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Cadmium and Selenium Absorption by Swiss Chard Grown in Potted Composted Materials

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Composting yard waste (Glenn 1990), sewage sludge and, to a lesser extent, municipal solid waste (MSW) which is supposed to consist of mainly food waste and paper is underway in a growing number of communities. It is also not uncommon to co-compost these materials (Goldstein 1991). In greenhouses and nurseries, plant growth media commonly consists of a combination of peat moss with perlite or vermiculite yielding a mixture much lighter than soil and therefore easier to handle. Since composted organic wastes are comparatively light, these are being mixed with material such as perlite and used for plant growth by some greenhouse operators and nurserymen, especially when the compost can be obtained at no cost.

Some greenhouse operators grow potted vegetable plants for transplanting as well as flowers. The various compost materials, especially those produced from sewage sludge or MSW, can contain significant concentrations of toxic elements such as cadmium and selenium (Lisk et al. 1992). It was of interest to learn the possible magnitude of absorption of cadmium by the edible portion of potted plants grown in the various compost materials. In the work reported here, swiss chard was grown in the various types of compost and analyzed for cadmium and selenium.

MATERIALS AND METHODS

Four composts were obtained for use in this study. These included composts made from (1) sewage sludge, (2) sewage sludge and yard waste, (3) sewage sludge, yard waste and municipal solid waste (MSW) or (4) yard waste, the latter used as the control. The compost resulting from the mixture of sewage sludge, yard waste and MSW was produced in an aerated vessel. Each of the other composts was produced by the windrow method.

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The total material (about 15 kg) obtained from each location was air-dried at room temperature. Stones, glass, ceramic, metal and plastic objects were removed and the remaining material was pulverized to pass through a 5-mesh (4-mm opening) screen. The compost was then reduced to a fine powdery consistency in a hammermill and the entire sample mixed by tumbling. Each compost was mixed with 25% perlite (v/v) by tumbling and the mixture was placed in plastic pots 12.5 cm both in height and top diameter. Light materials such as perlite are commonly added to composts by nurserymen to promote drainage and root aeration. In March, 1992, five replicate pots of each treatment were seeded with "Fordhook Giant" swiss chard (*Beta vulgaris* L.) and, after germination, they were thinned to 1 plant per pot. Each pot was fertilized biweekly with 100 ml of a solution containing, respectively, 449, 209 and 423 ppm of N, P and K. All plants were watered as required.

The swiss chard was harvested when the plants were about 12 cm high. The cuttings were freeze-dried, milled through a 16-mesh screen, mixed by tumbling and subsampled for the determination of cadmium and selenium. The composts were also subsampled for analysis. The analytical procedure for cadmium involved dry ashing 0.4 g of each plant or compost sample overnight at 450° C in a quartz test tube. After cooling, 0.5 ml of 50% hydrogen peroxide was added and the mixture was evaporated to dryness in an oven (80° C). The dry contents were again ashed at 450° C for 2 hours. The residue was dissolved in 1 ml of concentrated hydrochloric acid using ultrasonic agitation for 1 hour. The solution was diluted to 10 ml with distilled, deionized water. Cadmium was determined with a model 975 Jarrell Ash inductively coupled argon plasma emission spectrometer equipped with a fixed cross-flow nebulizer. Selenium was determined by the method of Olson (1969) employing wet digestion of the sample with nitric and perchloric acids and measurement of the fluorescence of plazselenol formed by the reaction of selenium with 2,3-diaminonaphthalene.

Comparison of the mean concentrations of cadmium and selenium in swiss chard grown in each of the compost medias versus that in the control was made using Students t test (Steel and Torrie 1960).

RESULTS AND DISCUSSION

The cadmium and selenium contents of the composts and the pH of the corresponding growth media are given in Table 1. The presence of appreciable levels of cadmium and selenium in composts derived from sewage sludge and/or MSW has been shown by Lisk et al. (1992). Heavy metals such as cadmium in the source materials would expectedly be further concentrated during the composting process as organic material is oxidized. This would also be true of selenium to the extent that it is not lost by vaporization during the composting process.

Table 1. Cadmium and selenium content of composts and pH of the corresponding growth media

Compost type	(ppm, dry wt) Cadmium	Selenium	pH of growth media
Sewage sludge	5.41	7.20	7.3
Sewage sludge and yard waste	6.12	8.80	7.1
Sewage sludge, yard waste and MSW[a]	6.91	0.60	7.3
Yard waste (control)	0.79	0.20	6.9

[a]Municipal solid waste

The concentrations of cadmium and selenium in the various compost-grown swiss chard are given in Table 2. The concentration of each element in swiss chard grown in each of the composts versus that in the control chard was significantly higher ($p < 0.01$). Uptake of heavy metals such as cadmium by vegetables (Hirschheydt and Schwergenbach 1985; Petruzzelli et al. 1989) and Petunias (*Petunia grandiflora*) (Smith 1992) grown on compost-treated soils has been reported.

The concentration of cadmium and selenium in plants grown in such composts will depend on a number of factors. The content of these elements in the compost is an important determinant. Thus, in this study, the correlation coefficients (r) between the concentrations of cadmium and selenium in the swiss chard and those in the corresponding composts were respectively, 0.9965 and 0.9319. Composts prepared from sewage sludge and MSW would typically be higher in cadmium than yard waste compost and sewage sludge is a contributor to the selenium content of compost (Lisk et al. 1992). The nature of the plant is important. Lettuce for instance (and also swiss chard) is known to concentrate cadmium more efficiently than many other plants when grown on sludge-treated soils (Furr et al. 1981). Cabbage has been shown to absorb more selenium than some other common vegetable crops (Furr et al. 1979). As compost pH diminishes below pH 7, cadmium availability to plants would also expectedly increase provided the degree of acidity does not ultimately retard plant growth (Furr et al. 1981). Conversely, the availability of selenium increases with increasing soil pH. The volume of compost in which the plants are grown and the maturity of the plants at the time of transplanting, would also expectedly affect the cadmium or selenium concentration in the plants.

Table 2. Concentration of cadmium and selenium in the various compost-grown swiss chard

Compost type	(ppm, dry wt)[a] Cadmium	Selenium
Sewage sludge	1.39 ± 0.18[x]	0.09 ± 0.01[x]
Sewage sludge and yard waste	1.70 ± 0.16[x]	0.17 ± 0.01[x]
Sewage sludge, yard waste and MSW	1.75 ± 0.18[x]	0.04 ± 0.01[x]
Yard waste (control)	0.50 ± 0.05[y]	0.01 ± 0.00[y]

[a]Average ± standard error (n = 5); dissimilar letter superscripts indicate significant differences ($p < 0.01$) between the cadmium or selenium concentration in swiss chard grown on each of the composts versus that in the control chard.

There is probably little risk in the growth of edible plants in potted compost for transplanting. Considerable growth dilution of the initial cadmium concentration in the potted plants will undoubtedly occur assuming that the crop is transplanted in uncontaminated soil. Conversely, the concentrations of selenium in the swiss chard grown in the sludge-containing composts (Table 2) are closer to the range considered adequate (0.1-0.2 ppm) to meet the dietary requirement of the element for animals and humans as compared to the deficiency level contained in the control chard. Nevertheless, to minimize cadmium concentrations in edible plants, composts deriving from yard waste would be a better choice for the growth of such transplants than sewage sludge or MSW composts.

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