LAND APPLICATION OF SEWAGE SLUDGE LANDFILL LEACHATE

Rhode Island
Water Resources Center

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Final Report

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Abstract

This investigation evaluated the feasibility of the "living filter" concept as an alternative method of heavy metal leachate disposal to prevent contamination of ground-waters. Leachate collected from a simulated sewage sludge landfill was applied at rates of 0, 200, 400, and 600 Kg N/ha/yr to plots of rye grass (*L. perenne*) to evaluate the attenuation of contaminants. The concentrations of metals Cd, Cu, Fe, Ni, Pb and Zn, as well as nitrogen content, were analyzed over a 5 month period in soil, soil-water lysimeter extracts, and grass samples before, during and after application of landfill leachate. Exchangeable nitrogen (NH_4 + NO_3^- + NO_2^-) concentrations in soil were significantly higher at the 600 Kg N/ha/yr rate while significantly greater concentrations were retained within the surface 30 cms. Soil-water extracts were significantly higher at the 400 and 600 Kg N/ha/yr rate and also highest in the surface layers. The concentrations of metals in the soil and soil-water extracts remained generally unchanged statistically. Yields of rye grass did not differ significantly within the three rates of N application, but exchangeable nitrogen was highest at the 600 Kg N/ha/yr rate. In general, heavy metal accumulation in the soil was not a problem but nitrogen contamination to ground-waters could be an area legitimate concern when applying sewage sludge landfill leachate to a grass crop.

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Objective

The objective of this research was to evaluate the feasibility of applying sewage sludge landfill leachate to a grass crop as a means of attenuating heavy metal contaminants. The effectiveness of such a "living filter" system was assessed over a five month period from June - November 1982. The concentration of metals Cd, Cu, Fe, Ni, Pb and Zn, as well as nitrogen content were analyzed in soil, soil-water lysimeter extracts, and grass samples collected from experimental plots before, during, and after treatment with landfill leachate at rates of 0, 200, 400 and 600 kg N/ha/yr.

Methods

A miniature landfill, 2 m deep x 8 m x 1.5 m was excavated, lined with 6 mil polyethylene, equipped with a leachate collection system and filled with primary treated, super-chlorinated sewage sludge from South Kingstown's treatment facility. Sludge samples were collected, oven dried at 60°C for 12 hours and ground in a Wiley mill through a 40 mesh sieve. One gram samples were ashed over night in a muffle furnace at 800°F, dissolved in 5 ml of 2N HCl, vacuum-filtered into a 50 ml volumetric flask and brought to volume with distilled water according to standard dry ashing procedures (Perkin Elmer Corporation, 1976). Heavy metal concentrations were determined using a Perkin Elmer (Model 5000) atomic absorption through #2 Whatman filter paper and analyzed by atomic absorption. Suction lysimeters were installed within each plot at depths of 30, 60 and 90 cm and sampled on a bi-weekly basis. Soil-water extracts were analyzed for nitrogen and metals according to previously referenced standard procedures. Each month, prior to heading, rye grass was harvested, oven dried at 60°C for 1 week, with dry weights and percent yields recorded. Samples were ground on a Wiley mill through a 40 mesh sieve and analyzed for metals following standard Perkin Elmer procedures. Total nitrogen content was determined using standard macro kjeldahl methods (Bremner, 1965). Duncan's multiple range test was performed on all laboratory and field data at the 95% level of confidence.

Results

Total analyses of the sewage sludge are presented in Table 1. Concentrations of Cu, Fe, Ni, and Pb were somewhat higher than concentrations extracted from similar material by Galgowski (1980), while concentrations of Cd and Zn were slightly lower. Total nitrogen data were comparable.

Properties of sewage sludge landfill leachate are presented in Table 2. Overall, metal and inorganic nitrogen concentrations significantly increased over time, with the exception of Pb.

Table 2. Average metal ion concentrations and total inorganic nitrogen content in raw leachate over time.

Sample Date	Metals						Exch. Nitrogen
	Cd	Cu	Fe	Ni	Pb	Zn	$NH_4 + NO_3 + NO_2$
—Month—	μg/gm						
7/82	0.03bc*	0.5b	55b	N.D.	1.1a	0.5b	964a
8/82	0.03bc	0.6b	76ba	0.01b	0.2a	0.7b	1349c
9/82	0.04b	0.7b	89a	0.05a	0.2a	0.9a	1458b
10/82	0.06a	1.9a	94a	0.07a	0.1a	1.6a	1504b

N.D. None detected.

*Values followed by the same letter within a column are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 3. Average metal ion and nitrogen concentration in soil samples as affected by rate of leachate application.

Leachate Rate	Metals						Exch. Nitrogen
	Cd	Cu	Fe	Ni	Pb	Zn	$NH_4 + NO_3 + NO_2$
kg N/ha/yr	μg/ml						
0	0.04ab*	0.32a	3.9a	0.16a	2.5a	0.53a	26.5b
200	0.04ab	0.30a	4.9a	0.16a	2.1a	0.57a	28.6b
400	0.03b	0.27a	3.2a	0.22a	2.1a	0.75a	32.6b
600	0.05a	0.23a	3.3a	0.18a	2.7a	0.84a	47.0a

*Values followed by the same letter within a column are not significantly different at the 5% level (Duncans Multiple Range Test).

Table 5. Average metal ion and nitrogen concentration in soil samples as affected by depth.

Soil Depth	Metals						Exch. Nitrogen
	Cd	Cu	Fe	Ni	Pb	Zn	$NH_4 + NO_3 + NO_2$
—cm—	μg/gm						
30	0.07a*	0.14a	1.5b	0.20a	3.4a	0.74a	41a
60	0.02b	0.29a	4.0ab	0.13a	2.1a	0.77a	32b
90	0.02b	0.39a	6.3a	0.19a	1.5a	0.51a	29b

*Values followed by the same letter within a column are not significantly different at the 5% level (Duncan's Multiple Range Test).

with 400 kg N/ha (Table 6). Cd levels in the soil-water extracts increased with higher rates of N application and attained highest concentrations in the top 30 cm of the profile (Table 7). This indicates that Cd would not present a problem to ground-water contamination at the present levels of leachate application. No differences in concentrations of Cu or Zn in depth were detected in the soil-water extracts. Sampling date was not significantly relevant to levels of Cu or Cd in soil-water extracts. However, concentrations of Cd were highest on 6/29, while Fe and Ni concentrations were generally highest in the last two sampling months. Zn concentrations increased ten fold after 1 month then significantly decreased each successive month thereafter (Table 8).

Nitrogen content and yield in grass harvests as affected by leachate application rate is presented in Table 9. In general, no significant differences in metal concentrations were detected. A slight increase in nitrogen content was shown in harvests from plots receiving higher rates of nitrogen when compared to control plots. Grass yields were significantly greater in samples from plots that were treated with leachate at a rate of 400 kg N/ha. Although no obvious trends in metal concentrations in harvested grass were detected for sampling dates, significant differences were observed. The concentrations of Cd were significantly higher in the initial month. Iron and Zn concentrations increased over time and were significantly more concentrated in grass samples collected from the final harvest. Levels of

Table 8. Average metal ion concentration and nitrogen content in soil-water extracts as affected by sampling date.

Sample Date	Metals						Exch. Nitrogen
	Cd	Cu	Fe	Ni	Pb	Zn	$NH_4 + NO_3 + No_2$
—Month—	µg/ml						
6/15	§	0.02ab*	0.06b	§	0.02c	0.06c	3.3b
6/29	0.03	§	0.02b	0.02b	0.04b	0.11bc	2.2b
7/20	§	0.01ab	0.06b	0.03b	0.18a	1.04a	6.8b
8/24	§	0.01ab	0.07b	0.02b	0.01c	0.92a	37.9a
9/28	§	0.03a	0.35a	0.12a	0.01c	0.47b	35.0a
10/13	§	0.02ab	0.03b	0.15a	0.02c	0.39bc	28.5a

*Values followed by the same letter within a column are not significantly different at the 5% level (Duncan's Multiple Range Test).

§Below detection limits.

Table 10. Average metal ion concentration, nitrogen content and yield in grass samples as affected by sampling date.

Sample Date	Metals						Exch. Nitrogen	Yield
	Cd	Cu	Fe	Ni	Pb	Zn	$NH_4 + NO_3 + NO_2$	
—month—	μg/gm							—kg/ha—
6/82	2.32a*	9c	222c	0.7b	3.6b	22d	3.0c	1915c
7/82	0.03b	17a	322b	3.2a	4.2b	27b	2.6d	4675a
8/82	0.05b	13b	281bc	1.0b	8.3a	24c	3.7b	3246b
9/82	0.23b	11bc	594a	0.6b	5.4b	29a	3.9a	3500b

*Values followed by the same letter within a column are not significantly different at the 5% level (Duncan's Multiple Range Test).

ment with sewage sludge landfill leachate was well within the expected range of soil nitrogen for this region (Millar, 1955). Preliminary analysis of the nitrogen content in soil-water extracts indicates that the nitrate-N exceeds maximum concentration levels of 10 ppm. Percent total nitrogen content in harvested rye grass samples was comparable to percent total nitrogen content typically found in 10-14" tall rye grass plants (Millar, 1955). In conclusion, accumulation of heavy metals in the soil was not a problem but nitrate-N in soil-water extracts is an area of legitimate concern when applying sewage sludge landfill leachate to a grass crop. However, further study is recommended to validate these results before any conclusive recommendations can be made regarding the effectiveness of the "living filter" system.