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Research Note

Lead, Cadmium and Chromium Levels in Vegetables Grown in Urban Sewage Sludge—Hyderabad, India

ABSTRACT

The present paper examines levels of metal contamination of vegetables grown on urban sewage sludge. Vegetable samples of spinach, amaranthus and cabbage, were collected along the cultivated sites of the River Musi, which carries the urban sewage load of Hyderabad city. Lead, cadmium and chromium levels of these metals were detected in both soil and food crops, indicating possible health hazard for consumers.

INTRODUCTION

Exposure of man to various metals has generated justified global concern and this is now reinforced by public cognisance. Food forms the major non-occupational source for the exposure of man to toxic metals, and varying amounts have been found in all foods (Hutchinson *et al.*, 1974). Vegetables absorb these metals from the soil in which they are grown. The principal access is through roots (Haghiri, 1973); nevertheless, Buchauer (1973) reported leaves as principal traps for metals, especially lead. Thus plants absorb toxic metals from both soil and atmosphere, although species specific differences are enormous (Dedolph *et al.*, 1970).

In drought-prone areas of India, it has been a common practice to cultivate food crops in sewage sludge. Municipal sewage water and untreated sludge may contain elevated concentrations of Pb, Cd, Cr, Ni, etc., resulting from industrial waste (Berrow & Webber, 1972), and these metals are frequently absorbed by edible crops grown therein (Furr *et al.*, 1980).

The present study has been aimed at understanding the levels of contamination of some toxic metals like lead, cadmium and chromium in

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fresh leafy vegetables grown in patches all along the bank of the River Musi, which carries the municipal sewage load of Hyderabad city. This study may serve as baseline data for further investigation.

MATERIALS AND METHODS

Sludge and vegetable samples were collected all along the bank of the River Musi, wherever cultivation is in practice. Vegetables and soils were also collected from areas free from sludge and industrial pollution, to serve as controls.

The vegetables were washed with distilled water to eliminate air-borne pollutants. The washed samples were dried on filter paper to eliminate the excess moisture. Once dry, each sample was weighed (20 g) and dried in an oven at a temperature lower than 80°C for 26–36 h and, from the dried sample, 1 g was placed in a muffle furnace and ashed at 450°C. The ashed sample was digested with 20% HCl following the procedure adopted by Zurera *et al.* (1985) with little modification.

Sludges were dried, pulverised and passed through +80 mesh and extracted with acid solution following the procedure of Kanicky *et al.* (1989). Analyses of lead, cadmium and chromium in vegetables and sludge were carried out using a Perkin–Elmer 273 atomic absorption spectrophotometer equipped with a lead hollow cathode lamp, operated at 283·3 nm, cadmium hollow cathode lamp operated at 228·8 nm and a chromium hollow lamp operated at 357·9 nm, respectively.

RESULTS AND DISCUSSION

Lead, cadmium and chromium in sludge

Results indicate a uniformly high degree of contamination in sludge (Table 1a), when compared to soil samples free from sewage pollution (Table 2a). Lead is found in higher concentration in sludge, followed by chromium and cadmium. The concentration of heavy metals in sludge is high, but it is comparatively less than that found in sludge of other countries like the UK (Williams, 1975). The main source of lead, cadmium and chromium is attributed to industrial wastes which are frequently drained into urban sewage.

Chromium exists in soil as Cr(III) and Cr(VI) ions. Cr(III) is the stable form of chromium (Cary *et al.*, 1977), but studies of Bartlett and James (1979) clearly indicate that Cr(III) could be readily oxidised to Cr(VI). They

TABLE 1a
Heavy Metal Concentrations in Sludge (ppm)

Metal	*No. of samples*	*Range*	*Arithmetic mean*
Lead	20	80·00–280·35	183·5
Cadmium	20	12·50–35·50	22·00
Chromium	20	42·00–143·25	83·20

TABLE 1b
Heavy Metal Concentrations in Different Food Crops Grown in Sewage Sludge (ppm)

Food crops	*No. of samples*	*Range*	*Arithmetic mean*
Lead			
Spinach leaf	20	5·50–22·58	14·94
Spinach root	20	6·00–23·61	16·10
Amaranthus leaf	20	7·50–14·50	12·2
Amaranthus root	20	3·00–68·20	38·57
Cabbage leaf (inner leaves)	10	5·50–10·14	7·52
Cabbage root	10	9·00–15·58	12·64
Cadmium			
Spinach leaf	20	0·95–9·67	6·40
Spinach root	20	3·20–14·70	8·20
Amaranthus leaf	20	1·50–2·70	1·10
Amaranthus root	20	2·50–14·10	8·44
Cabbage leaf (inner leaves)	10	1·30–4·75	2·88
Cabbage root	10	3·15–8·10	6·40
Chromium			
Spinach leaf	20	5·50–22·58	13·48
Spinach root	20	6·00–23·61	15·00
Amaranthus leaf	20	7·50–14·50	10·12
Amaranthus root	20	3·00–68·20	29·22
Cabbage leaf (inner leaves)	10	4·00–9·00	6·21
Cabbage root	10	8·00–13·58	10·55

TABLE 2a
Heavy Metal Concentrations in Soil Free from Sludge and Industrial Pollution (ppm)

Metal	*No. of samples*	*Range*	*Arithmetic mean*
Lead	20	0·5–7·8	3·4
Cadmium	20	0·02–2·8	0·5
Chromium	20	10·5–25·5	18·55

TABLE 2b
Heavy Metal Concentrations in Different Food Crops from Uncontaminated Sites (controls) (ppm)

Food crops	*No. of samples*	*Range*	*Arithmetic mean*
Lead			
Spinach leaf	10	0·03–0·18	0·05
Spinach root	10	0·08–2·45	1·4
Amaranthus leaf	10	0·09–1·55	0·12
Amaranthus root	10	0·94–2·30	1·41
Cabbage leaf (inner leaves)	10	0·19–1·00	0·64
Cabbage root	10	0·98–3·52	2·66
Cadmium			
Spinach leaf	10	0·05–0·58	0·13
Spinach root	10	0·15–1·11	0·41
Amaranthus leaf	10	0·08–0·22	0·14
Amaranthus root	10	0·14–0·28	0·18
Cabbage leaf (inner leaves)	10	0·01–0·05	0·02
Cabbage root	10	0·14–0·24	0·19
Chromium			
Spinach leaf	10	0·14–1·22	0·55
Spinach root	10	0·86–2·64	1·11
Amaranthus leaf	10	0·41–1·61	0·53
Amaranthus root	10	2·24–3·88	2·64
Cabbage leaf (inner leaves)	10	0·86–1·88	0·98
Cabbage root	10	2·6–4·1	3·81

also show that significant amounts of chromium oxidised by soil may remain as Cr(VI) for several months, which is potentially toxic.

Lead, cadmium and chromium in vegetables

In Table 2a metal concentrations of vegetables grown in sewage sludge are presented. It is clear from the results that all the leafy vegetables have accumulated higher amounts of metal when compared to those from unpolluted areas (Table 2a).

Even though lead is considered to be an immobile element and tightly bound in roots (Malone *et al.*, 1974), its concentration is found to be uniformly high, reaching up to 14·94 ppm in spinach. Probably aerial deposition might have contributed to some extent.

Vegetable crops, especially leafy ones, usually show higher concentrations of cadmium than those found in grains and tubers (Underwood, 1979). Though natural variations in concentrations of cadmium observed for crops vary substantially, cabbage and spinach showed higher uptakes of cadmium than amaranthus from the soil. Our results are consistent with the report of Williams and David (1973), who showed that spinach and cabbage have the ability to accumulate more cadmium than other vegetables.

Though the transport of chromium up the roots is slow (Skefflington *et al.*, 1976), Bourque *et al.* (1967) concluded that chromate, but not chromic ions were absorbed by the roots. Though species differed in their ability to accumulate the elements in roots and shoots (Cary *et al.*, 1977), spinach was found to contain higher amounts of chromium even in normal soils (Renan *et al.*, 1979). We did not find any significant differences in the uptakes of chromium in the vegetables.

CONCLUSION

From our studies we conclude that, in an urban community, dietary intake of leafy vegetables constitutes a major source of long term low level body accumulation of heavy metals, especially cadmium. The detrimental impact of these metals becomes apparent only after decades of exposure. Monitoring of heavy metals in plant tissues becomes essential to prevent excessive build up of these metals in the human food chain.

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