

# Municipal sludge as source of nitrogen and phosphorus in perennial pasture *Eragrostis curvula* production: Agronomic benefits and environmental impacts

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## ABSTRACT

Land application of sludge has been shown to improve soil properties and aid crop growth, but the possibility of constituent nutrients such as nitrogen and phosphorus reaching environmentally toxic levels has caused governing authorities to set limits to how much sludge can be applied to agronomic land. The high nitrogen utilisation potential of pasture grasses suggests that more sludge can be used in this cropping system without the risk of excess nitrates. This study investigates the effect of exceeding the South African sludge application limit on hay yield, soil nitrates and phosphorus. Field plots were arranged in a complete block design comprising 4 replications of 4 treatments planted to *Eragrostis curvula*. The treatments consisted of 0, 4, 8 and 16 Mg·ha<sup>-1</sup> anaerobically digested sludge. Soil samples were collected before treatment application and at the end of each growing season for N, P, NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>, and Bray-1P analyses. Plant samples were collected at flowering stage for hay yield and N and P uptake determination. Statistical analyses were conducted using analysis of variance (ANOVA) and general linear model (GLM) procedures of Windows SAS 9.0 to evaluate the effect of sludge application rates on hay yield. Results over 4 growing seasons indicate that exceeding the recommended limit increased hay yield by 4% in a dry season (11.7 vs. 12.36 Mg·ha<sup>-1</sup>) and by 16% in a wet season (14.19 vs. 17.31 Mg·ha<sup>-1</sup>) and also increased nitrogen uptake by 15%. Sludge applied at double the recommended limit did not cause the accumulation of nitrate and ammonium in the soil, however, both total and Bray-1P were doubled. The study shows that the potential long-term environmental risk of doubling the sludge application rate norm would be from labile P accumulation in the soil profile despite a sludge P:Fe molar ratio of less than unity.

**Keywords:** sludge, *Eragrostis curvula*, nitrogen, phosphorus, leaching

## INTRODUCTION

Use of sewage sludge on agricultural land has been practised for a long time around the world, and has been shown to have several benefits. Sludge acts as a source of essential crop nutrients (Smith and Tibbett, 2004; Ferreiro-Domínguez et al., 2011), stimulates microbial activity (Boyle and Paul, 1989; Lakhdar et al., 2010), immobilises toxic elements in soil (Neunh userer et al., 2001), improves soil structure, and minimises soil erosion and runoff (Ojeda et al., 2008).

However, nutrients applied above a crop's nutrient requirement can be detrimental to plant growth and may ultimately pollute water bodies (Neal et al., 2002). Excess nitrates from sludge may be leached down and contaminate groundwater or be washed out into water bodies and exacerbate algal blooms. Excess phosphorus washed away from the soil may also enhance the rate of eutrophication in nearby water bodies (Xie et al., 2011). In addition, waste products from cities and industrial areas contain pathogens, toxic elements and organic contaminants which can pose a serious health hazard especially when they enter the food chain. For these reasons, many countries have developed sewage sludge guidelines to optimise agricultural benefits without compromising the environment.

In South Africa, where beneficial agricultural use of sludge accounts for only 28% of the total sludge produced from South African wastewater treatment plants, the Water Research Commission initially pegged sludge application on land at not more than 8 Mg per hectare per year. This is despite the enormous pressure on South African wastewater treatment plants to dispose of or utilise their sludge in an environmentally sustainable way. This limit has recently been increased to 10 Mg per hectare per year (Snyman and Herselman, 2006). Nevertheless, the problem of sludge disposal still persists.

Generally, sludge of acceptable quality for agricultural use is applied according to crop nitrogen requirements (Milne and Graveland, 1972; Dotson, 1973), but some studies have shown that this approach may lead to a build-up of phosphorus in the soil profile (Pierzynski, 1994; Maguire et al., 2000; Tesfamariam et al., 2009). While these sludge application limits may be appropriate for most agronomic crops, can they be exceeded for perennial dryland pasture without compromising the environment? Perennial grasses have the potential to reduce nitrate leaching compared to annual crops due to their established root system. They are considered a good choice for repeated sludge applications because of their efficient nitrogen utilisation under intensive management practices and because a number of harvests can be made in a year (Bary et al., 2001). If sludge application rate can be increased for dryland pasture without compromising the environment, this management option may prove a better disposal method and help reduce the huge amounts of sludge that are usually left unutilised.

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