Evaluation of sewage sludge for use in extensive sheep production - Some preliminary results.

D.L.Michalk[1], I. Bamforth, C.Hird, P.C.Simpson, C.Langford and G.J.Osborne

[1]*NSW Agriculture, Agricultural Research & Veterinary Centre, Pasture Development Group, Orange NSW 2800.*

With a rapidly growing interest in the use of a range of sewage products in Australian agriculture, it is important that we develop guidelines which will foster safe and sustainable use of biosolids in our agricultural systems. Inevitably, the development of such guidelines require an assessment of both the benefits and risks associated with the application of different biosolid products and rates to agricultural production systems. Project 18, a joint project between the Sydney Water Board and NSW Agriculture, is designed to examine the effect of organic waste products on the soil, pasture and livestock products, and to help to frame the guidelines for the use of sludge in extensive sheep production systems. The risk pathways of this grazing ecosystem are shown in Figure 1.

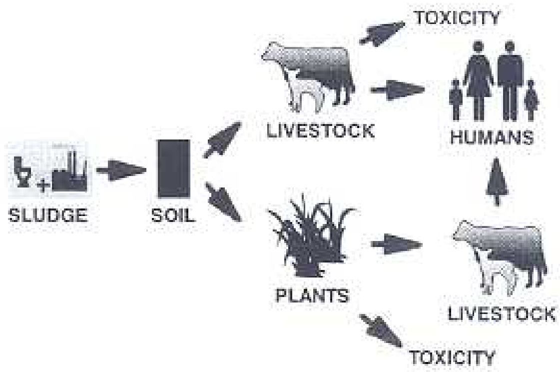

Figure 1. Risk pathways for contamination of a pasture-based livestock production system by heavy metals and organochlorines derived from sewage sludge.

The trial site is located about 7 km north of Goulburn, adjacent to the Hume Highway. Extensive soil sampling prior to the application of sewage treatments identified three soils (Hill A, Hill B and Hill C) which are typical of the poor acid soils in grazing tableland situation.

This paper reports some preliminary results of the various sludge treatments on the water, soil and sown pastures measured on Hill A.

Pre-treatment measurements

Hill A has topsoil $pH_{(Ca)}$ of 4.7 which increases to 5.7 at 50 cm. Cation exchange capacity is low (6.1 meq/100 g) as is exchangeable Al (7% of CEC) which is below levels toxic to the production of most sown grasses or legumes. The low soil P level (1.4 mg/kg Bray available P) indicated that the soil should respond to applied P. Heavy metals detectable in the soil prior to sludge application were: arsenic, zinc, chromium, nickel, lead, copper and manganese.

Background samples of water undertaken in 1992 prior to sludge application showed that the levels of N and P in farm dams around the Boxers Creek and Murray's Flat catchments are sufficiently high to stimulate aquatic growth. In general, metals and pesticides were present only in trace quantities throughout the catchment.

Treatments applied

The four biosolid treatments and control are described in detail by Simpson (1994). They include:

(1) Control - based on lime/super inputs recommended for these soils;

(2) N-Viro soil - applied at the lime equivalent rate to the control (*ie.* approximately 7.5 dry t/ha);

(3) Dewatered sludge cake applied as a one-time application at the rates of 30, 60 and 120 dry t/ha and incorporated with offset discs.

N-Viro Soil is primarily a soil ameliorant which

Table 1. Loading rate and availability in year of application (in brackets) of macro-nutrient and contaminants contained in sludge applied at Goulburn.

Loading rate of nutrients (kg/ha)	Treatment application rate (dry t/ha) 30	60	120
Nitrogen	773 (193)	1548 (387)	3096 (774)
Phosphorus	450 (45)	900 (90)	1800 (180)
Calcium	789	1578	3156
Potassium	36	72	144
Magnesium	93	186	372

Heavy metal or organic compound loading rate (kg/ha)	Sludge product (applied as dry t/ha) Dewatered sludge 30	60	120	N-Viro Soil 7.5
Arsenic	0.14	0.27	0.54	0.03
Cadmium	0.39	0.78	1.56	0.06
Chromium	9.12	18.24	36.48	1.35
Copper	36.8	72.56	145.11	4.59
Manganese	5.82	11.64	23.28	NA
Mercury	0.17	0.33	0.66	0.04
Nickel	4.89	9.78	19.56	0.68
Lead	9.72	19.44	38.88	1.20
Selenium	0.64	1.28	2.55	0.20
Zinc	83.01	166.02	332.04	9.0
HCB	0.004	0.008	0.016	0
BHC	0.004	0.008	0.016	0

contains little useful nitrogen or phosphorus whereas the dewatered sludge contains large amounts of essential plant nutrients, particularly N and P (Table 1). Not all of the N and P applied is immediately available, but other studies suggest that about 25% of N and 10% of P is available in the first year following sludge application. This still represents a massive nutrient input for pastoral agriculture with potentially available N and P of 774 and 180 kg/ha in the 120 t/ha treatment (Table 1). Inputs of Ca, K and Mg in the high sludge level also exceed levels likely to be applied as fertiliser to pasture in the Goulburn area (Table 1).

Of the metals present (Table 1), only Cu and Zn exceeded the maximum cumulative loading permissible under the current draft guidelines in the 120 t/ha treatment. Chlordane and dieldrin, were also present in the 120 t/ha plots in concentrations which approached the guideline for organochlorines. These levels of contaminants provide a good environment to test the risk of accumulation in grazing livestock.

Post-treatment soil analyses

Soils were sampled in July 1993, six months after sludge application. The results for the control and 120 t/ha treatments on Hill A (Table 2) are indicative of the effects of traditional fertilisers and sewage sludge on soil chemistry.

Changes in soil fertility

Lime application increased pH by 1.3 units on control plots and more than doubled the level of exchangeable Ca (Table 2). Application of lime-super increased Bray P from <5 mg/kg to 24 (Table 2).

Application of 120 t/ha of sludge which contained >3 t/ha of Ca (Table 2), did not change soil pH, but produce a large increase in exchangeable Ca). Total CEC was doubled by sludge application, but this was due mainly to the increase in Ca as the levels of exchangeable Mg, K and Na were similar to the pre-treatment levels (Table 2), even though sludge applied at 120 t/ha had high concentrations of these cations (Table 1). Total N was more than doubled and Bray P was increased to a level 10 times greater than control.

Changes in heavy metals and organochlorine loadings

The high concentration of heavy metal present in the Malabar sludge increased the levels of Zn, Cr, Cd, Ni, Pb and Cu in the soil (Table 2). Zn and Cu were between 10 and 30 times higher than those of the controls, while the levels of Cr, Cd, Ni and Pb doubled Only the levels of As and Mn remained similar in control and 120 t/ha plots.

Plant measurements

Ryecorn response

Ryecorn was sown at a 10- kg/ha as a nurse crop to prevent soil loss during the pasture establishment

Table 2. Chemical characteristics and heavy metal loadings (mg/kg) of Hill A Goulburn soil after application of fertiliser and lime (Control) or 120 t/ha of sewage sludge.

Chemical characteristics Treatment	pH(Ca)	Bray P mg/kg	Total C dag/kg	Total N dag/kg	EC dS/m	Exchangeable cations (meq/100g) Ca++	Mg++	K+	Na+	Total CEC (meg/100 g)
Control	6.0	24	2.9	0.13	0.11	5.00	1.00	0.31	0.08	6.39
120 t/ha	5.4	304	5.9	0.34	0.93	13.00	2.10	0.38	0.21	15.69

Heavy metal loadings Treatment	Arsenic mg/kg	Zinc mg/kg	Chromium mg/kg	Nickel mg/kg	Lead mg/kg	Manganese mg/kg	Copper mg/kg
Control	9.5	20	39	7	30	254	6
120 t/ha	11.5	477	74	28	69	242	178

Table 3. Nutrient and heavy metal content of ryecorn grown on sludge and N-Viro Soil treatments on Hill A at Goulburn.

Treatment	Plant part	P dag/kg	S dag/kg	Ca dag/kg	Mg dag/kg	K dag/kg	B mg/kg	Zn mg/kg	Mn mg/kg	Cu mg/kg	Fe mg/kg
Control	Stem	0.31	0.34	0.39	0.21	3.4	5.3	62	192	25	2068
	Leaf	0.24	0.18	0.15	0.11	3.8	2.1	33	79	9	87
N-Viro	Stem	0.28	0.32	0.41	0.17	3.9	5.5	38	172	18	2060
	Leaf	0.22	0.16	0.15	0.11	3.6	2.3	35	98	9	71
120 t/ha	Stem	0.56	0.49	0.70	0.30	3.2	6.4	296	168	65	1014
	Leaf	0.42	0.27	0.29	0.21	3.3	2.6	178	86	11	65

phase. There was a significant dry matter yield response of ryecorn to sludge application (Simpson, 1994, this proceedings Figure 5): yield recorded on Hill A ranged from 3.4 t/ha on the control to 5.8 t/ha in the 120 t/ha treatment.

Nutrient and heavy metal content of ryecorn

Application of dewatered sludge increased the level of most macro-nutrients in both the stem and leaf samples when compared with the control and N-Viro Soil treatments (Table 3). Leaf P and Mg of ryecorn growing on the 120 t/ha treatment was almost twice that of the control. Leaf Mg was marginally deficient in the control and N-Viro Soil treatments.

Zn and Cu in both stem and leaf increased in proportion to loadings applied in sewage products to levels which may reduce plant yield

Post-treatment water quality monitoring

During 1993, water samples were taken regularly from 24 fixed locations. Water quality in the catchments surrounding the trial has not been affected by the sludge application. While elevated levels of some nutrients, trace levels of metals and faecal contamination were evident in some samples, these were not confined to waterbodies downstream of the trial site. Further, there was no difference between these results and those taken from the Gundarry catchment, a nearby catchment with similar land uses, but to which no sludge has been applied.

Conclusion

These preliminary results highlight the rapid improvement in soil properties that takes place when sewage sludges are applied to poor soils and the benefit that the nutrients contained in these products have on the quality and growth of pasture plants. Further, the extensive testing of dams and streams adjacent to the experimental site shows that the heavy metals have remained on the plots and do not pose a threat to the environment. Future monitoring will assess the impacts of applied N and P on the leachate and surface runoff. Also, the effect of sludge treatment on sheep production will be measured over the next several years.

Reference

Simpson, P.C. (1994) Beneficial use of waste material. In "Putting the Farm Under the Microscope", Edited by D.L.Garden and D.L.Michalk, Proceedings of the Ninth Annual Conference, Grassland Society of NSW. pp. 54-59.