

**AGRICULTURAL RECYCLING OF SEWAGE SLUDGE FOR MAIZE
AND OATS CULTIVATION**

by

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DECLARATION

These studies have not been submitted in any form to another University and, except where acknowledged in the text, are results of my own work



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SUMMARY

Sewage sludge can be a valuable resource if used as a fertilizer and soil conditioner. South African farmers using sewage sludge as a fertilizer amendment reported a 20% increase in the yield of cultivated maize and 40% saving on inorganic fertiliser (du Preez *et al.*, 1999). The major benefits of sludge application are; increased supply of major plant nutrients; provision of some of the essential micronutrients (Zn, Cu, Mo, and Mn) and; improvement in the soil physical properties, i.e. better soil structure, increased water holding capacity, and improved soil water transmission characteristics (Korentajer, 1991).

Toxic compounds such as heavy metals and pathogens could compromise the beneficial use of sewage sludge. To minimise the risk of toxic effects and environmental contamination a "Guide: Permissible utilization and disposal of sewage sludge" (WRC, 1997) was developed. It is therefore critical to establish the safe application rate of sewage sludge in different environmental conditions. Furthermore, with repeated sludge applications as soil conditioner, these heavy metals may accumulate in the soil to phytotoxic concentrations for crops (Schmidt, 1997), although at certain concentrations the metals may be deficient for crop growth (Alloway, 1995). The potential impact of the four main sludge-borne metals (Pb, Cd, Zn and Cu) was monitored in the research (glasshouse and field experiments) when sludge was amended to agricultural soils, taking into consideration the current S.A. guidelines interpreted as total metal content.

Research was done in glasshouses on maize (*Zea mays* L.) (summer crop) and oats (*Avena sativa* L.) (winter crop), grown on different soil types (clay, loam, and sand) at a specific sewage sludge application rate (24t ha^{-1}) using two different sludge types (low metal and high metal) over a period of 28 days. Poor sample homogenisation caused invariable results. Availability of sludge-borne metals differed between sludge types. The heavy metals were less available in the high metal industrial sludge compared to the low metal domestic sludge. The accumulation of sludge-borne metals in soil could not be proven to be in excess, even at a high application rate (24t ha^{-1}). Furthermore, accumulation of heavy metals in seedlings did not reach phytotoxic levels. A significant increase in certain yield aspects was seen after sludge amendment to the different soil types, especially in the low metal sludge treatment.

Field experiments on maize and oats using different total application rates (4t ha^{-1} and 8t ha^{-1} dry sludge for oats cultivation; and 12.5t ha^{-1} and 25t ha^{-1} for maize cultivation) of the low metal sludge was also completed. Difficulty in sampling was evident and possible errors in sample taking and/or analyses caused results that were difficult to interpret. No phytotoxic levels of metal accumulation were seen in different plant parts of the crops. The sludge treatment plots compared well with plots where inorganic fertilizer (positive control) was added, when yield differences were calculated.

In the field experiments, no significant differences in yield were found between sludge-amended plots and the control treatments, although the amount of ears per plant was significantly increased for maize plants after sludge amendment at 4t ha^{-1} . The

insignificance in yield between treatments was possibly due to the varying environmental conditions (e.g. hail during maize field experiment, and drought during oats field experiment) and change in soil conditions (e.g. soil pH controls availability of metals and nutrients). However, under more stable conditions in the glasshouse, a significant increase in yield (dry mass and shoot length) of crop seedlings was found. This was possibly due to the increased organic and nutrient status of the soil. A 50 and 20% increase in the yield of maize seedlings occurred when grown in the low metal and high metal sludge-amended soils, respectively, when compared to the positive (soil amended with inorganic fertilizer) and negative controls (soil left unamended). However, when yield of oats seedlings was calculated on the sludge-amended soils, compared to the control treatments, the increase was 20 and 48% for the low metal sludge treatment compared to the positive control and negative control, respectively. No significant increase occurred in the yield of oats seedlings grown in the high metal sludge-amended soil compared to the controls. Insignificant differences occurred in the yield of seedlings between soil types, although the yield of seedlings in the loamy soil was higher.

The value of sludge amended to soils as a soil conditioner and fertilizer was seen in the experiments although long term experiments under field conditions still need to be done to assess possible accumulation of heavy metals in agricultural soils.

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ABBREVIATIONS

(Excluding SI units)

ARC	Agricultural Research Council
B	Beginning
CEC	Cation Exchange Capacity
Cv.	cultivar
d.	days
E	End
EPA	Environmental Protection Agency
exp.	experiment
fig.	figure
ISCW	Institute for Soil, Climate and Water
HI	Harvest Index
kg ha ⁻¹	kilograms per hectare
kg t ⁻¹	kilograms per ton
kg m ⁻³	kilograms per cubic metre
l ha ⁻¹	litres per hectare
m/m	mass per mass
mg kg ⁻¹	milligrams per kilogram
mol dm ⁻³	mol per cubic decimetre
N/a	Not analysed for
N/s	Not specified

NH ₄ -EDTA	Di-ammonium ethylenediaminetetra-acetic acid
PTE	Potentially Toxic Element
S.A.	South Africa, South African
STD	Standard Deviation
t ha ⁻¹	tons per hectare
US EPA	United States Environmental Protection Agency
WRC	Water Research Commission
WWTP	Wastewater Treatment Plant