AN INCUBATION STUDY TO ASSESS THE EFFECT OF WASTE SLUDGE ADDITIONS ON SOME CHEMICAL CHARACTERISTICS OF MINE SPOILS

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ABSTRACT

In 1985 a study undertaken by the New Zealand Soil Bureau identified a major shortfall in topsoils for mining rehabilitation works and the use of surrogate materials to overcome this shortfall was postulated (Wills, 1992). The Resource Management Act 1991 places constraints on the disposal of wastes and may act as a catalyst for research into the beneficial utilisation of once waste products for land rehabilitation.

The most common problem reclaiming of derelict and degraded land is a shortage of organic matter (Pulford, 1991) in the growing medium. The overall objective of the research reported in this study was to investigate chemical interactions between various mine spoils and sludge materials as organic amendments and to determine the level of sludge application (based on organic matter content) that maximised the chemical benefit to the mine spoils.

A controlled incubation study was used to achieve the objectives of the study. Six mine spoils from two sources (a gold mine and a coal mine) and three sludge amendments from two sources (municipal sewage sludge and paper sludge) were used. The sludge amendments were applied to the mine spoils to supply three different rates of organic matter (2, 5 and 10% in the amended spoils) and incubated for 38 weeks. The incubations were sampled every four weeks until week 20 and finally at week 38 for chemical analysis.

Results of the study revealed that organic matter, total and mineral N, total and Olsen P levels of the amended spoils could be predicted directly from the characteristics of the sludge and spoil constituents but pH, EC, CEC could not. The benefit of sludge addition on many of the chemical characteristics of the mined spoil increased with increasing level of sludge addition.

Manukau sewage sludge was the most beneficial sludge to apply with respect to P fertilisation. North Shore sewage sludge presented the greatest benefit for mine spoil rehabilitation with respect to N and it provided less risk of heavy metal contamination than Manukau sewage sludge. Paper sludge presented the most benefit with respect to pH and organic matter and the least risk of heavy metal contamination; however, nutritionally it was inferior to the sewage sludges.

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DEFINITION OF TERMS USED

The various terms used in the thesis are defined as follows:

REHABILITATION:

A number of interpretations of the term rehabilitation are used in literature and there is often confusion or interchangeability between the terms rehabilitation, restoration and reclamation. These terms are used in issues relating to land disturbances caused by natural or human induced processes. They embody improvements of a visual nature to a natural resource- putting back into good condition or working order; restoring ecological attributes of particular interest to human society, but not all ecological attributes (Cairns, 1992).

WASTE:

Products of manufacturing, or of a physiological process (Sykes, 1987) which is of no value to the original process.

SLUDGE:

(As defined in the Collins English Dictionary 1991)"...4. (in sewage disposal) the solid constituents of sewage that precipitate during treatment and are removed for subsequent purification."

SPOIL:

Nelson and Nelson (1967) define spoil as the gangue, dirt or waste produced by underground mining or quarry or opencast operation, or by preparation plants, surplus excavated material as from pond, drainage ditch or other cut in engineering works. In this thesis the term spoil will be used as a general term to cover the materials that require rehabilitation, and are related to a mining operation i.e. tailings, oxidised waste, mudstone, subsoils, and fireclay. These specific terms will be defined in sections 3.1 and 3.2.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

All systems with transformations have outputs, some of which may be considered undesirable. The safe disposal of effluent and solid wastes is hence an important part of many enterprise or company's activities. However, it is becoming increasingly realised that many once waste products have some economic value.

In 1985 a study undertaken by the New Zealand (NZ) Soil Bureau identified a major shortfall in topsoils and subsoils for mining rehabilitation works. The shortfall was estimated as 220 000 m^3 of topsoils and 1 200 000 m^3 of subsoil materials. It occurred largely as a result of poor stripping practice from 1945 to the late 1970's (Wills, 1992).

The use of surrogate materials to overcome the shortfall in topsoils was postulated by the NZ Soil Bureau (Wills, 1992) and research into potential materials has been undertaken by other countries in the past. Examples include the use of sewage and some other sludges on European and North American soils (and to a lesser degree mine sites) (Sopper, 1992, Lue-Hing *et al.*, 1992; Hall, 1991). Such work has until recently received little attention in New Zealand and the special characteristics of New Zealand soil and climate conditions may not allow extrapolation of overseas results to New Zealand soil and site conditions. However, the Resource Management Act (1991) places constraints on the disposal of wastes and may act as a catalyst in New Zealand for research into the beneficial utilisation of once waste products for land rehabilitation e.g. as surrogate topsoils.

The use of waste sludges to aid revegetation of mine land offers a route for otherwise unutilised resources to be usefully employed to assist in the production of surrogate soils. This appears to be consistent with the Resource Management law in that it utilises what was a waste product, disposed of to landfill, as a useful additive to improve soil quality in mine rehabilitation.

Levels of contaminants must be fully monitored in the soils, plants, waters and livestock at sites where sludge is applied. The need for such thorough monitoring may be relaxed

in future when the particular risks are better identified and appropriate management strategies developed.

1.2 OBJECTIVES

The information presented in 1.1 was the catalyst for the present research undertaken with the following objectives:

1. To investigate chemical interactions between various mine spoils and sludge amendments, applied to increase the organic matter content of the mine spoils.

2. To determine the level of sludge application for each of three sludges, that maximises the benefit to the mine waste with respect to chemical fertility (N, P, CEC, pH, EC) while not exceeding permissible concentrations of heavy metals.

Aims achieved by objectives:

1. To determine the most beneficial sludge (of three trialled) to amend a range of mine spoils with respect to addition of nutrients, amelioration of pH, low input of heavy metals.

2. To investigate the influence of incubation period on the effect of sludge addition to mine spoils with respect to chemical fertility.

1.3 STRUCTURE OF THE STUDY

A controlled incubation experiment was used to answer the objectives of the study.

In Chapter 2, Part 1 of the review of literature provides an overview of extractive industries, their productivity, by-products and associated problems in New Zealand. Mine spoils, and methods that have been employed to rehabilitate them are considered. Part 2 of the literature review considers the potential utilisation of sludges in mine spoil rehabilitation.

In Chapter 3, a description of the materials utilised in this research is given. These materials include six mine spoils that require rehabilitation, and three sludges that may be utilised as amendments. Details of the location of the spoils are also presented.

Chapter 4 describes the controlled incubation experiment used to assess the effect of the sludge additions on the chemical characteristics of spoils. Details of analytical procedures to assess the effects of sludge additions and the incubation on the spoils are presented.

The Results and Discussion section (Chapter 5) considers the results of the incubation study, and the implications for rehabilitation of the mine spoils.

Chapter 6 presents conclusions and suggestions for future research that may expand on the results obtained from this preliminary incubation study. Subsequent green house and field work is required to confirm the results presented in this thesis.