EFFECTS OF SEWAGE SLUDGE ON PASTURE PRODUCTION AND SHEEP PERFORMANCE

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Summary. A grazing experiment commenced at Goulburn, NSW, in 1992 to assess the benefits and risks associated with recycling sewage waste products on pastures grazed by sheep. Results show that sewage waste application increased yield of green dry matter and perennial grass content. Nutrient content in plant tops was improved by dewatered cake, but Zn and Ni concentrations also increased in all pasture components. Production and health of ewes and their offspring have not been significantly affected by these sludge induced changes.

INTRODUCTION

Disposal of sewage biosolids is a major economic and environmental problem, and countries around the world are committing increasing resources to find effective long-term solutions. In NSW, the biosolids from the treatment of sewage exceeds 150 tonne (dry weight) per day, with Sydney accounting for more than half of this output. Application of liquid, dewatered and alkali-treated biosolids to agricultural land is an attractive disposal option which recycles organic matter and nutrients to restore soil condition (3). However, sewage waste also contains heavy metals and persistent organochlorines which pose a severe environmental hazard where biosolids are used injudiciously. Contaminants in large quantities may pollute surface and ground water, inhibit plant growth, adversely affect long-term productivity, and accumulate in the food chain.

This means that before biosolids can be used commercially in our cropping and livestock systems, it must be shown that they are safe for the environment as well as beneficial for agriculture production. The potential to pollute ecosystems through land application of biosolids is determined by the concentration of contaminants in the sludge source, the amount and frequency of application, the nutrient requirements of the target crops and pastures, and the properties of the soil to which they are applied. These aspects have been extensively studied in the United States and Europe, but there is little Australian information available to frame regulations regarding rates and frequency of application of biosolids to our soils which are infertile and acidic. In 1991, Sydney Water provided NSW Agriculture with funding to assess the risks associated with the use of biosolids in a range of agricultural production systems in NSW.

One area of potential use targeted in the program are degraded pastoral lands in southern NSW which are most commonly used for extensive wool and sheep production. Pasture productivity is low and the acid (pH[$CaCl_2$]<4.5) soils have low cation exchange, low organic matter, and low levels of N and P. In 1992, a large-scale grazing trial was established at Goulburn (34^{o}47'S; 149^{o}43'E) to: (1) assess the soil ameliorant and fertiliser potential of sewage products to increase output of a Merino ewe enterprise; and (2) measure the effects of contaminants on the water, soil, plant and livestock components of the pasture ecosystem. The 100 ha experimental site selected covers three soil types (two duplex soils with light-textured topsoil differing in physical characteristics overlaying heavy clay, and a free-draining loamy sand soil) representative of 70% of the soils of the region. Descriptions of the site, pre-treatment earth works undertaken to minimise off-site movement of biosolids, water quality testing program, runoff studies, and soil analysis monitoring movement of nutrients and metals are reported by Michalk *et al.* (1, 2).This paper reports preliminary results of the effects of sewage products on soil chemistry, pasture production and sheep performance measured on the two duplex soils during the first two year of grazing (Oct. 1993 to Sep. 1995).

MATERIALS AND METHODS

Treatments: A control and four biosolid treatments were duplicated in plots (1.4 ha in area) on each soil type. The control was based on best practice for pasture establishment consisting of 2.5 t/ha of lime incorporated before sowing followed by 400 kg/ha of lime:super (50:50) applied at sowing and an annual maintenance of 250 kg/ha of superphosphate. N-Viro Soil, an alkali-treated sludge designed to reduce availability of heavy metals, was applied at 7.5 t/ha which is equivalent to the neutralising value of lime applied to the control. Dewatered sludge cake (28% solid) was applied at 30, 60 and 120 t/ha as a one-time application and incorporated with offset discs prior to sowing. Loadings of nutrients, heavy metals and pesticides contained in the biosolid products applied (1, 2) provided a good range of contaminants to assess the risk of accumulation in grazing sheep. Only at the 120 t/ha rate were maximum cumulative loadings permissible under interim guidelines exceeded for some metals (Cu, Zn, Ni) and pesticides (dieldrin and chlordane).

Pastures: In autumn 1993, all plots were sown with a pasture mixture which included subterranean clover (*Trifolium subterraneum*), white clover (*T. repens*), cocksfoot (*Dactylis glomerata*), phalaris (*Phalaris aquatica*), perennial ryegrass (*Lolium perenne*) and ryecorn (*Secale cereale)*. Pasture yield and botanical composition were monitored using dry weight rank and estimation procedures. In spring (1994) species present were sampled and analysed for heavy metals and organochlorines.

Sheep: Fine wool Merino ewes commenced grazing the experiment in spring 1993, initially at 5/plot but stocking rate was increased to 10/plot in spring 1994. Ewes were joined to commence lambing in July, and lambs were weaned in November. Liveweight gains of ewes and lambs were measured at six weekly intervals, but only data for July are presented here. Wool production was measured at shearing in October 1994, and grease and fibre samples analysed for metal and organic pollutants. Samples were collected in December 1994 to monitor metals and organics present in liver, kidney and muscle tissues of ewes and lambs. Milk samples were also tested for contamination.

RESULTS AND DISCUSSION

Effects of sewage products on soil chemistry

Fertilisers and sewage products both produced desirable changes in soil chemistry. Lime and superphosphate increased pH in the control, doubled exchangeable Ca and increased Bray P from 5 to 22 mg/kg. N-Viro Soil also increased soil pH and available P (5 to 16 mg/kg). For dewatered sludge the increase in available P was linearly related to total P loading with the gradient suggesting that about 22% of total P applied became available to plants in the first spring following incorporation. The 120 t/ha increased available P to >300 mg/kg in the surface and 31 mg/kg at 30 cm. Nitrogen was also leached down the profile to 40 to 50 cm where it accumulated at the top of the B-horizon where there is a change in clay content from 12 to 58%. Post-treatment analysis detected high concentrations of Zn, Cr, Cd, Pb and Cu in the topsoil of plots treated with sewage cake compared to N-Viro Soil plots which caused little change to metal content relative to the control. Downward movement of Zn and Cu was detected at 30 cm in 120 t/ha plots at concentrations 3 times those of the control.

Effects of sewage products on pasture parameters

Production and composition: Pasture production responded significantly to nutrients supplied by dewatered cake. During winter when feed supplies are most critical for sheep production, cake-treated plots consistently had higher total ($P<0.05$) and green ($P<0.01$) dry matter yield than plots treated with conventional fertilisers or N-Viro Soil (Fig. 1). Cake treatments were superior due to the combined effect of the high N input (ranging from 744 to 3528 kg/ha for the 30 and 120 t/ha treatments, respectively) and the improved moisture status of cake-treated soils. Measurements undertaken in the dry autumn of 1995 showed that the 30, 60 and 120 t/ha cake treated plots contained 11%, 24% and 46% more water than the control in the topsoil (0-20 cm). This resulted in the 120 t/ha plots producing five times the total yield and 15 times the yield of green pasture during the dry winter compared with the control or N-Viro Soil plots.

Botanical composition has changed significantly since sowing in 1993 (Fig. 1). Ryecorn accounted for >80% of feed on offer (FOO) during the establishment phase, but declined to <30% of pasture by winter 1994 when it was replaced by perennial grasses and legumes, and to a minor component in 1995. Cocksfoot was the most abundant grass accounting for almost all the perennial grass present in the control and N-Viro Soil plots. However, phalaris responded to sewage supplied N and made up about 20% of the perennial grass component in the 120 t/ha cake treatment in 1994 and 1995. White clover and subclover accounted for about one-third of winter production in the control and N-Viro Soil plots in 1994, but due to the dry autumn conditions did not re-establish in 1995. Due to the high N loadings, little legume established in the dewatered cake treatments (Fig. 1).

Nutrient and metal content of pastures: Application of dewatered cake significantly increased the concentration of N, P, S, Ca and Mg in the top growth of all pasture species compared to the control and N-Viro Soil. However, Zn concentration measured in winter 1994 were higher in all pasture species in cake-treated plots with the concentration increasing (60 to 240 mg/kg) with application rate (30 to 120 t/ha), depending on species. Ni concentrations were also elevated in sludge-treated plots, and Cu, Cd, Cr, Se, As, and Pb were all high in capeweed (*Arctotheca calendula*). Management strategies are needed to minimise the incidence of forbs like capeweed which are known to accumulate metals.

Effects of sewage products on sheep production

Production parameters: Despite differences in pasture composition and green FOO in 1994, there was no significant difference in ewe liveweight measured in early spring (Table 1). However, by November 1994 ewes grazing the control and N-Viro Soil plots were heavier than those grazing cake treatments. This was due to a rapid decline in pasture quality in cake-treated plots as the ryecorn matured. This also led to lower lamb liveweight at weaning and a reduction in wool production and