Cadmium transfer through a soil-plant-aphid system to the larvae of the green lacewing (*Chrysoperla carnea*) after the amendment of soil with sewage sludge.

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Introduction

Recycling the nutrients in sewage sludge within agriculture may contaminate soil with Cd (1). Subsequent biomagnification of Cd in the food chain may result in the secondary poisoning of predatory arthropods important in the biological control of crop pests. However, little is known about the transfer of Cd in agricultural soil-plant-arthropod systems. This work examines the transfer of sludge applied Cd in a sludge amended soil-barley-aphid-predator system, with particular reference made to the role of the plant.

Method

A sandy loam soil was amended with anaerobically digested sewage sludge at four treatment rates (0, 10, 30 or 100 t (dry solids) ha^{-1}). Six 7.5 litre pots were filled with the soil from each treatment and pots seed with spring barley (*Hordeum vulgare* cv. Optic). Cultures of grain aphids (*Sitobion avenae*) were established on the plants during tillering. Pots were then covered with netting and placed in a randomised block in a glasshouse. Ten days later,10 second instar green lacewing larvae (*Chrysoperla carnea*) were added to each pot. When the larvae pupated, they were sampled along with the soil, roots, shoots and aphids from each pot for subsequent determination of Cd concentrations.

Results

- Cd concentrations (Figure 1) differed significantly among treatments only in the soil ($F_{(3,19)}$ = 18.6, P < 0.001) and shoots ($F_{(3,19)}$ = 3.7, P = 0.03).
- Appreciable biomagnification was only found in lacewing pupae (Table 1).
- Accumulation in barley shoots appeared to reach a plateau around 0.22 mg kg^{-1}, as a result of decreasing translocation from the root (Figure 1 & Table 1).
- A planned polynomial comparison showed a significant quadratic trend in shoot Cd concentration with increasing sludge amendment ($F_{(1, 20)}$ = 8.4, P = 0.01), confirming a plateau had been reached.
- Significant correlations were only found between Cd concentration in the soil and in the root and between the concentration in the shoots and in aphids (Table 2).

Figure 1. Cd concentrations in soil, barley shoots , grain aphids and lacewing pupae following the amendment of soil with sewage sludge (error bars ± 1 SE).

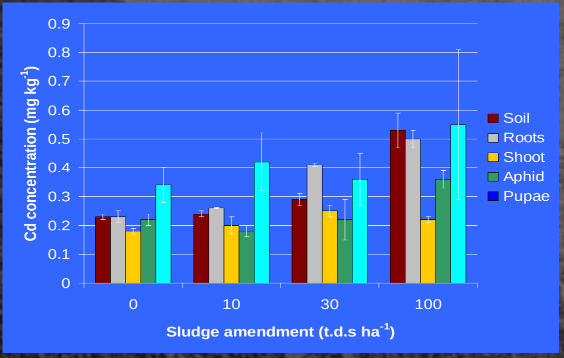

Table 1. Cadmium transfer co-efficients between the various components of the soil-barley-aphid-lacewing system.

Amendment Rate	Soil-Root	Soil-Shoot	Root-Shoot	Shoot-Aphid	Aphid-Pupae
0	0.99	0.77	0.83	1.21	2.20
10	1.08	0.84	0.80	0.91	3.62
30	1.47	0.90	0.69	0.86	1.5
100	0.98	0.44	0.46	1.56	3.19

Table 2. Spearman rank order correlation coefficients for Cd concentration between the various components of the soil-plant-aphid-lacewing system.

	Soil	Root	Shoot	Aphid
Root	0.63**	-	-	-
Shoot	0.18	0.30	-	-
Aphid	-0.23	-0.27	0.43*	-
Pupae	-0.03	0.08	-0.11	-0.18

* P < 0.05, ** P < 0.01

Discussion and Conclusions

- Cd was freely accumulated by the roots. However, translocation to the shoot was regulated, resulting in a plateau in shoot concentrations.
- Cd concentrations in the aphids were related to those in the shoot. Therefore, regulation of the shoot concentration resulted in no accumulation of Cd in aphids.
- The lack of accumulation in the aphids was repeated in the lacewing pupae. However, there was considerable biomagnification of Cd in the pupae compared to the aphids on which they fed.
- Biomagnification may reflect that lacewing larvae feed on soft tissues, in which both concentration and availability of Cd may be high compared to the whole animal (3, 4). This would also account for the lack of a significant correlation between the concentration of Cd in the whole aphids and in the lacewing pupae.
- We conclude that the regulation of root to shoot Cd translocation is of fundamental importance in restricting Cd transfer from sewage sludge amended soils to higher trophic levels. This may protect *C. carnae* larvae from the potential toxic effects caused by their biomagnification of Cd.

References

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