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An Analysis of Nutrients Accumulation and Heavy Metals in Selected Vegetable Crops Grown in district Sirsa, Haryana

Research Article

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Abstract

The present study investigated the accumulation of heavy metals in some vegetable crops irrigated with treated wastewater at some sites of District Sirsa of Haryana. The analysis of variance revealed the significant differences among the treatment for all the twelve traits under study, indicating substantial variability in the minerals. Wastewater irrigation can lead to the accumulation of heavy metals in the soil and, consequently, in the vegetables, which can pose health risks when consumed in excessive quantities. Results indicated that T7 is suitable for most of the minerals under the study area.Treatment T7 is ideal for calcium, magnesium, and sodium traits. Calcium exhibited a highly significant and positive association with magnesium and sodium. However, a negative association with potassium was observed. Sodium showed a positive and significant association with magnesium. Chromium also exhibited positive and significant association with sodium, and sodium itself demonstrateda negative and non-significant association with potassium followed by iron and copper. Selenium showed a positive and non-significant correlation with iron and potassium. However, it was exhibited a negative and non-significant correlation with calcium followed by magnesium, copper, zinc, and nickel.

Keywords: Correlation; Minerals; Heavy metals; Wastewater; Vegetable crops

Introduction

The application of treated wastewater into agricultural lands is standard practice in several countries. Globally, 2 million sq km of land are irrigated with wastewater [1]. It is most evident in the peri-urban and sub-urban areas in developing countries. The long-term irrigation with treated waste water is known to have a significant contributor for elements such as Cd, Cu, Zn, Cr, Pb, and Mn in surface soil of agricultural fields [2], and it also increase the level of physicochemical properties in soil. Extent of toxic elements enrichment in irrigated soil depends on concentrations of heavy metals in irrigation water, period of application of treated wastewater and texture of soil. The availability of nutrient and various elements in vegetables depends on soil properties like pH, organic carbon, cation exchange capacity [3-5]. The accumulation of metals occurs in edible and non-edible parts of vegetables.Wastewater can contribute heavy metal accumulation significantly in soil and crops [2,6].

There are different types of wastewaters. Industrial wastewater contains a wide variety of inorganic toxicants and synthetic organic pollutants, which are not biodegradable such as, solvent oils, plastics, plasticizers, metallic wasters, suspended solids, phenols, and various other derivatives. Almost all industries (dairy, tannery, cannery, distillery, oil refinery, textile, coal and coke, synthetic rubber, steel *etc.*) produce their own characteristic wastewater. Domestic wastewater, discarded from houses, contains especially organic matter. Wastewater has threats to vicious environment, humans, plants, and animals. It also affects the soil like salinity, alkalinity and water logging which change the physical, chemical and biological properties of soil and affect fertility of the soil. It is the rich sources of both beneficial as well as harmful elements. Since some effluents are a rich source of plant nutrients, therefore soil provides the logical sink for their disposal. But many untreated and contaminated wastewater and industrial effluents may have high concentration of several heavy metals such Cd, Ni, Pb and Cr [7].

The present study area which is located between Latitude $29^0 32'$ 11.5' N and Longitude 75^0 1' 31.81' E in peri urban and sub urban area of Sirsa District, Haryana, where soil and water samples were collected to determine and evaluate such impacts due to unscrupulous use of treated wastewater for growing vegetable crops. Controlled fields were selected in the same locality, considering the use of tube well and canal water for irrigation. The study was conducted to know the accumulation of nutrients and heavy metals in selected vegetable crop.

Materials and Methods

The following approach was used to bring together the information to meet the objectives and answer the various research questions.The research consisted of three phases: preparation, field data collection, data analysis and documentation. The first activity was an explorative field visit to appreciate the context of the research methods and site selection. Following this, questionnaires were designed, and interviews held to investigate the perceptions among farmers for calculation cost benefit analysis, study the perception among customers on the use and cultivation of vegetables cultivated with wastewater and to collect additional information derived from key informants and other stakeholders. Third phase of the research included data entry and statistical analysis of the perception studies and the cost benefit analysis. Field surveys were carried out in and around Sirsa city, to collect soil, water, and vegetable samples. Water samples collected from different sources included wastewater, ground water and surface water. Soil samples from 0-20, 20-40 and 40-60 cm depths and leaf and fruit parts samples of vegetables grown on these fields and irrigated with various water types was collected. The water samples were collected in plastic bottles and brought to laboratory for analysis work. The collected soil samples were air dried, grounded with wooden mortar and pestle, passed through 2 mm sieve, and kept for further analyses. The collected plant vegetables samples were washed with distilled water and dried in oven at 60°C till constant weight. The soil and water samples were analyzed for their physical, chemical, and biological properties while vegetable samples analyzed for nutrients and heavy metals contents by standard protocol methods (IUPAC, 1990). Analysis of soil physicochemical parameters *viz.,* pH, conductivity, soil organic carbon and heavy metals were carried out in the laboratory by following protocol of handbook of methods in environmental studies written by S.K.Maiti.

Vegetables samples available during the various season at study area collected randomly from both fields (control and treated). It was washed thoroughly with tap water followed by distilled water to get rid of dirt and soil, dried at 68°C for 24 hours and then powdered with mortar pestle. Metal concentration in different vegetables analyzed by digesting in microwave taking500 mg of dried powdered samples with di-acid mixture (3:1) of concentrated HNO_3 and $HClO_4$ [8]. The suspension filtered by rinsing with distilled water using Whatman 42 filter paper and made the volume to 50 ml. This was analyzed for lead (Pb), manganese (Mn), chromium (Cr), cadmium (Cd), zinc (Zn) and cupper (Cu) by atomic absorption spectrophotometer. The effect of irrigating wastewater on available N (Kjeldahl method), P (UV-Vis Spectro-photometric method), K (Flamephotometer method) and quantum of enrichment and bioaccumulation of nutrients in soil and vegetables were observed. All Samples were analyzed at Maharaja Ganga Singh University, Choudhary Charan Singh Haryana Agriculture University Hisar and Central Soil Salinity Research Institute, Karnal.

The values of Pb, Mn, Cr, Cd, Zn and Cu was obtained from analysis of irrigated water, soil and cultivated different vegetables were used to calculate metal transfer factor. The degree of soil pollution for each metal measured using the pollution load index (PLI) technique. The following modified equation was used to assess the PLI level in soils [9].

$$PLI = \frac{Conc.\ of\ metal\ in\ waste\ water\ irrigated\ soil}{Conc.\ of\ metal\ in\ control\ soil}$$

Enrichment factor [10] also calculated to determine the degree of soil pollution and heavy metal accumulation in vegetable grown in contaminated soil sites.

$$EF = \frac{Conc.\ of\ metal\ in\ plant\ at\ contaminated\ site}{Conc.\ of\ metal\ in\ at\ uncontaminated\ site}$$

After study of such indices the statistical analysis with descriptive statistics (mean, standard deviation, minimum and maximum) was calculated. Correlation between the physico-chemical constituents and heavy metal in soil and metals content of the vegetable was performed by using the software SAS 9.4 version.

Results and Discussion

Analysis of variance of different minerals

Analysis of variance revealed significant differences among the treatment of all the twelve traits under study indicating the presence of substantial variability in the minerals.However, mean square due to replication were significant for six minerals namely Mg*, Na*, K**, Fe*, Mn** and Cr**except Ca, Cu, Zn, Cd and Ni (Table 1).

Table 1: Analysis of variance for different minerals

Source of Variation	Replicate	Treatments	Error
df	2	7	14
Ca	1,251.54	4,486,407.52**	799.83
Mg	23.29*	441,109.95**	5.91
Na	1.70*	53,590.98**	0.30
K	82.29**	39,019,109.23**	6.91
Fe	0.65*	729.48**	0.34
Mn	0.14**	100.12**	0.02
Cu	0.41	10.94**	0.15
Zn	0.06	10.47**	0.07
Cd	33,648.88	2,204,607.28**	33,768.21
Cr	28.17**	1,022,853.88**	2.02
Ni	5.79	514,332.45**	6.08
Se	24.54**	48,501,118.33**	0.54

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Mean performance of treatments

For each of the minerals evaluated, the descriptive statistics including the extreme genotype mean values and the means together with their standard errors obtained based on average data are summarized in (Table 2). In general, treatment showed wide range of variability for most of the characters and all the traits exhibited broad spectrum of ranges between the maximum and minimum treatments mean values. For instance, Ca ranged from 985.33 to 4193.33 with a mean of 2228.17 and treatment T7 showed maximum mean value for Ca minerals followed by T3 (4061.67), T8 (2157), T6 (1837.33) and T5 (1707.33) mean values.Similarly, Mg ranged from 634.67 to 1793.67 with mean value of 1044.042 and CV of 0.23%.Highest mean value for minerals was expressed in T7 (1793.67) followed by T3 (1451.67), T5 (1009.67) and T6 (925.33%). Sodium (Na) was highest in T7 (491.33) followed by T3 (246.73), T6 (233.77) and T8 (205) with range varied from 91.13 to 491.33 and general mean 199.32. Similar finding [13,14].

Potassium (K) ranged from 7581.67 to 16905.33 with mean of 13157.46. T1 (16905.33) exhibited maximum mean value followed by T6 (16043.67), T5 (15882) and T2 (15382.67). Maximum mean value for Iron (Fe) T8 (73.83) followed by T1 (64.53), T3 (45.17) and T2 (43.73). The value varied from 26.90 to 73.83 with mean value of 46.03.Mn ranged from 3.80 to 21.63 and mean value of 7.70. Treatment T3 (21.63) was expressed highest mean value followed by T2 (7.8) and T4 (6.7).

T1 showed maximum mean value of 18.57 followed by T2 (17.73), T6 (16.83) and T5 (16.50) with ranged varied from 12.57 to 18.57 for Cu. Similarly range of variation for Zn varied from 5.40 to 10.67 with mean value 7.77.T7 (10.67) showed maximum mean value for these minerals followed by T1 (9.44),T5 (8.60) and T3 (8.47).

Cd range varied from 229.33 to 3002.67 with mean value of 1022.38 and T7 (3002.67) was exhibited maximum mean value followed by T8 (1342.00), T5 (837) and T4 (797.33). Maximum mean value was expressed in T1 (5539.33), T6 (5104.33), T3 (4749.00) and T4 (4485) with ranged varied from 3561.33 to 5539.33 for Cr. Ni range varied from 754.00 to 1752.67 with mean value of 1338.92. T2 was exhibited maximum mean value (1752.66) followed by T1 (1732.33), T5 (1619.00) and T6 (1604.67).Similar finding reported by [9, 10-14].

For Se range varied from 1518.00 to 13352.00 with mean value of 8491.29 and T8 showed maximum mean value 13352.00 followed by T4 (12951.67), T5 (10426.67) and T1 (9345.00).

Correlation between different minerals

Table 3 indicated that Calcium (Ca) exhibited highly significant

Table 2: Mean, CV SE CD and range for different minerals of plant sample/ treatments

Treatments	Ca	Mg	Na	K	Fe	Mn	Cu	Zn	Cd	Cr	Ni
T1	985.33	634.67	114.50	16905.33	64.53	5.80	18.57	9.44	713.00	5539.33	1732.33
T2	1571.67	856.33	91.13	15382.67	43.73	7.80	17.73	7.37	606.67	4308.00	1752.67
T3	4061.67	1451.67	246.73	7581.67	45.17	21.63	15.37	8.47	229.33	4749.00	994.00
T4	1311.67	830.33	104.73	14079.33	34.87	6.70	14.40	5.40	797.33	4485.00	754.00
T5	1707.33	1009.67	107.33	15882.00	41.60	6.50	16.50	8.60	837.00	4404.67	1619.00
T6	1837.33	925.33	233.77	16043.67	37.63	4.67	16.83	6.77	651.00	5104.33	1604.67
T7	4193.33	1793.67	491.33	10106.00	26.90	3.80	15.47	10.67	3002.67	4473.00	1422.67
T8	2157.00	850.67	205.00	9279.00	73.83	4.70	12.57	5.47	1342.00	3561.33	832.00
Mean	2228.17	1044.04	199.32	13157.46	46.03	7.70	15.93	7.77	1022.38	4578.08	1338.92
C.V.	1.27	0.23	0.28	0.02	1.27	1.60	2.41	3.42	17.97	0.03	0.18
S.E.	16.33	1.40	0.32	1.52	0.34	0.07	0.22	0.15	106.09	0.82	1.42
C.D. 5%	49.53	4.26	0.96	4.60	1.03	0.22	0.67	0.47	321.80	2.49	4.32
C.D. 1%	68.74	5.91	1.34	6.39	1.42	0.30	0.93	0.65	446.65	3.46	5.99
Range Lowest	985.33	634.67	91.13	7581.67	26.90	3.80	12.57	5.40	229.33	3561.33	754.00
Range Highest	4193.33	1793.67	491.33	16905.33	73.83	21.63	18.57	10.67	3002.67	5539.33	1752.67

Table 3: Correlation analysis for different minerals of plant sample/ treatments

Minerals	Ca	Mg	Na	K	Fe	Mn	Cu	Zn	Cd	Cr	Ni	Se
Ca	1.000	0.952**	0.837**	-0.825*	-0.351	0.467	-0.331	0.467	0.480	-0.174	-0.256	-0.366
Mg		1.000	0.868**	-0.661	-0.566	0.304	-0.223	0.577	0.610	-0.122	-0.121	-0.417
Na			1.000	-0.585	-0.385	-0.045	-0.266	0.504	0.797*	-0.069	-0.088	-0.268
K				1.000	-0.069	-0.507	0.710*	-0.027	-0.311	0.493	0.672	0.009
Fe					1.000	-0.023	-0.156	-0.280	-0.285	-0.167	-0.133	0.399
Mn						1.000	-0.034	0.086	-0.508	0.114	-0.291	-0.233
Cu							1.000	0.516	-0.280	0.761*	0.892**	-0.545
Zn								1.000	0.433	0.447	0.556	-0.532
Cd									1.000	-0.284	-0.014	-0.117
Cr										1.000	0.508	-0.168
Ni											1.000	-0.567

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and positive association with Mg (0.952**) and Na (0.837**). However, it was exhibited negative association with K (-0.825*). Sodium (Na) showed positive and significant association with Mg (0.868**). Cd also exhibited positive and significant association with sodium (0.797*) while sodium also showed negative and non-significant association with K (-0.585) followed by Fe (-0.385) and Cu (-0.266). Similar reported by [15 16], Gupta and Mitra (2002). Potassium (K) exhibited positive and significant correlation with Cu (0.710*) and exhibited non-significant and positive association with Cr (0.493), Ni (0.672) and Se (0.009). Cu showed positive and significant correlation with Cr (0.761*) and Ni (0.892**), while Zn showed non-significant and positive correlation with Cu (0.516). Similarly, Se showed positive and non-significant correlation with Fe (0.399) and by K (0.009).However, it was exhibited negative and non-significant correlation with Ca (-0.366) followed by Mg (-0.417), Cu (-0.545), Zn (-0.532) and Ni (-0.567). [17,18, 6] reported similar results [19-28].

Conclusion

Wastewater irrigation can lead to accumulation of heavy metals in the soil and, consequently, in the vegetables, which when consumed in excessive quantities can pose health risks. The results found that T7 is good for most of minerals under the study. Treatment T7 was good for these traits namely Ca, Mg, and Na. Calcium (Ca) exhibited highly significant and positive association with Mg and Na. However, it was exhibited negative association with K. Sodium (Na) showed positive and significant association with Mg. Cadmium (Cd) also exhibited positive and significant association with sodium, while sodium also showed negative and non-significant association with K followed by Fe and Cu. Se showed positive and non-significant correlation with Fe and K. However, it was exhibited negative and non-significant correlation with Ca followed by Mg, Cu, Zn and Ni.

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