# The potential value of biosolids for revegetation at landfill sites

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**Abstract**
Landfill soils or Technosols are challenging environments on which vegetation is grown. In this paper, the usefulness of biosolid application to improve plant growth is investigated. The capping material over the landfill site, situated in South Australia, Australia, possessed high clay content, low organic carbon and poor soil structure. The application of biosolids enhanced growth of sunflower dramatically. Heavy metal enrichment in soils and translocation to sunflower shoots were limited. Biosolid application to the landfill cover material shows considerable promise in the revegetation of landfill sites.

**Key Words**
Technosols, revegetation, biosolid, heavy metals, bioavailability.

**Introduction**
Globally, disposal of waste to landfill remains the most common method of waste management. Up to 95% of generated refuse is placed in landfill, both worldwide and in Australia. Landfills are often found within urban areas as a result of urban expansion. With the large demand for space within expanding urban areas, there is a push to increase the beneficial use of brownfield areas. Landfill sites are unlikely to be suitable for redevelopment for most land use purposes in urban areas. Landfill of municipal wastes is typically achieved by adding a clay liner over the waste with low hydraulic conductivity to reduce water flow through the waste and limit contamination of the surrounding environment. Most landfill liners, however, inevitably crack and deteriorate allowing water seepage into the landfill. An alternative landfill "lining," often known as *Phytocapping,* shows promise in minimizing cracking and effective water interception through evapotranspiration. Soil materials or Technosols (IUSS 2007) on top of the clay liners themselves are not good environments for plant growth. They may be contaminated by a range of chemicals, be low in nutrients and have poor physical characteristics for plant growth. Selection of appropriate plant species and amendments to improve the growing conditions of the substrate is essential to advancing this promising capping technique. In this study, the effect of biosolid application rates was investigated on Sunflower and Giant Reed *in situ*. The aim of this study was to test the hypothesis that plant growth at the Coleman Rd landfill site would be enhanced by biosolid application.

**Methodology**
A landfill site (~17 Ha) located at Coleman road in South Australia owned and operated by Salisbury City Council was used in the field study. Basic soil properties before amendment with Biosolids are shown in Table 1. Typical properties of the biosolids are presented in Table 2. The soils on top of the clay liner are classified as a Technosol (IUSS 2007) or as Anthroposol in the Australian classification system (Isbell 1996). Soils in the top 60cm depth show very high clay content, high pH (8.6-8.7), high effective cation exchange capacity (ECEC) (21.0 - 471.1 cmol/kg) and high electrical conductivity (313-426 µS/cm). The site shows low levels of organic carbon (0.8-1 % OM). Soils were tilled manually to form farrows.

**Table 1. Soil properties from Coleman Rd landfill site for the 0-20 and 20-40 cm depths.**

| | pH(1:5) water | EC (µS/cm) | OM (%) | %Clay | ECEC (cmol/kg) | SAR |
|---|---|---|---|---|---|---|
| 0-20cm | 8.6 | 313 | 1.1 | 64.8 | 41.1 | 8.3 |
| 20-40cm | 8.7 | 426 | 0.8 | 64.3 | 21.0 | 3.2 |

**Table 2. Typical Biosolid characteristics used in field trial.**

| | pH(1:5) water | EC (µS/cm) | OM (%) | N (%) | P | K | Cu | Zn | Cd | Pb |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | mg/kg | | | | | |
| Biosolid | 6.64 | 8680 | 43.4 | 0.84 | 800.0 | 2285 | 444.4 | 766.6 | 7.620 | 96.88 |

The experimental layout consists of three levels of biosolid application as main treatments and 3 plant species as subplots. To separate plots (50 m$^2$) soils were amended with biosolids from Bolivar Treatment Plant at rates of 0, 25 and 50 tonnes/ha (dry-weight). Biosolids were mixed approximately to the top 0.2 m of the soil. Biosolids were added 20/11/08. Within each main plot, Sunflower (*Helianthus annas*) seeds were sown on 09/02/09. Giant Reed (*Arundo donax*) was planted on 20/12/08. Plants were watered once per week using drip irrigation.

**Results**

A significant level of heterogeneity in soil texture existed laterally within and between each experimental plot. Soil sampling showed that the clay liner was approximately 50-60cm from the soil surface. Reducing conditions commonly existed from 30-40 cm depth to the clay liner. The black appearance of soil at 50-60 cm and smell suggested the formation of sulfidic material. Visual assessment of plant growth showed a dramatic improvement in the performance of sunflower due to biosolids (Plate 1). Sunflower heights in the control ranged from 30 cm to approximately 1m. By comparison, a large proportion of sunflower plants ranged in height from 1 -1.5 m. In both biosolid treated plots germination of sunflower was good. Germination in the control plot by contrast was poor and delayed. Biosolid application was shown to significantly increase sunflower growth from the control (Figure 1), although different application rates did not significantly affect yield. Despite excellent growth at 50 t/ha, few plant roots ventured below a depth of 30 cm. Sunflower roots usually formed a small cup-shaped root zone with little vertical expansion. The lack of root growth down profile may be due to the lack of aeration and poor soil structure with increasing depth. *A. Donax* appeared to have performed better in the 50 t/ha biosolid treatment. However, the overall performance was modest with poor establishment in all plots.

**Sunflower 50 t/ha 09/05/09 Sunflower control 09/05/09**

**Plate 1. Performance of sunflower in 50 t/ha and control plots at Coleman Rd.**

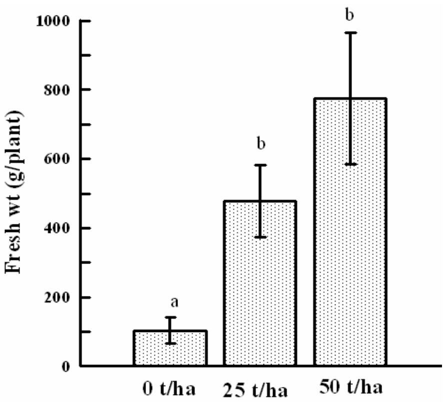


**Figure 1. Effect of biosolid application on sunflower growth in the landfill field trial. Different letters indicate a significant difference (α=0.05).**

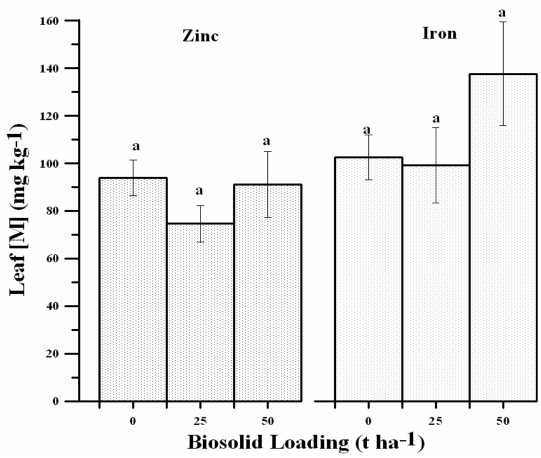


**Figure 2. An example of metal concentrations in leaves of sunflower grown at Coleman Rd. Different letters indicate a significant difference (α=0.05).**

Total extractable concentrations of Cu, Zn, Ni, Cd, As and Pb concentrations in soil were low for all treatments (< 30 mg/kg or < 0.5 mg/kg). Furthermore, no significant differences between treatments were observed ($P$=0.05). Similarly, $NH_4NO_3$ extractable contents, which are often used as a chemical indicator of plant available metals, were very low for divalent metals. The low plant available metal contents in these soils may partly be due to the high pH of these soils. The non-significant differences observed in total and plant available concentrations in biosolid amended soils were reflected in shoot concentrations in sunflower. With biosolids containing relatively low heavy metal concentrations, biosolid application to Technosols at landfill sites shows promise for re-vegetation and reuse of these areas.

## Conclusions

The capping material over the Coleman Rd landfill possessed high clay content, low organic carbon and poor soil structure. The application of biosolids appeared to enhance germination and growth of sunflower. Heavy metal enrichment in soils and translocation to sunflower shoots were limited. Biosolid application to the landfill cover material shows considerable promise in the revegetation of landfill covers.

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## References

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