Biosolids application for revegetalization of an abandoned nickel mine from New Caledonia

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Abstract
Old nickel mines from New Caledonia expose large surfaces without any plant cover. The lack of topsoil and the natural low fertility of soils were not favourable to plant growth in these places. In order to limit erosion and environment impact for the lagoon, it is important to restore the vegetation of these degraded sites. Numerous plantation programs have been established with process including fertilizers or organic amendments such as poultry litter.
In this study, sewage sludge had a positive impact on the growth of the different indigenous species planted in the experimental site. The tree heights were significantly higher after two growing years. The efficiency of sewage sludge was slightly better than poultry manure but it was not significant.
These results indicate that biosolids were as useful as poultry litter for fertilisation of ultramafic soils for mine site remediation.

Key words
Sewage sludge, lateritic soil, fertilisation, vegetal growth, *Carpolepis laurifolia*, *Grevillea exul rubiginosa*, *Gymnostoma deplancheanum*.

Introduction

New Caledonia is a small south Pacific island with a high plant diversity and high endemism. The plant specificity is partly linked to the ultramafic soils which were characterized by a poor concentration in nutrients (N, P, K) and high levels in heavy metals like Ni, Co Mn (Becquer *et al.* 2003). Moreover, since the 60s, nickel exploitation processes have removed vegetation on large surface with no rehabilitation program. It results in numerous places, free of topsoil, with a poor fertility, and subsequently, with high difficulties for a plant reinstallation. These soils are usually considered as toxic for plants. Revegetalization programs with plantations are essential for the remediation of mine sites.
Nevertheless, in order to facilitate the plant installation and growing, it is important to increase the soil fertility. In New Caledonia, chicken litter (with fertilizers) is often used as an organic amendment. Numerous authors have tested sewage sludge to replace fertilizers for plant cover restoration (Blechschmidt and al 1999; Delschen on 1999).
The aim of this study consisted of verifying that these biosolids promote plant establishment on a lateritic soil. A field experiment was conducted in an old mine location, comparing the traditional use (chicken litter) with sewage sludge amendments.

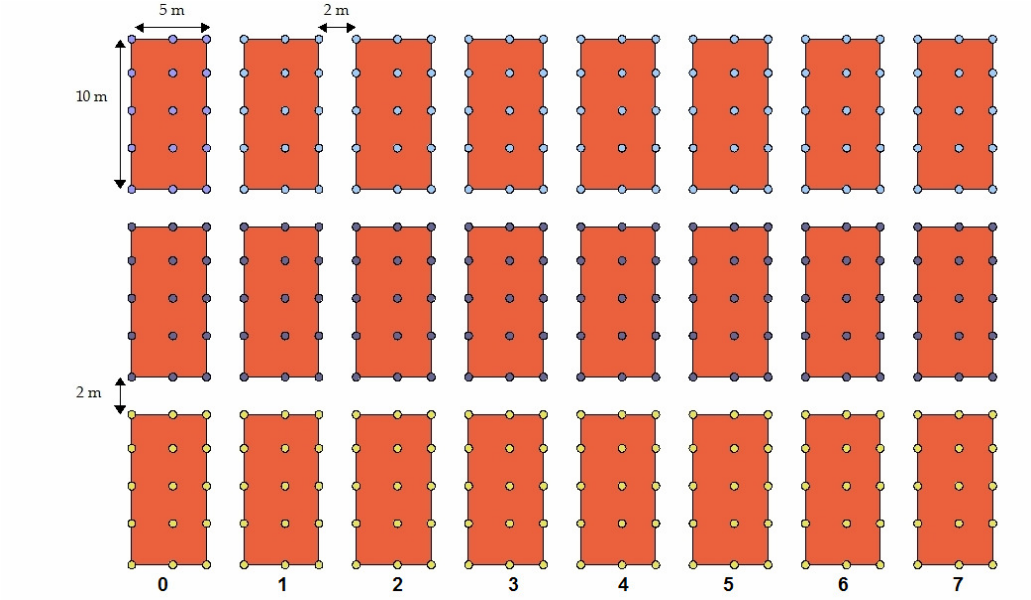
Methodology

Experimental design
The experimental site was located in an old mine (mine Claudette, Mont Dor, New Caledonia) characterised by a rocky soil totally free of topsoil. In this sloping area, 24 plots (5x10m) were delimited for the different amendment treatments. Plots were separated with a 2 m passages in order to limit material transfer from one plot to another.

The sewage sludge used for this study came from the activated sludge treatment plant of Koutio, New Caledonia. This sludge, obtained with a compression filter, was taken at the outlet of the water treatment plant, put in single-dose packets and directly transported to the experimental site. This sludge was characterized by a low level for heavy metals (in accordance with European policy) and 1.0% P and 4.6% N. Poultry litter and fertilizer were obtained from a commercial dealer.

In each plot, 15 seedlings were sown as described in the Figure 1 corresponding to a plant density around 1600 seedlings per hectare. Three local species (*Carpolepis laurifolia*, *Grevillea exul rubiginosa*, *Gymnostoma deplancheanum*) received either poultry litter or sewage sludge. The amendment level was

calculated in order to provide the same nitrogen quantity (10g of nitrogen/kg) from each source (sewage sludge, poultry litter and fertiliser). Then, this organic matter was either spread on the top or mixed into the soil with or without fertiliser.



Treatment	0	1	2	3	4	5	6	7
OM	P	P+F	P	P+F	SS	SS+F	SS	SS+F

Figure 1. diagram of the planting methodology. P: poultry; SS: sewage sludge; F: fertiliser.

Vegetation measurements and sampling
All sown seedling were individually followed during their growth. Their heights were measured at the beginning of the experiment and twice a year from August 2007 (the beginning of the experiment). The survival rate was estimated by counting the individuals in each plot.
Ramification number from Carpolepis was also measured.

Statistical analysis
The effects of amendments on trees heights and mortalities were evaluated using a one-way ANOVA or a Kruskal-Wallis one-way ANOVA on the ranks when normality or equal variance tests failed. Comparisons of mean heights of a single plot between two measurement periods were conducted using a t-test. All the statistical analyses were carried out with SigmaPlot v11 software.

Results

During the experiment a high mortality was observed for *Grevillea* planted plots (until 100%). *Carpolepis* had the highest survival (70%).

During the first 6 months, no significant effects were observed on growth either for sludge or for poultry litter. Significant growth was observed after the first year for all treatments with no significant difference, between organic matters. A significant effect was observed for fertiliser additions for *Carpolepis*.

Discussion

For agricultural soils, since the early 70s (Hinesly *et al.* 1972; Kirkham 1974), and forestry (Bramryd 2002; Selivanovskya and Latypova 2006; Wang *et al.* 2004; Egiarte *et al.* 2005), sewage sludge has been used as a fertilizer. It provides an interesting option for lateritic mine soil restoration. Some authors have already demonstrated the role of biosolids for the establishment of a vegetal cover on mine sites, mine spoils or old quarries (Seaker and Sopper 1983; Blechschmidt *et al.* 1999; Delschen 1999; Kahl *et al.* 2000; Rate *et al.* 2004; Dudeney *et al.* 2004). Nevertheless, the current study showed that sludge did not result in immediate growth of plants. This delay may be due to the mineralization time as described by Garcia *et al*. (1991). Moreover, a high mortality was found at our site, and de Andrès *et al*. (2007) also observed increased mortality after sludge amendment, which may be due to high tropical precipitation immediately after plantation.

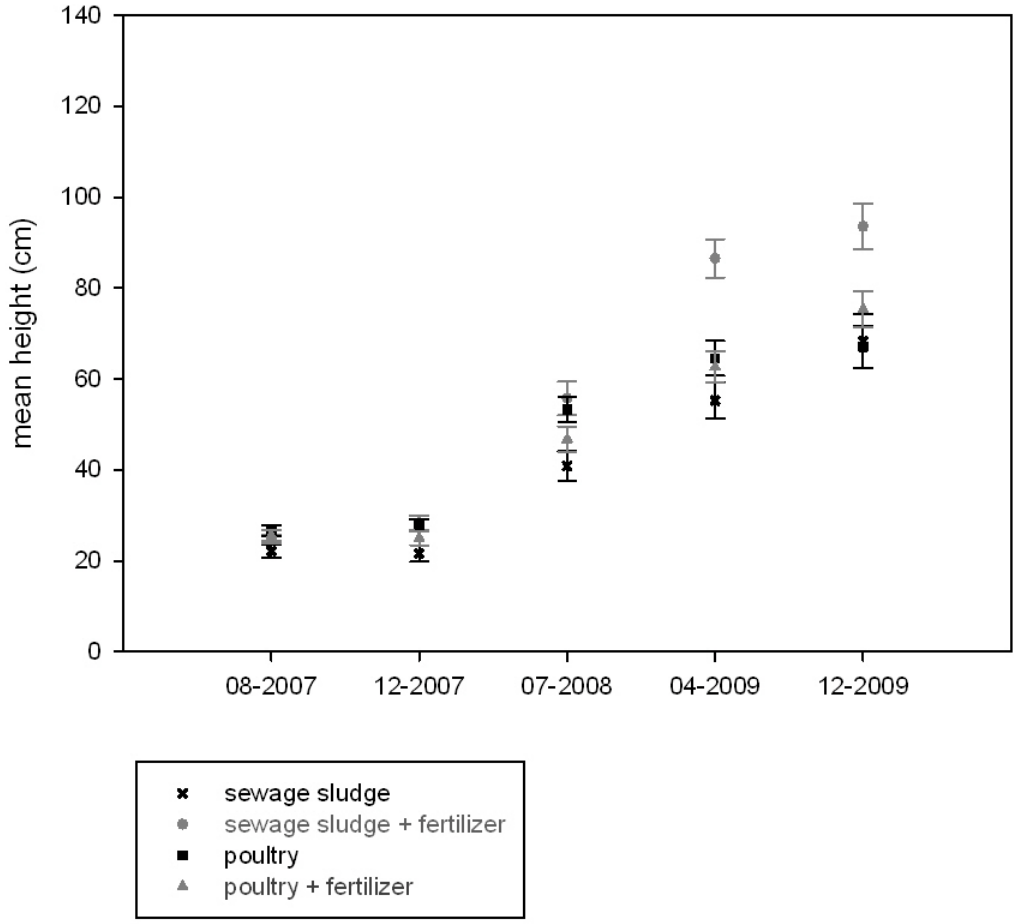


Figure 2. mean height of *Carpolepis* in amended plot with (+F) and without fertiliser.

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