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Long-term effect of Raw Sewage Application on Chemical Composition of Vegetables Grown on Sandy Soils of Western Rajasthan.

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Abstract

Sewage water from Nathusar drain irrigating the vegetable crops in Shriramsar and Sujandesar area was collected and analysed for the various chemical constituents. Five vegetables of winter season Spinach, Fenugreek, Cauliflower, Cabbage, and Radish and five vegetables of summer season Bottle gourd, Ridge gourd, Amaranth, Cucumber and Brinjal from the fields irrigated with sewage were collected at the stage to be picked up for marketing. The sewage water of Nathusar drain of Bikaner city contain higher values of EC, adjusted SAR, TSS and BOD, however, the metallic cations content were below the recommended maximum permissible concentrations. A higher inorganic and organic loading of sewage water and metallic cations buildup particularly Zn, Cu and Fe in vegetables under study call for passing of the sewage water through an effluent treatment plant before being diverted for irrigation in this area also as it is being passed through treatment plant in the Jorbeer area of the city.

Key words: *Sewage water, sandy soils, vegetables*

Introduction

Demogeraphic growth, increasing urbanization, industrialization and change in life style triggering greater use of detergents, domestic sprays, medical wastes, etc. are expected to produce larger quantities of anthropogenic wastewaters with different composition. It is estimated that the present population of India of more than one billion is expected to cross 1.5 billion marks by 2050. More than 50% of the total population will be in urban sector and number as well as size of settlements will multiply. Presently about 15% of India's water resources are consumed in domestic and industrial requirements and share of these two sectors will grow to about 30% by 2050.

The disposal of domestic waste water through crop irrigation is an age-old practice in India, which is an excellent and a convenient means of sewage disposal through land application. Irrigation with sewage water not only meets the water requirement but also fulfill partial nutrient need of the crop. Besides this, under arid and semi arid conditions, where irrigation is a pre-requisite for successful agriculture, sewage water as a source of irrigation is equally important as the need for its disposal.

Use of sewage water in agriculture can contribute to a reduction in stress on the utilizable water resources. It will not only reduce disposal problems of sewage but also contribute towards the up-gradation of soil fertility as it contains appreciable amounts of macro and several micronutrients (Mitra and Gupta 1999). In general, sewage effluents from municipal origin contain appreciable amounts of plant nutrients and therefore, its use as a source of irrigation in agriculture is worth. The raw sewage water contain beneficial (Zn, Cu, Fe, Mn) as well as toxic-metals such as Cd, Pb, Ni, Cr, etc in addition to various bacteria and viruses. These contaminants behave differently after entering a particular medium or following a particular path depending upon the stability of the contaminant, interaction of the contaminant with the medium and the interaction of contaminant with other contaminants (Lundgren, 1986). A long-term and indiscriminate use of raw sewage water may prove hazardous to human health since it contains variable amounts of metallic cations. Thus, keeping in view the importance and risks of using raw sewage water to irrigate different vegetable crops in the arid area, this study was conducted to achieve the objectives.

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Material and Methods

The sewage water being used in the Sriramsar and Sujandesar area of Bikaner city is raw (untreated) mainly for growing vegetables and berseem and sorghum for fodder. The major portion of sewage water in Bikaner city is contributed from the domestic waste water and a very small portion contributed from the wool industries and cottage tying and dyeing industries. Most of the soils of the area are sandy in texture having very low to low soil fertility. Organic carbon content of most of the soils rarely exceeds 1 gm kg^{-1}. Phosphorus and potassium status of soil varies from low to medium and medium to high, respectively. So far as micro nutrients are concerned zinc and copper are low but iron and manganese are sufficient to support the crop plants. However, the calcareous nature of the soils imparts hindrance in micro nutrient availability to plants. Soils of the region were slightly alkaline in reaction having pH ranging between 7.66 to 8.67 and non saline, EC ranging between 0.30 to 1.24 dS m^{-1}.

Raw sewage water from Nathusar area drain irrigating the vegetable crops in Shriramsar and Sujandesar area was collected to analyse the chemical constituents. A part of sample so collected was acidified by adding Nitric acid at the rate of 5 ml/l and kept for analysis of metallic cations. The metallic cations Zn, Cu, Fe, Mn, Ni, Pb and Cd were analysed with the help of Atomic Absorption Spectrophotometer. The un-acidified part of the sample was analysed for pH, EC, BOD, TSS, Cations, Anions, Phosphates and Nitrates employing the methods suggested by Trivedi and Goel (1984) and APHA-AWWA-WPCF (1975).

Five vegetables of winter season Spinach (*Spinacea oleracea*), Fenugreek (*Trigonella foenum-graecum*), Cauliflower (*Brassica oleracea var. Botrytis*), Cabbage (*Brassica oleracea var. capitata*), and Radish (*Raphanus sativus*) and five vegetables of summer season Bottle gourd (*Lagenaria siceroria*), Ridge gourd (*Luffa acutangula*), Amaranth (*Amaranth* spp), Cucumber (*Cucumis sativus*) and Brinjal (*Solanum melongena*) from the fields irrigated with sewage were collected at the stage to be picked up for marketing. From locations under study five samples of each vegetable were collected and chopped to make a composite sample for analysis. The vegetable samples so collected were dried at 65 ^{o}C in hot air circulating oven to a constant weight. After processing, the vegetable samples were digested with $HClO_4$-HNO_3 acid mixture and analysed for N, P, K and metallic cations (Zn, Cu, Fe, Mn, Ni, Pb and Cd) using standard methods of analysis.

Results and Discussion

Chemical composition of sewage water (Table 1) indicated that pH and EC of water sample were 8.3 and 2.1 dSm^{-1}, respectively. The sewage water was slightly alkaline in reaction having a higher electrical conductivity and could be categorized into category of causing slight to moderate degree of restriction when used for irrigation (Ayers and Westcot, 1985). Further, the sewage water contains considerable amounts of basic cations. Na^+ was the dominant cation followed by Mg^{+2}, Ca^{+2} and K^+ and Cl^- was the dominant anion followed by SO_4^{-2}, HCO_3^- and CO_3^{-2}. The Na^+ and Cl^- was 14.1 and 12.1 meL^{-1}. Adj. SAR of the water sample was 18.19. It was observed that adj SAR and Cl^- content of the sewage water was so high that it may cause severe problems for the sensitive crops (Ayers and Westcot, 1985). NO_3-N and phosphate contents were 12.5 and 2.8 mgL^{-1}, respectively. BOD and TSS of water samples were 388.0 and 347.2 mgL^{-1} were higher than the values prescribed for their tolerance limit (200 mgl^{-1} and 100 mgl^{-1}, respectively) to be used for irrigation (ISI-standards, 1982).

As regards micronutrients composition, Zinc, Copper, Iron and Manganese contents of the water sample were 259.3, 231.6, 485.4 and 311.0 μgL^{-1}, respectively. The Nickel, Lead and Cadmium contents were 119.7, 68.2 and 57.7 μgL^{-1}, respectively. The metallic cations content of sewage water were below the recommended maximum permissible concentrations of these trace elements in irrigation water for continuous use on all types of soils (Pratt, 1972).

The nutrient contents in the vegetable samples presented in Table 2 showed that the nitrogen content was of higher magnitude in the leafy vegetables spinach, fenugreek, amaranth and cabbage (3.80, 3.51, 3.69, and 3.65 %, respectively) and was of lower magnitude in radish (1.89 %). However, the phosphorous content recorded ranged to a narrow range, ranging between 0.37 to 0.51 per cent for all the vegetables under study. The potash content was of higher magnitude in the radish and cucumber (6.08 and 5.21%) and was of lower order in the ridge gourd and cauliflower (3.33 and 3.67%).

The metallic cations content i.e. zinc, copper, iron and manganese (Table 3) in different vegetables under study ranged from 82.3 to 131.2 mg kg^{-1}, 19.9 to 48.3 mg kg^{-1}, 239.9 to 850.7 mg kg^{-1} and 45.9 to 73.4 mg kg^{-1}, respectively. The nickel and lead content in the vegetables under study ranged between 14.9 to 20.5 mg kg^{-1} and 0.84 to 2.69 mg kg^{-1}, respectively. However, the Cadmium content was in the order not detectable on AAS. The Zn, Cu and Fe in different vegetables under study were below the phytotoxicity limits (150-200, 20-100 and >500 mg kg^{-1}, respectively) as reported by Mortvedt *et al.*, 1991. However, when compared with the critical levels of Zn, Cu and Fe (30, 6 and 60 mg kg^{-1} for leafy vegetables and 25, 5 and 75 mg kg^{-1} for tuber/root crops, respectively) reported by Ankerman and Range (1988) the concentration of these cations observed for the vegetables under study were much above the critical levels suggested. The Mn and Ni contents were much below the phytotoxicity level of >500 mg kg^{-1} and 50 mg kg^{-1}, respectively, in the dry matter of plant tissue (Mortvedt et al., 1991). The Pb and Cd content in different vegetable samples were also below the phytotoxicity limits of >20 mg kg^{-1} (Mortvedt *et al.*, 1991) and 0.8 mg kg^{-1} (Alloway, 1968), respectively.

The sewage water of Nathusar drain of Bikaner city contain higher values of EC, adjusted SAR, TSS and BOD, however, the metallic cations content were below the recommended maximum permissible concentrations. A higher inorganic and organic loading of sewage water and metallic cations buildup particularly Zn, Cu and Fe in vegetables under study call for passing of the sewage water through an effluent treatment plant before being diverted for irrigation in this area also as it is being passed through treatment plant in the Jorbeer area of the city. Further, quality of sewage plays an important role for its use as a source of nutrients. Therefore, regular monitoring of the quality of sewage should be done and threshold limit of sewage application should be estimated based on its quality. However, a gap of at least 1-2 seasons may be given after every 3-4 years of sewage application to allow the soil to come back to the equilibrium.

Table 1. Chemical composition of sewage water of Nathusar drain of Bikaner city.

Chemical characteristics	Range	Chemical characteristics	Range
pH	8.3	Phosphates (mgL^{-1})	2.8
EC (dSm^{-1})	2.1	Adj. SAR	18.19
Ca^{+2} (meL^{-1})	3.4	T S S (mgL^{-1})	347.2
Mg^{+2} (meL^{-1})	3.7	B O D (mgL^{-1})	388.0
Na^{+2} (meL^{-1})	14.1	Zinc (μgL^{-1})	259.3
K^{+} (meL^{-1})	0.8	Copper (μgL^{-1})	231.6
Cl^{-} (meL^{-1})	12.1	Iron (μgL^{-1})	485.4
CO_3^{-2} (meL^{-1})	0.9	Manganese (μgL^{-1})	311.0
HCO_3^{-} (meL^{-1})	3.8	Nickel (μgL^{-1})	119.7
SO_4^{-2} (meL^{-1})	5.2	Lead (μgL^{-1})	68.2
No_3- (meL^{-1})	12.5	Cadmium (μgL^{-1})	57.7

Table 2. N, P and K content (%) of vegetables from sewage water irrigated areas

Vegetables	Nitrogen	Phosphorus	Potash
Winter season			
Spinach (*Spinacea oleracea*)	3.80	0.41	3.79
Fenugreek (*Trigonella foenum -graecum*)	3.51	0.47	4.53
Cauliflower (*Brassica oleracea* var. *Botrytis*)	3.49	0.51	3.67
Cabbage (*Brassica oleracea* var. *capitata*)	3.65	0.51	3.75
Radish (*Raphanus sativus*)	1.89	0.37	6.08
Summer season			
Bottle gourd (*Lagenaria siceroria*)	2.79	0.44	3.64
Ridge gourd (*Luffa acutangula*)	2.57	0.40	3.33
Amaranth (*Amaranth spp*)	3.69	0.48	3.83
Cucumber (*Cucumis sativus*)	3.29	0.49	5.21
Brinjal (*Solanum melongena*)	2.92	0.43	3.98

Table 3. Metallic cation content ($mg\ Kg^{-1}$) of vegetables from sewage water irrigated areas

Vegetables	Zn	Cu	Fe	Mn	Ni	Pb	Cd
Spinach	131.7	40.1	525.6	65.5	14.9	1.88	ND
Fenugreek	130.1	48.3	850.7	45.9	14.9	2.04	ND
Cauliflower	120.2	19.9	303.7	54.4	20.5	2.69	ND
Cabbage	113.2	27.0	263.6	63.9	19.6	2.30	ND
Radish	82.3	23.1	239.9	73.4	13.5	1.84	ND
Bottle gourd	101.2	30.5	607.0	66.2	15.2	2.31	ND
Ridge gourd	117.4	39.5	695.3	66.3	16.5	2.53	ND
Amaranth	106.1	42.5	699.9	62.1	13.3	1.81	ND
Cucumber	120.6	37.5	421.8	61.4	16.2	1.77	ND
Brinjal	97.4	44.7	438.0	65.0	19.6	2.12	ND

ND = Not detectable

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