14]. A number of serious health problems can develop as a result of excessive uptake of dietary heavy metals. Furthermore, the consumption of heavy metal contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho-social behavior, disabilities associated with malnutrition and a high prevalence of upper gastro-intestinal cancer[15].

The present study was planned to assess, the status of metal accumulation in different parts of vegetables grown using the sewage for agriculture. The sewage has health implications for both consumers and farmers, proper health education is indispensible.

Material and Methods

Seven vegetable species viz; Spinach (*Spinacea oleraceae*), Beet root (*Beta vulgaris*), Egg plant (*Solanum melongena*) Tomato (*Lycopersicum esculentum*), Dill (*Anethum graveolens*) were collected in and around Jamkhandi area. This area is located in the suburb of Jamkhandi (Karnataka).

Sewage sample is collected in a large presterilized containers and transported to the laboratory for physicochemical analysis as per standard methods[16] and Na analysis is made by Atomic Absorption Spectrophotometer. Soil sample is collected with an average depth of 5.20cm where the vegetables were growing. The soil is air dried, sieved to desired particle size for analysis. Different vegetables were dried at 80^0 in an oven for 24 hours to a constant weight. The dried part of the plant is homogenized with a blender to a powdery form. One 1gm of sample was digested by using AR grade chemicals such as nitric acid (HNO_3), sulphuric acid (H_2SO_4), hydrogen peroxide (H_2O_2) and perchloric acid (60%) in a 'Gerhardt' digestion unit. The solution was filtered through Whattman filter paper number 44 in a volumetric flask by adding double distilled water and the final volume is made to 100ml and analyzed for heavy metals such as Zinc (Zn), Copper (Cu), Manganese (Mn) and Nickel (Ni) with a GBC-932 plus Atomic Absorption Spectrophotometer (Austrelia) with an air / acetylene flame and metal hollow cathode lamps. Respective wavelengths were used for the estimation of different heavy metals present in sewage soil and vegetables. Standard solutions for heavy metals were purchased from Siscochemical laboratory Bombay (1000 µg/L). The working standards were prepared by serial dilution of standard stock solutions and were used for the calibration of the instrument[17].

Results and Discussion

The physico-chemical characteristics of sewage and soil sampled from Jamkhandi are presented in Table 1. The sewage was dark brown in colour with an unpleasant smell and is analyzed for its physico-chemical parameters. All the parameters except chlorides, COD and alkalinity almost all are within limits of WHO[18] range. The alkalinity of sewage is due to detergents and soap[19]. The P^H of the sample is 7.6. The sewage also contains good amount of zinc, copper, manganese, and Nickel. These heavy metals to the extent are exceeding the sufficient or normal status but are at tolerable level in agricultural crops[20]. The concentration of heavy metals in different vegetables at its different parts are presented in the table-2. The analysis of the data showed that the metal translocation vary from one plant another and also the different parts of the plants (table 3).

Among the vegetables the underground edible parts and the fruit bearing plants shows significant accumulation of metals. The brinjal shows the accumulation of metals in the following orders.

Root – Mn (185.6±1.52) > Zn (91.60 ± 1.17) > Ni (22.96 ± 1.50) > Cu (7.2 ± 0.3 µg/gm)

Fruit - Mn (151.3 ±1.52) > Zn (53.36 ± 2.20) > Cu (26.9 ±1.75) > Ni (25.20 ± 1.05).

It is found that in brinjal the accumulation of Mn is more in root and fruit followed by Zn at higher concentration. Tomato also shows significant accumulation of metals in the following order:

Root – Zn (68.68 ± 1.55) > Mn (57.43 ± 1.35) > Cu (27.43 ± 1.17) > Ni (22.26 ± 1.05)
Fruit – Zn (69.73 ± 1.30) > Mn (60.76 ± 1.15) > Ni (30.50 ± 1.27) > Cu (25.66 ± 1.55).

Similarly the tomato also shows significant accumulation of Zn both in the fruit and the root followed by Mn. The order of accumulation in beetroot, spinach and dill are as follows:

Beetroot: Root- Mn (178.6 ± 1.15) > Zn (60.76 ± 1.26) > Cu (29.53 ± 1.57) > Ni (12.13 ± 0.66)
Leaf – Mn (168.0 ± 2.0) > Zn (55.10 ± 1.11) > Cu (19.36 ± 1.10) > Ni (11.10 ± 0.70)

Spinach: Root- Mn (150149.0 ± 1.73) > Zn (59.60 ± 1.45) > Cu (17.4 ± 1.55) > Ni (9.33 ± 0.40)
Leaf- Mn (159.6 ± 1.52) > Zn (64.53 ± 1.12) > Cu (22.93 ± 1.15) > Ni (10.40 ± 1.12).

Thus, the order of accumulation in beetroot and spinach is found that Mn is maximum followed by Cu and Ni.

Dill: However in dill root leaf Zn is maximum followed by Cu and Ni is as follows:

Root- Zn (58.56 ± 1.20) > Mn (34.96 ± 0.96) > Cu (18.8 ± 0.75) > Ni (11.70 ± 0.65)
Leaf- Zn (59.93 ± 1.71) > Mn (38.. ± 1.01) > Cu (21.3 ± 2.06) > Ni (16.63 ± 0.64).

Table-1
ISI and WHO standards

parameters	pH	Odour	Ec	TDS	Hardness	Alkalinity	COD	Chloride	Ca	Mg	Na	SO_4
Sewage	7.8	Foul smell	1.301	785	349.0	560.5	273	458	98	85	140	55
ISI (std) (1991)	6.5 to 8.5	Acceptable	-	500	300-500	50-200	-	250-1000	75-100	36	-	150
WHO (1993)	6.5 to 8.8	Acceptable	1400 µohms	1000	500	120	5	250	100	150	200	250

Table-2
Kabata -Pendias(1995)

parameters	pH	Odour	Ec	TDS	Hardness	Alkalinity	COD	Chloride	Ca	Mg	Na	SO_4
Sewage	7.8	Foul smell	1.301	785	349.0	560.5	273	458	98	85	140	55
ISI (std) (1991)	6.5 to 8.5	Acceptable	-	500	300-500	50-200	-	250-1000	75-100	36	-	150
WHO (1993)	6.5 to 8.8	Acceptable	1400 µohms	1000	500	120	5	250	100	150	200	250

Table-3
Accumulation of heavy metals (µg/g)

Plant	Plant parts	Zinc (Zn)		Copper (Cu)		Manganese (Mn)		Nickel (Ni)	
		control	sewage	control	sewage	control	sewage	control	Sewage
Brinjal	Root	60.74±1.51	91.60±1.17	6.73±0.30	7.2±0.3	30.53±1.40	185.6±1.52	3.23±0.51	22.96±1.50
	Stem	49.33±0.98	50.03±0.83	6.46±0.35	7.9±0.49	29.56±0.80	175.6±2.08	2.46±0.51	19.40±0.60
	Leaf	44.90±0.75	49.63±0.87	12.03±0.60	15.60±0.62	25.30±0.80	141.6±1.42	2.53±0.45	20.60±1.61
	Fruit	42.96±1.70	53.36±2.20	15.70±1.45	29.9±1.75	32.86±0.75	151.3±1.52	3.7±0.60	25.20±1.05
Tomato	Root	23.23±1.68	68.63±1.55	19.8±1.60	27.43±1.17	40.80±1.30	57.43±1.35	8.0±0.36	22.26±1.05
	Stem	19.56±1.55	53.0±1.44	17.43±1.72	23.1±1.70	35.33±1.15	55.20±1.05	6.63±0.75	25.00±0.95
	Leaf	25.63±1.12	53.93±1.26	16.06±1.25	19.70±1.30	32.63±1.16	53.8±0.36	8.66±0.66	25.10±1.20
	Fruit	28.50±0.98	69.73±1.30	20.03±1.85	25.66±1.55	49.73±1.40	60.76±1.15	6.80±0.36	30.50±1.27
Spinach	Root	41.86±0.83	59.60±1.45	5.80±0.70	17.4±1.55	49.9±0.72	149.0±1.73	6.83±0.70	9.33±0.40
	Leaf	46.66±1.55	64.53±1.12	15.13±1.25	22.93±1.15	82.53±0.72	159.6±1.52	8.73±0.77	10.40±1.12
Beetroot	Root	38.4±1.21	60.76±1.26	11.43±1.30	29.53±1.57	22.96±1.15	178.6±1.15	8.36±0.50	12.13±0.66
	Stem	33.1±1.20	56.1±1.60	11.33±1.20	27.1±0.92	21.80±0.65	159.3±1.52	7.73±0.60	12.33±0.77
	Leaf	33.3±1.07	55.10±1.11	14.30±1.04	19.36±1.10	22.6±1.11	168.0±2.00	7.13±0.75	11.10±0.70
Dill	Root	47.63±0.94	58.56±1.20	14.16±0.94	18.8±0.75	21.2±1.60	34.96±0.96	7.36±0.70	11.70±0.65
	Stem	38.96±1.10	50.43±1.40	11.06±0.87	13.3±1.45	22.33±0.80	32.83±0.83	6.43±0.35	10.66±0.65
	Leaf	48.96±1.72	59.93±1.71	13.56±1.40	21.3±2.06	26.13±0.96	38.3±1.01	7.96±0.60	16.63±0.64
Soil		29.2±1.15	71.76±1.42	16.40±1.17	32.83±1.59	43.03±1.10	292.3±0.65	3.93±0.85	46.86±0.45
Water		426.3±4.71	490.6±2.08	38.33±1.25	213.6±1.52	319.6±1.52	456.6±1.15	110.3±1.15	195.7±0.929

Vegetables and soil- µg/g, Sewage- µg/L, Mean values ± standard error

It is well documented that the level of metals was found to be greater than the normal but were at the tolerable limits in the agricultural crops (Kabata- Pendias) due to the waste water receiving from both natural and anthropogenic sources. The plants grown using this water accumulate significantly high amount of metals. Plants take up metals via roots, which depend upon physico chemical characteristics of soil, concentration, solubility, species and organ of the plant.

Entry of heavy metals to the food chain has been reported through vegetable consumption[21,22]. The use of sewage contaminated vegetables with heavy metals has significant health implications for both consumers and farmers[14]. The toxicity metals commonly involves the brain and kidney damage. Many authors also reported considerable risk and impact of metals on the human health in the exposed area receiving waste water[23]. The xenotoxic of various heavy metal after in vitro acute exposure in mice and found significant increase in chromosome aberration when compared to control mice this dose was relatively higher than the amount of vegetable a human can consume in a day[24].

The results of the present study showed the vegetables grown by using sewage constitute the risk due to accumulation of heavy metals. One general method used to clean vegetables in a tap water rinse, with respect to the beetroot, the rinse procedure alone was not sufficient to remove soil particles attached to the surface and brush washing had to be used[25]. The bacteriological contamination of vegetables / crops by the use of waste water in irrigation increases the gastrointestinal diseases. The vegetables should be transported to the market in proper containers[26]. The sewage has significant health implications for both consumers and farmers and hence, proper health education is essential for women and men who are in contact with sewage during farming[12].

The increased circulation of toxic metals in the vegetables results in the inevitable buildup of xenobiotics in human food chain. Raising awareness among the farmers, policy makers, polluters, consumers, and others is seen by many as the immediate and most important strategy to reduce health risks in most low income countries.

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