SURFACE APPLICATION OF BIOSOLIDS TO PASTURES -? PRELIMINARY RESULTS OF ENVIRONMENTAL RISK

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Abstract

Surface application could increase the potential area available for recycling sewage derived biosolids in NSW, provided there are no adverse impacts on the surrounding environment. In an experiment at Goulburn (NSW), 30 dry t/ha of dewatered biosolids (DWB) was surface applied to an existing cocksfoot pasture. Preliminary results of the monitoring program designed to measure the impact of surface applied DWB on metal concentrations are reported for soil, runoff water, water in catchment dams, dam sediments and dust emissions. For soil, water and dam sediments, Cd, Cu, Ni and Zn levels were all 10% of those permitted under EPA Guidelines, but dust emissions exceeded permitted levels for Cd and Zn. However, calculated enrichment factors suggest that other sources of contamination (*eg.* bird droppings and vehicle emissions) contributed to these metal levels. Where enrichment was not a significant factor, metals from bisolids in dust remained within 100 m of the application site. In general, the results suggest that surface application poses no greater risk to the environment than incorporated DWB but additional monitoring is need to substantiate this claim.

Key words: Biosolids, surface application, pastures, environmental risk.

Biosolids products derived from sewage waste could become a valuable resource for restoring soil condition and improving pasture growth on degraded grazing land. Results from a large grazing experiment at Goulburn show that application of dewatered biosolids (DWB) significantly increased pasture production and livestock performance due to the effects of DWB on physical (*eg.* increased infiltration rate) and chemical (*eg.* levels of P and N) properties of both duplex and gradational soil types (3). However, while these results are encouraging, commercial use of DWB in grazing systems is restricted to newly sown pastures where the EPA requirement to incorporate DWB into the soil surface can be met.

The requirement for incorporation of all bisolids products assumes that surface application poses a more significant risk of environmental pollution (particularly of surface water) than when biosolids are mixed into the soil surface by disc implements. However, research in the USA indicates that one-time surface treatment with up to 90 dry t/ha of DWB with metal concentrations similar to those contained in DWB produced in metro-politian Sydney did not adversely effect surface or ground water quality when applied to grassland. Rather, surface applied DWB improved pasture ground cover, increased yield, promoted infiltration and reduced runoff on slopes with gradient of 6 to 11% (1). If it could be shown that surface application also poses minimal risk when applied to highly infertile and acidic (pH <5.5) soils in temperate Australia, it would significantly increase the scope to top-dress existing but degraded pastures with DWB products.

To assess the benefits and risks associated the non-incorporation of DWB, the Goulburn experiment was extended in 1997 to include a one-time surface applicat-ion treatment of 30 dry t/ha. This paper reports some of the preliminary results that assess the impact of surface application on the soil as well as the surrounding environment.

Materials and methods

Following a series of meetings held in Nov./Dec. 1996 with government agencies and adjoining land-holders, EPA approval for surface application was granted on Jan. 31, 1997. The surface treatment was completed on Feb. 10, 1997, using a rate of 30 dry t/ha of DWB from the Cronulla Sewage Treatment

Plant applied to an existing cocksfoot-dominated pasture. This DWB source had lower metal concentrations than the Malabar product that was originally applied to the site in 1993 (Table 1).

Runoff plots were installed and the metal content of runoff water was measured after each rainfall event as part of the site monitoring program. Additional contour banks were erected and the catchment dams enlarged according to EPA specifications for surface application. The water quality in these dams was also assessed following each significant rainfall event after which the dams were emptied and sediment sampled and analysed.

Dust emission were collected in standard funnel collectors with a circular horizontal open surface. These were located at different distances surrounding the surface applied DWB treatments and from the Hume Highway. At about 4-monthly intervals, the dust sedi-ments were collected and analysed for Cd, Cu, Ni and Zn content. Enrichment factors (E) were calculated to determine the origin of elements in collected airborne particulates using copper as a tracer and the equation reported by Lin *et al.* (2).

Results

Metal content in soil of surface treated plots

Table 1: Metal content of soil surface treated with 30 dry t DWB/ha measured in 1997 compared to levels found in soil prior to the application of lime-amended biosolids in 1993.

Depth (cm)	Metal concentration (mg/kg)							
	Cd		Cu		Ni		Zn	
	O	SA	O	SA	O	SA	O	SA
0-10	<0.01	0.10	6	9	9	7	25	27
10-20	<0.01	0.02	7	6	10	10	26	24
20-30	<0.01	0.01	10	7	13	11	34	28

Parameter		Cd	Cu	Ni	Zn
Biosolids	Malabar[1]	12	1389	159	2546
(mg/kg)	Cronulla	3	1073	24	960
Loading	NVS®	0.05	3.94	0.61	7.40
(kg/ha)	DWB	0.08	29	0.64	25
EPA_{max}.[2]	Soil	1.0	100	0	200

[1]Metal concentrations in DWB produced at sewage treatment plants at Malabar and Cronulla in metropolian Sydney; [2]EPA Guidelines fo biosolids use in production of human food given in mg/kg; O = Metal levels in soil prior to biosolids application in 1993; SA = metal levels in soil after surface application in 1997.

Metal levels in soil previous treated with N-Viro Soil? and then topdressed with 30 dry t DWB/ha were assessed in autumn 1997, about two months after surface application. The combined metal loadings in the N-Viro Soil ? and DWB applied are well within the limits set by EPA Guidelines (Table 1). The metals derived from the DWB had little effect on the soil as shown by a comparison between the soil analysis undertaken in 1992 and the metals measured in 1997. This indicates that the combination of 7.5 t/ha of lime-amended biosolids applied first to raise soil pH from 4.5 to 5.5, followed by surface application of 30 dry t DWB/ha is unlikely to elevate metals to levels that pose a risk to the environment.

Metal content of trapped airborne sediments

Concentrations of Zn, Ni and Cd in dust trap sediments collected during winter and spring (1997) are shown in Fig. 1 where the data are arranged according to distance downwind from the surface application plots based on the prevailing wind direction that came mostly from the SW, W and NW in both winter and spring. During winter (1997) metals originating from biosolids were detected only at very low concentrations outside a 100 m downwind perimeter from the surface application (Fig. 1). In contrast, higher than expected levels of Zn, Ni and Cd were detected in traps outside this perimeter in spring. However, biosolids may not be solely responsible for these elevated metal levels as high enrichment factors (shown in brackets) were calculated for Zn (12.3), Ni (12.8) and Cd (29.2) using Cu as the tracer. An enrichment factor greater than 10 indicates that a substantial proportion of the element does not come from the immediate soil (2). Possible sources of these metals other than bisolids include vehicle emissions from traffic on the Hume Highway that are high in Zn and Ni and droppings from birds perching on the surface of the dust collectors are also known to be high in Zn and Cu. Although the concentrations of Zn, Cd and Cu exceeded the EPA levels for soil in the spring measurement, the total amount of dust collected was small, averaging less than 0.5 g over a 4-month period which means that the total amount of metal leaving the site was also very small.

Metal content in runoff water

A number of rainfall events produced measurable runoff from the surface treated plots. Analyses for samples collected on Feb. 14 and Mar. 3, 1997 (Table 2) are compared to a 120 dry t/ha treatment where the DWB was incorporated by discing, but where about 30 dry t DWB/ha remained on the surface (4). The simple comparison suggests that surface application poses no greater risk to the quality of surface runoff than that expected from incorporated biosolids under normal rainfall conditions. This was supported by analyses of water quality in on-site catchment dams where levels of Zn, Cu, Cd and Ni averaged less than 10% of the concentrations permitted under the Quality Guidelines for Livestock Water (Table 2).

Table 2: Metal content in runoff water and in on-site catchment damns.

Treatment	Date	Metal content (mg/L)			
		Cd	Cu	Ni	Zn
30 t/ha surface applied	14.02.97	BR	BR	BR	BR
30 t/ha surface applied	03.03.97	BR	0.06	0.04	0.07
120 t/ha incorporated	11.03.93	BR	0.55	0.18	1.75
Dam water samples1	02.07.97	BR	0.02	BR	0.04
Dam water sample1	15.09.97	BR	0.03	0.04	0.11
Dam water samples1	23.10.97	BR	0.03	0.05	0.13
Control2		BR	0.06	0.02	0.08
Guideline3		0.01	0.50	1.0	20

[1] Mean of 3 catchment dams; [2]Control taken as the higest metal level recorded in Gungarry Catchment in 1993 monitoring program where there was no influence of biosolids; [3]Quality guidelines for livestock water; BR indicates metal level below reporting limit.

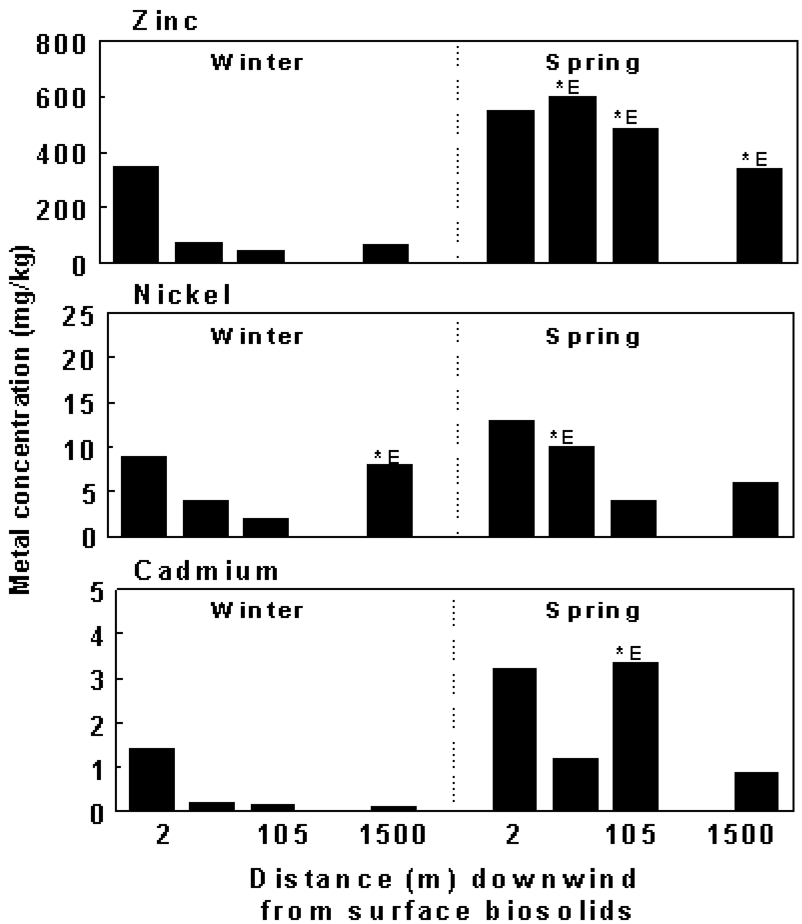

Figure 1

Metal content in dam sediments

Sediments in catchment dams were also analysed for changes in metal content over time. This was based on the assumption that while there may be little change in the metal content of water, sediments may become enriched with metals due to movement of biosolids particulates. However, as with water, metal concentrat-ions in sediments have not exceeded the permissible levels for soil. In fact, Zn, Cu and Cd concentrations (Fig. 2) were not significantly different from the levels measured in the gradational sandy loam prior to original biosolids application in 1993. Only Ni content was elevated to about twice the level of untreated soil, but was still well below the permissible Ni content in soil (60 mg/kg).

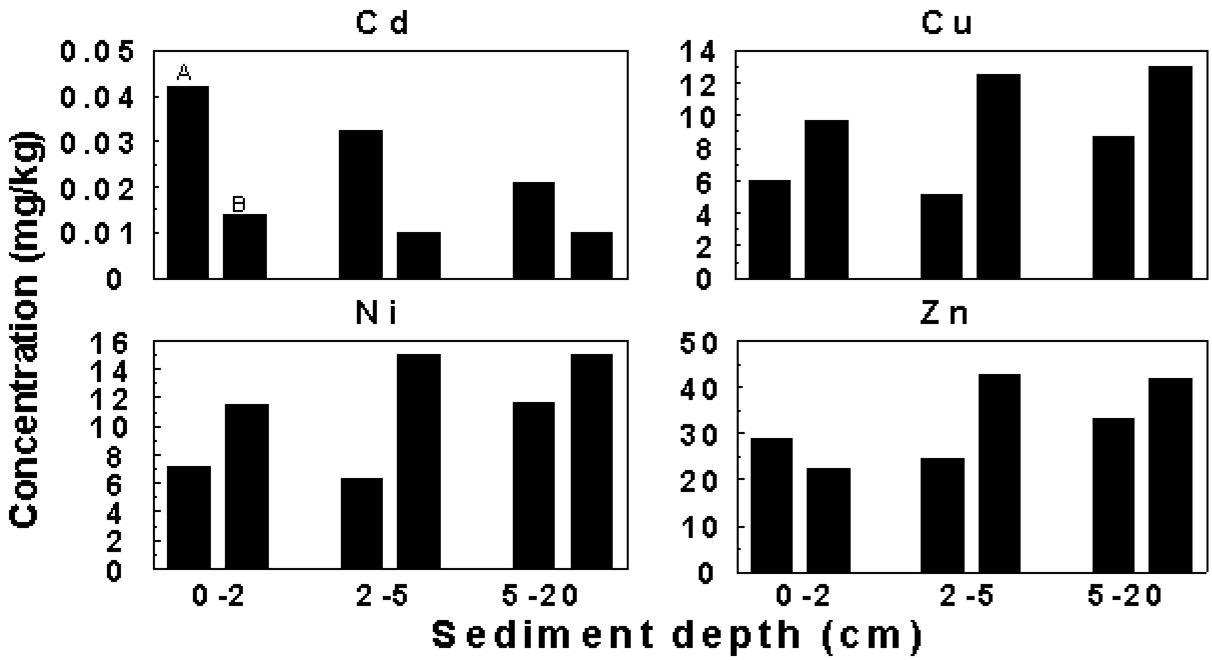

Figure 2

Discussion and conclusion

Regulations in NSW specify that all sewage waste products used to produce food for human consumption must be incorporated into the soil surface after application. For pasture systems, this means that biosolids can only be used when pastures are being resown. However, there is a large area of degraded pasture land in NSW that would benefit from the organic matter and nutrients contained in DWB, but either erode severely when ploughed or currently support native or improved pastures with sufficient density of desirable species to significantly increase production if additional nutrients were supplied. Biosolids could be used to improve a significant proportion of pasture in these categories if surface application was permitted.

Preliminary results from this experiment where a one-time rate of 30 dry t DWB/ha was surface applied show that neither nutrient (D. Michalk and I. Curtis, unpub. data) or heavy metal loadings exceeded the soil limits established by the NSW EPA. Rather, the nutrients increased feed-on-offer by 1 t DM/ha (Nov. 1997 measurement) compared to a fertilised control grazed at a similar stocking intensity and increased the quality of the pastures with higher N, P, Ca, Mg and S levels measured in plant top growth (D. Michalk and I. Curtis, unpub. data). Contrary to common perception that surface application should result in substantial movement of contaminants, no significant change in metal levels was detected in runoff water or catchment dams. In fact, the increase in surface roughness of surface applied DWB may be a major factor in reducing surface flow and enhancing infiltration (1).

Dust emissions are not usually regarded as a significant means of movement of contaminants away from biosolids treated land. This is because the amount of dust removed is small, as was the case in this study. However, the high levels of Zn, Cd and Ni measured in dust collected over spring is of concern, especially since the high enrichment factors suggest that other sources of metal pollution are involved. Since there was a high degree of variability between seasons, a more detailed analysis of the effects of wind speed and direction is required. Further monitoring is also needed to confirm the overall effect of these different point sources of metal contamination and to clarify the importance of dust from surface application as a means of metals leaving the application site.

In conclusion, these preliminary results suggest that surface application pose no greater threat to the soil or water resources than is the case with incorporated DWB. This suggests that the use of surface applied DWB to rehabilitate degraded pastures represents an alternative to applying DWB to cropland or newly sown pastures. However, further monitoring is required to assess the impact of metal accumulation in grazing livestock surface treated pastures. This forms part of the on-going risk assessment program at the Goulburn site, including the impact of pathogens on livestock health.

Acknowledgments

We gratefully acknowledge the finanical support provided by Sydney Water.? We also thank trainees Ben Zyla and Kirsten Young for able assistance in collecting field data and achnowledge the support of the Management Committe for Project 18.

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