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CADMIUM AND CHROMIUM CONCENTRATIONS IN SIX FORAGE SPECIES IRRIGATED WITH CANAL, SEWAGE OR MIXED CANAL AND SEWAGE WATER

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Abstract

Cadmium (Cd) and chromium (Cr) concentrations were investigated in six different forage species, *i.e., Trifolium alexandrium*, *Cichorium intybus*, *Avena sativa*, *Medicago polymorpha*, *Brassica campestris and Medicago sativa,* irrigated with canal, sewage or mixed canal and sewage water. The Cd levels of the forages irrigated with different water treatments in this study were greater than the tolerance level for grazing livestock reported in the literature. Thus, the Cd levels in the six plant species found in the current study showed high potential threat for livestock consuming these forages. Similarly, high levels of Cr in the six forages were observed with sewage water treatment only. However, in the present investigation, Cr concentration of forages was below the toxic level. Therefore, there was no threat of Cr toxicity for animals being reared on these forages.

Introduction

Plants are the premier source of food for animals. Forage plants absorb most of the minerals and heavy metals from the soil and some from the polluted air. Heavy metals are added to the soil through fertilization practices. Most of the heavy metals are a threat to livestock due to being highly toxic (Tokalioglu *et al.,* 2000).

Mineral deficiencies in most soils and the forages grown in such soils cause poor animal growth as well as reproductive problems even with adequate supply of forage to the animals (McDowell, 1997). Sheep and goats obtain about 60 percent of their feed from rangelands, while horses, donkeys and camels receive about half of their feed requirement from rangelands (Mahmood & Redriguez, 1993). Usually an animal needs fodder approximately 9-10 percent of its body weight each day. Based on the estimates, about 30-40 kg forage per day is consumed by a buffalo (Akram, 1987; Malik, 1988). Prasad (1992) pointed out that it is economically possible to raise dairy animals based on cultivated forage and crop residues properly. Furthermore, Gill & Bhatti (1996) have reported that the costs of livestock production can be reduced using enhanced forage production and preservation technologies.

The treated waste water is widely used for unrestricted irrigation all over the world (Khan *et al.,* 2010). Treated waste water enhances crop growth and yield in addition to providing a wide variety of nutrients to plants. It also serves as a water source for agriculture (Bouwer & Idelovitch, 1987; Feigin *et al.,* 1991; Al-Jaloud *et al.,* 1995). Despite its advantages, waste water also contains a variety of heavy metals that cause toxicity in plants and finally in animals consuming these plants. One of the toxic heavy metals is Cd, which is contemplated as one of the environmental contaminants, because many commodities of daily use are the sources of this metal (Mathew, 2002). In view of Jarvis *et al.,* (1976) 34 to 97 percent of total plant Cd is accumulated in the roots. It is fortunate that retention of heavy metals in roots is high, particularly in forages, vegetable crops and cereals the roots of which are not utilized, consequently reducing the heavy metal consumption risk for the animals and humans.

Although chromium (Cr) is placed in the category of essential nutrients for animals while it is toxic for plants even at very low concentrations (McDowell, 2003). Chromium can affect growth, lipid metabolism, immune response and it interacts with nucleic acids. Increased growth has been known in various ruminants because of Cr in their diets (Stoecker, 1996). Various plant parts have variable amount of Cr (Anderson *et al.,* 1990). Chromium concentration is found to be higher in legumes than that in most of the other foods (McDowell, 2003).

In most regions of Pakistan sewage water is used for irrigation purpose, which is usually a rich source of metals. In some parts of Sargodha, Pakistan, this practice is very common, so it is highly likely that forage species being grown on such soils may accumulate high amounts of metals including Cr and Cd. Thus, the main purpose of carrying out this investigation was to determine the accumulation of Cd and Cr in different winter forage species often irrigated with sewage water.

Materials and Methods

Experimental sites: The experimental sites were agricultural pasture lands of Chak No. 101 NB, district Sargodha. The pastures are located 13 km from the Sargodha city. The district receives yearly, on an average, 180 to 200 mm rain. The city has an extreme hot and cold climate. The maximum temperature reaches 50 ºC in the summer season, while the minimum recorded temperature is as low as freezing point in the winter season.

Treatments: Six forage species including berseem clover (*Trifolium alexandrium*), cichory (*Cichorium intybus*), oat (*Avena sativa*), California burclover (*Medicago polymorpha*), field mustard (*Brassica campestris*) and lucerne (*Medicago sativa*) were obtained from three pasture fields irrigated with canal water, sewage water, and mix water (canal + sewage water). Five samples from each forage species were obtained randomly from five feeding sites of each field following Fick *et al*. (1979).

Digestion of samples and mineral determination: After carefully separating the shoot from roots, the shoot samples were washed with tap water and then with distilled water. After recording the fresh weights the shoot samples were oven-dried at 65^{o}C to constant weight. Dried shoot samples of different forages were ground into a fine powder (80 mesh) using a commercial blender (TSK-Westpoint, France) and stored in polyethylene bags, until used for acid digestion.

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The digestion of shoot samples was performed using the wet digestion method. One gram of sample was digested with 4.0 ml of H_2SO_4 and 8.0 ml of H_2O_2 in a flask by placing the digesting material in a digestion chamber. When fumes stopped evaporating, the samples were removed from the digestion chamber. Two ml of H_2O_2 were added to each sample and it was heated again in the digestion chamber. The process was repeated until the sample became colorless. The volume of the sample was increased to 50 ml by adding double distilled water. All diluted samples were kept in labeled plastic bottles in a refrigerator. Measurement of Cd and Cr concentrations in the digested samples was performed using an atomic absorption spectrophotometer (Perkin Elmer Corp., 1980) according to Dudjak *et al.* (2004).

Statistical analysis: Experimental treatments consisted of factorial arrangement of type of irrigation water and forage species. The data were analyzed using the GLM procedure of Anon., (2003) according to the following model:

$$Y_{ijk}=\mu + W_i + F_j + WF_{ij} + \varepsilon_{ijk}$$

where Y_{ijk} is observation, μ is overall mean, W_i is the effect of source of water (i= 1 to 3), F_j is effect of forage (j= 1 to 6), WF_{ij} is the effect of interaction of W and F and ε_{ijk} is the residual effect. Duncan's New Multiple Range test was employed to determine the differences among the means.

Results

Shoot Cd concentration in all six forage species (Fig. 1) was significantly affected by water treatment. The forage species differed significantly ($P < 0.05$) in shoot Cd concentration. However, the interaction term (water x forage species) was not significant. Cadmium concentration in the shoots of all forages was lower when used mixed canal and sewage water compared to canal water or sewage water (6.60 *vs.* 8.04 and 7.79 mg/kg dry weight) for irrigation. Cadmium concentration in the shoots of different forage species ranged from 6.69 to 8.32 mg/kg of dry weight being higher in oat compared to that in berseem clover, cichory and lucerne.

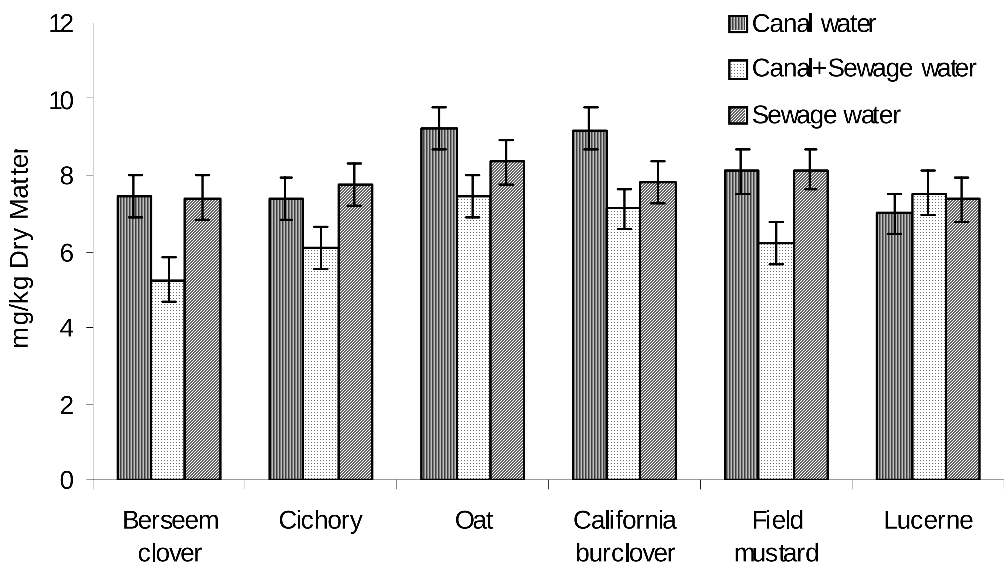

Fig. 1. Cadmium concentration (mean and standard error) in shoots of different forage species irrigated with canal, sewage or mixed canal and sewage water.

Shoot Cr concentration in the six forage species (Fig. 2) was significantly affected by different water treatments. Shoots of California burclover, irrigated with sewage water, had the highest Cr concentration (11.78 mg/kg dry weight) of all forages examined in the study. Shoots of oat irrigated with canal water or mixed canal and sewage water, had the lowest Cr concentration (2.58 and 2.81 mg/kg dry weight, respectively). Other treatments yielded moderate shoot Cr concentrations.

Discussion

The concentrations of shoot Cd in different forages found in our study were higher than the tolerated level (5.0 mg/kg) for grazing livestock suggested by Anon., (1980), so Cd concentration revealed high potential risk for livestock consuming the forages irrigated with different water treatments. The Cd concentrations found in the present investigation are lower than those reported earlier in some areas of Nigeria polluted with cement kiln dust (Oluokun *et al*., 2007), while the values are higher than those from urban, suburban, rural, roadside and industrial areas reported by Aksoy *et al*. (2000). It has been shown that sewage water (Dheri *et al.,* 2007) contain high quantities of Cd. Therefore, it is possible that Cd had been accumulated in the soil from which the forages were harvested. Due to higher Cd concentration of sewage water compared to that in canal water, it is expected that forages irrigated with canal water would have the lowest

Cd concentration and those irrigated with sewage water would have the highest Cd concentration. The results of this experiment show that forages irrigated with canal or sewage water had the highest Cd concentration while those irrigated with mixed canal and sewage water had the lowest Cd concentration. The cause for this discrepancy is unknown. Hence, further research regarding Cd concentration in canal and sewage water and soil is needed.

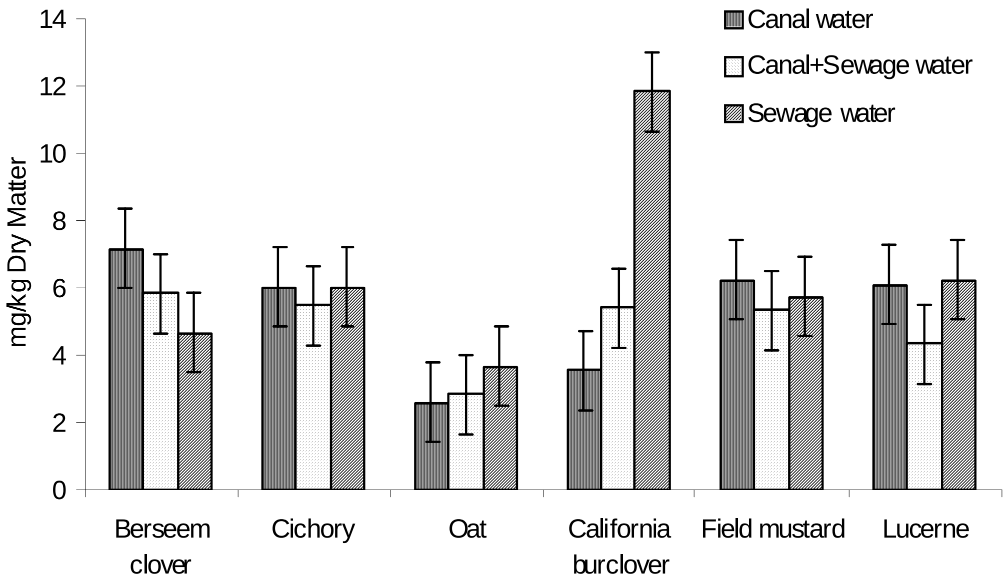

Fig. 2. Chromium concentration (mean and standard error) in shoots of different forage species irrigated with canal, sewage or mixed canal and sewage water.

All the mean Cr concentrations in the shoots of forage species irrigated with various water treatments were lower than the Cr level suggested by Ahmad *et al*. (2009). Chromium has been reported to be very dangerous for livestock health if a diet contains higher levels Cr than the tolerated level as reported by Anon., (1980). In the present investigation, Cr level was below the toxic limit, so hazardous effect of Cr to the animals consuming these forages cannot be expected.

In conclusion, Cd levels in the shoots of all six forages were low when mixed canal and sewage water was used and the forage species differed in Cd concentration regardless of water treatment. Shoot Cr levels were also affected by different water treatments. California burclover irrigated with sewage water had the highest shoot Cr concentration while the oat shoots had the lowest Cr concentration regardless of water treatment.

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