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Assessment of Cadmium in Sewage Water Irrigated Soil and its Transfer to Fodder with Respect to Health of Livestock

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Abstract: *Heavy metal concentration in sewage water irrigation of fodders, milk, and soil was studied. It was a serious issue because excess of sewage water is used for irrigating crops and due to excessive use of waste-water heavy metals build up in plants and when animals consume these plants metals transfer to their bodies and milk causes different problems. Six samples were collected Trifolium alexandrinum, Avena sativa, Zea mays, Pennisetum glaucum, Sorghum bicolor, Brassica campestris from five sites. All the samples were digested by wet digestion method. After digestion a clear transparent solution of all samples was obtained which was analyzed in atomic absorption spectrophotometer. Different indices were applied including bio concentration factor, daily intake of metals, health risk index, enrichment factor, pollution lad index, correlations of fodders, soil and milk was done. Pollution load index of current study was less than 1 which indicates that soil was less polluted. Health risk for Cd was present higher than 1 which was an indication of risk to health of animals in eating Cd contaminated fodders. Daily intake of metal was lower than 1 it showed there was no risk in consuming fodders to health of animals. In water samples level of Cd was higher above permissible limit. Cd mean concentration was higher in milk than permissible limit which showed that animals graze more contaminated fodder in open areas and drink waste-water that's why metals accumulate in their tissues and milk causing toxicity.*

Keywords: *Fodders, Health risk index, Milk, Sewage water*

1. Introduction

Agriculture is an important part for the development of our country as it contributes towards the gross domestic production for country. And also provide support services. Agriculture has great importance for the Pakistan the role of agriculture in the economy and economic development of Pakistan cannot be taken side as Pakistan is still characterized as an agricultural country [1]. Due to lack of fresh water resources, water deficient countries are using waste-water for irrigation purpose. Waste-water contains important nutrients which are very important for irrigation purpose, but its continuous use build up poisonous metals in soil and plants [2]. Sewage water is polluted with industrial waste and harmful metals. In Pakistan shortage of fresh water resources leads to the use of waste water for agriculture [3]. The use of waste-water for long time builds up harmful metals in agricultural soil and plants [4,5]. The waste-water is used for irrigation continuously which causes health risk for organisms.

Water is the most important resource that supports all life on earth and it is very important to uplift the economy of country. Most of developing countries are deprived of renewable freshwater resources. The nations that have good supply of freshwater are better in economy than those that are facing limited sources of water. Irrigation requires more than eighty percent of all the available water supplies in Asia [6]. Waste-water not only solves the problem of water shortage but it also contains essential nutrients. Disposal of sewage effluents can easily be overcome through sewage water irrigation.

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Plants absorb different toxic substances when irrigated by waste-water, in this way heavy metals accumulate in the roots, shoot and leaves, which are then transferred to animals which feed on these contaminated fodder crops [7]. Through dust, waste-water and vehicular pollution fodders absorb metals which are very dangerous for health of animals who consume these fodders [8]. Sewage water contain high amount of essential nutrients adds available Cu Mn, Zn, Fe, N, P, K, and to soil. It can act as chemical fertilizer and reduce the need of fertilizers [9,10]. Most of the metals in the soil come from waste-water [11,12]. Sewage water is an important source of irrigation for fodder crops growing in vicinity of sewage contaminated sites. Sewage water contains lot of nutrients including organic and inorganic nutrients for the growth of plants. Sewage farming is commonly practiced in all urban areas of Pakistan. In cities, industries discharge waste-water which contains toxic metals. The composition of domestic sewage may vary with the type of industrial effluents released by industrial plants [13,14]. The fodder plants are important source of food for the livestock. Analysis of forages for mineral elements is important for botanical and environmental concerns. Uptake of minerals present in soil by plants give information about concentration of fodder minerals [15]. The study was carried out to evaluate the movement of Cd along soil-plant-animal continuum in response to waste-water irrigation and their implication for well-being of livestock.

2. Materials and methods

2.1. Study Area

Study area was district Mandi Bahauddin, a district of Punjab province. Soil, water, fodder and milk samples were collected during the course of study. The fodder samples used in this study were:

Table 1. List of Fodders

Barseem	*Trifolium alexendrinium*
Makai	*Zea mays*
Sarson	*Brassica campestris*
Jawar	*Sorghum bicolor*
Bajra	*Pennisetum glaucum*
Jodri	*Avena sativa*

2.2. Collection of samples

Soil was taken from depth of 0-15 cm. Fodder samples were taken into tagged plastic bags. Water and milk was taken into plastic bottles and these all were carried to lab for further analysis.

2.3. Preparation of Samples

Fodder samples were air dried and then ground in to fine powder then placed in oven at 70˚C for 72 h. 1g of sample was taken into digestion chamber and then 5mL of 68% of HNO_3 was added into sample with the help of measuring cylinder. Mixture was then left for night. The samples were then transferred to the digestion block and were provided heat for about 1 h then place to cool after this 5mL of 30% H_2O_2 added and were heated again the process of addition of H_2O_2 was repeated again and again. Until it becomes clear and allowed to cool. Then it was transferred to 50mL volumetric flask and was then taken to the atomic absorption spectrophotometer for heavy metal analysis [16]. Soil was air dried at room temperature then placed into oven at 70˚C then it was ground into pestle and mortar. After that 0.5g of soil was taken into digestion tubes and then 20 mL of HNO_3 was added and heat the tubes then cool it at room temperature and10mL H_2O_2 was added into digestion tubes. It was then heated again until it becomes colorless [16]. Water samples were digested in digestion tubes. There was 50mL of water samples and then added 10mL of HNO_3 and heated the digestion tubes in to digestion chamber and after that they were allowed to cool and were collected into volumetric flask 50mL after that they were was subjected to atomic absorption spectrophotometer for heavy metal analysis [17]. Milk samples were prepared by wet digestion method 1mL of raw milk was taken and HNO_3 about 10mL and quantity of H_2O_2 about 3mL was added the samples were heated in digestion tubes for 1 h after that the samples were cool down and H_2O_2 added again into digestion tube until it becomes colorless then filtrate was diluted with 50mL of water and were taken to atomic absorption spectrophotometer for detection of heavy metal [18].

2.4. Bio-concentration factor (BCF)

Transfer of heavy metals from soil to fodder is called bio concentration factor on the basis of dry matter

$$\text{Bio concentration} = C_{fodder}/C_{soil}$$

C_{fodder} means concentration of metals in fodders and C_{soil} means concentration of heavy metals in soil mg/kg dry weight [19].

2.5. Daily intake of metals (DIM)

The formula to determine daily intake of metal was given by Chary et al. [20].

$$DIM = C_{metal} \times \text{Conversion}_{factor} \times C_{daily}\ \text{intake of food B/ average weight}$$

C_{metal} means concentration of heavy metals, C_{daily} intake of food shows daily intake of fodder consume by animals per day in kg and conversion factor was 0.085mg/kg and B/ average weight indicates the average body weight of cattle of that area that was selected in this study. The average daily consumption of fodder was taken as 12.5kg and average weight of animal was 550 kg per cattle [21].

2.6. Health Risk Index HRI

To evaluate risk of heavy metals to health of animals by consumption of particular fodders HRI was used to determine health risk of animals by consuming contaminated fodder [22].

$$HRI = DIM/RfD$$

RfD means oral reference dose and DIM indicates daily intake of metal.

2.7. Pollution load index (PLI)

The quantity of metals present in the soil was measured by (PLI) [23].

$$PLI = C_{soil}/C_{reference\ value}$$

C_{soil} means concentration of metals which is present in soil and $C_{reference\ value}$ means reference value of soil.

2.8. Enrichment factor (EF)

EF means with holding of heavy metals in soil it. EF was applied to determine the extent of heavy metal present in the soil.

$$EF = \text{concentration of metals in contaminated soil/concentration of metals in less contaminated soil}$$ [24]

3. Results and discussions

3.1. Water

Data showed significant effect of sites on the concentration of Cd which is present in sewage water (Table 2). Cd had high concentration in water samples of site 2 and lowest was present in samples of site 4 (Figure 1). The trend of Cd was low given by Ahmad *et al*. Cd had lower value in waste water reported in current study as suggested by Ahmad *et al*. [25].

Table 2. Cd concentration in water

SOV	DF	Mean Square
Sites	4	0.006**
Error	10	0.001

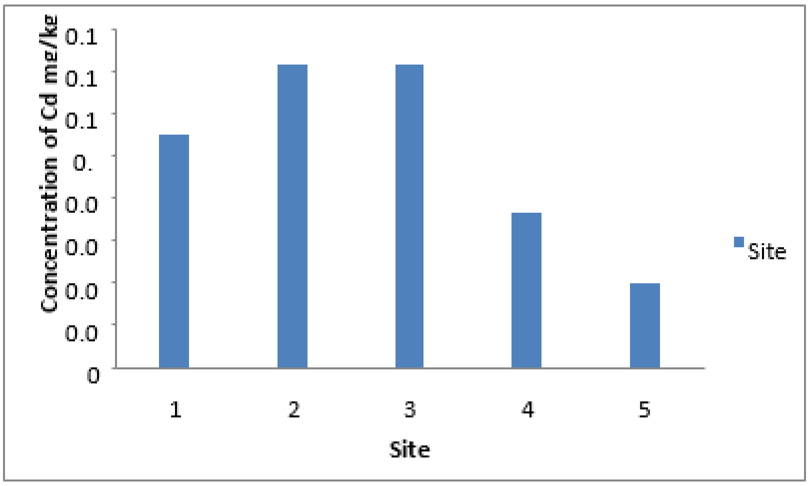

Figure 1. Cd fluctuations in water samples collected from five sites

3.2. Soil

Data showed significant effects of Cd on sites, fodders and Sites * Fodders (Table 3). The highest value of Cd was present in soil of *T. alexandrinum* at site 4 and lower value was found in *S. bicolor* at site 3 (Figure 2). Zn, Cr, Cd, Fe, Ni, Cu and Pb mean concentrations were lower as studied by Adekiya *et al*. [26]. It was found higher in contrast to present work [27]. It detected lower values of Zn, Cr, Cd while the Pb concentration was high than of these metals found in this study [28]. He suggested concentration of these heavy metals found in soil were higher Zn, Pb, Cu, Cr, Cd, Ni than present study.

Table 3. Data for Cd in soil of five sites of sewage water irrigation

SOV	DF	Mean Square
Sites	4	0.008**
Fodders	5	0.020***
Sites * Fodders	20	0.026***
Error	60	0.002

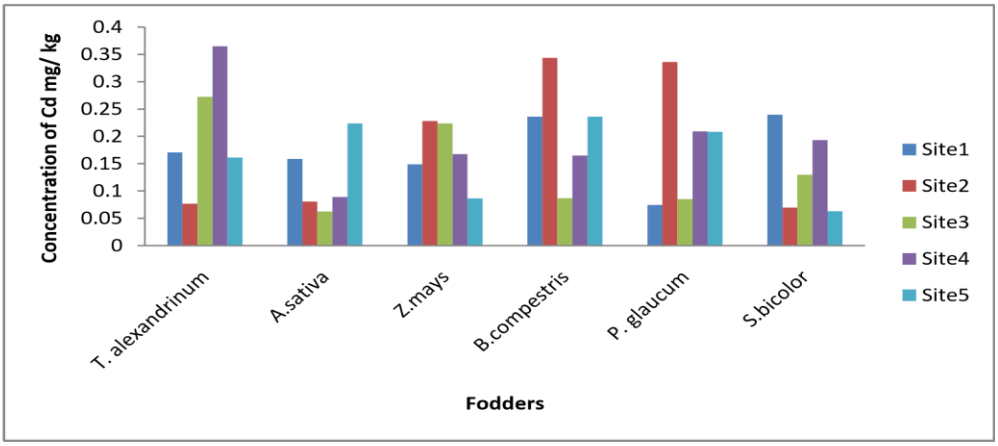

Figure 2. Cd fluctuations in soil at five sites of sampling

3.3. Fodder

Data showed significant effects of Cd on sites non significance effect on fodders and Sites * Fodders (Table 4). The highest value of Cd was found in *T. alexandrinum* at site 5 and the lowest concentration was found in *T. alexandrinum* at site 3 (Figure 3). The trend of metals observed in selected River Vaigai flowing sites. The trend was given as Ni, Cd, Cr, and Pb which was low than the present study [29].

Table 4. Cd in sewage water irrigated fodders

SOV	DF	Mean Square
Sites	4	0.263***
Fodders	5	0.045^{ns}
Sites * Fodders	20	0.054^{ns}
Error	60	0.048

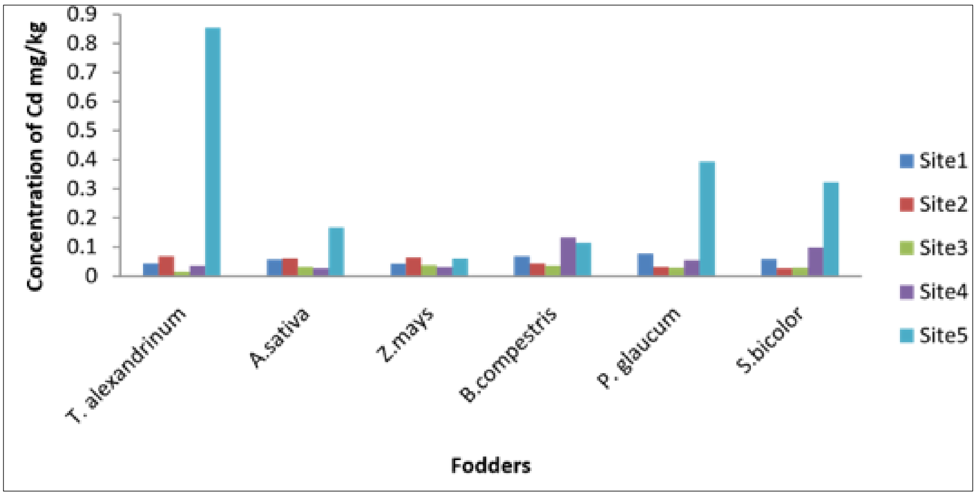

Figure 3. Cd fluctuations in fodders at five sites of sampling

3.4. Milk

Data showed there as non-significant effect of sites on concentration of Cd in milk (Table 5). Higher mean concentration of Cd was present in milk samples of site 4 and lower was present in milk from site 1 (Figure 4). The mean concentration of Cr, Cd, Fe, Zn, Cu were found higher in this work as observed by Bousbia [30]. Ismail *et al*. reported concentration of Cd, Cu, Ni, Pb in milk samples were in low quantity than of these metals found in current study [31].

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Table 5. Cd in Milk samples of five sites

SOV	DF	Mean Square
Sites	4	0.000^{ns}
Error	10	0.000

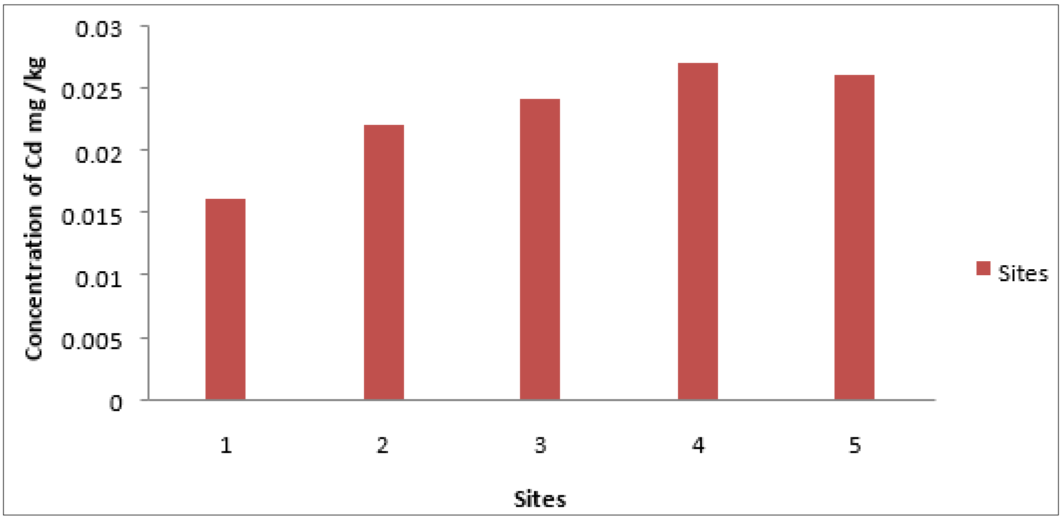

Figure 4. Cd fluctuations of Milk at five sites of sampling

3.5. Pollution load index of Cd

High concentration of Cd was recorded in soil of *T. alexandrinum* from site 4 and the least concentration of Cd was present in soil of *A. sativa* at site 3 (Table 6). Values of PLI of Cd, Cu showed by El-Aassar was higher than given in present study [31].

Table 6. PLI of Cd in soil irrigated with sewage water from five sites

Sites	*T. alexandrinum*	*A. sativa*	*Z. mays*	*B. campestris*	*P. glaucum*	*S. bicolor*
1	0.2133	0.1981	0.1858	0.2952	0.0928	0.2997
2	0.096	0.1008	0.285	0.4297	0.4202	0.0871
3	0.3403	0.0781	0.2797	0.1085	0.1065	0.1625
4	0.4562	0.1112	0.2091	0.2058	0.2612	0.2412
5	0.2016	0.279	0.1081	0.2952	0.26	0.0787

3.6. Bio concentration factor of Cd

The maximum and minimum values of BCF were found in *T. alexandrinum* at site 3 and 5 respectively (Table 7). The bio concentration factor for Cd, Cr, Zn and Cu was found high in this work in comparison to reported by Asdeo [32]. Low bio concentration factor showed the metals have high retention in the soil. The bio concentration depends upon the *p*H of the soil and they do not easily transfer to the fodder plants [19- 33]. *p*H affects the mobility of metals present in soil. High *p*H of soil causes low mobility of metals in soil [34].

Table 7. Bio concentration of Cd in fodders from five sites of sewage water irrigation

Sites	*T. alexandrinum*	*A. sativa*	*Z. mays*	*B. campestris*	*P. glaucum*	*S. bicolor*
1	0.2548	0.3659	0.2911	0.2921	1.0363	0.2460
2	0.8984	0.7583	0.2837	0.1279	0.0945	0.3916
3	0.0594	0.5152	0.1689	0.4147	0.3403	0.2207
4	0.0978	0.3011	0.1870	0.8136	0.2626	0.5077
5	5.2975	0.7479	0.6913	0.4877	1.8908	5.1317

3.7. Enrichment Factor

The highest value of enrichment factor for Cd observed was present in *T. alexndrinum* at site 5 and the lowest was detected in same plant at site 3 (Table 8). Alghobar & Suresha reported lower enrichment factor of Pb, Cr, Ni, Zn, Cu, Mn, Cd, Fe in contrast to this work. Chopra & Pathak reported significant enrichment category for Cr, Cd, Zn than present in current work which showed extremely high enrichment category [35].

Table 8. Enrichment factor of Cd in soil of five sites irrigated by sewage water

Site	*T. alexandrinum*	*A. sativa*	*Z. mays*	*B. campestris*	*P. glaucum*	*S. bicolor*
1	10.1933	14.6372	11.6476	11.6850	41.4535	9.8415
2	35.9375	30.3345	11.3508	5.1192	3.7834	15.6671
3	2.3797	20.608	6.7560	16.5898	13.6150	8.8307
4	30.9123	12.0449	7.4835	32.5440	10.5071	20.3108
5	211.9033	29.9195	27.6531	19.5088	75.6346	205.269

3.8. Daily intake of metal and Health risk index

Data depicted the maximum concentration of daily intake of heavy metals in *T. alexandrinum* at site 5 and lower concentration was present in *P. glaucum* at site 3. The highest health risk index was present in *T. alexandrinum* at site 5 and lower concentration was present in *Z. mays* at site 1. According to the values of DIM of metals Zn, Ni, Pb, Cd, Cr suggested by Ali *et al*. were lower in comparison to concentrations observed current work [36]. The heavy metals Ni, Zn, Pb, Cd, Cr was found high than given by Ali *et al*. [36]. In this work all the concentration of HRI was lower in contrast to 1 except for Cd. It means there is risk in consuming waste water irrigated fodders. Increase of heavy metal causes risk to health like neurological functions, neurotransmitter production, cardiovascular issues and gastrointestinal problems [11, 37].

Table 9. Daily intake of Cd and health risk in sewage water irrigated fodders from five sites

Sites	DIM&HRI	*T. alexandrinum*	*A. sativa*	*Z. mays*	*B. campestris*	*P. glaucum*	*S. bicolor*
1	DIM	0.0000840	0.000112	0.0000836	0.000133	0.000149	0.000114
	HRI	0.0840	0.112	0.083	0.133	0.148	0.113
2	DIM	0.0001332	0.000118	0.000124	0.000085	0.0000614	0.0000527
	HRI	0.1332	0.1182	0.1249	0.085	0.0614	0.0527

3	DIM	0.00003129	0.0000622	0.00007302	0.0000695	0.000056	0.0000554
	HRI	0.0312	0.0622	0.0730	0.0695	0.0560	0.0554
4	DIM	0.00006896	0.0000518	0.00006046	0.000259	0.000106	0.000189
	HRI	0.0689	0.0517	0.0604	0.258	0.1060	0.189
5	DIM	0.001650	0.000323	0.0001155	0.000223	0.00076	0.000625
	HRI	1.6507	0.3233	0.1155	0.2225	0.7597	0.6245

4. Conclusions

The study was done on contamination of fodders, soil water and milk by heavy metals. Sewage water is mostly used for agricultural purpose in Pakistan farmer are using sewage water for irrigation of agricultural fields because they don't have supply of water. Sewage water increase the yield of plants but at the same time build up heavy metals in soil and plants and increase soil pollution also increase the risk of plant diseases. sewage water pollute the water bodies and fodders growing in vicinity of contaminated water site accumulate heavy metals and these heavy metals gain entry into the animal body when the cattle's feed on such contaminated fodder, soil and drink wastewater. The amount of heavy metals in soil plants depends upon the irrigation and fertilizers application to the field. Sewage water contain lot of beneficial organic or in organic nutrients. Use of waste water increase growth of plants and improve the soil properties *p*H soil fertility.

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