Edaphic properties of fly ash from Australian power stations

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Australian power stations annually produce 3.7 million tonnes of fly ash, the residue of combusted coal. Approximately 10% of this material is used in industry, but the remainder constitutes a waste disposal problem. The need to stabilize ash dumps and to define alternative uses for the waste led to an investigation of the potential of fly ashes from 13 Australian power stations to support plant growth. This was done by mineralogical, chemical and physical characterization.

All fly ash samples were dominated by both amorphous and crystalline alumino-silicates and quartz, and these were associated with minor amounts of Fe oxides, lesser amounts of Ca, Mg, Na, K, Ti and P oxides and variable levels of incompletely combusted C. Twelve of the 13 ashes were alkaline to slightly alkaline (pH range 7.l to 13.5). Soluble salt levels varied greatly depending on coal source. Electrical conductivity of the saturation extracts (E.C.) varied from 0.63 to 7.00 m S cm-l for 11 of the samples; two ashes produced from brown coal had E.C. values of 46.0 and 55.0 m S cm^{-1}.

The nutritional status of the wastes was assessed on samples leached with water to reduce the soluble salts to equilibrium levels. The ashes contained negligible amounts of N but their P status was variable with extractable P values (0.5m $NaHCO_3$) ranging from 3 to 330 pg g-l. The amounts of NH_4OAC-extractable Ca and Mg were generally high in most samples and considered more than adequate for the growth of most species; however, NH_4OAC-extractable K values were generally low. Adequate levels of sulphate S existed in 13 of the 13 samples (35.0 to 4600 pg S g^{-1}). The levels of D.T.P.A. extractable Cu, Zn, Mn and Fe in all ashes were high when compared with published critical values, but deficiencies of one or more of these elements could be anticipated at the extremely high pH of some of the wastes. Six of the 13 unleached samples contained potentially toxic levels of B. Leaching decreased hot water-extractable B levels, but 5 out of 6 ashes still exceeded the level considered toxic for plant growth.

The ashes were dominated by particles in the silt plus fine sand fraction (67 to 98%), and the textural classes varied from loamy sands to clay loams. Electron microscopy revealed that ash matrices consisted of glassy spherical particles and less regularly shaped spongy particles. The gravimetric water held between 0.l bar and 15 bars was high and varied from 37.0 to 105% with 11 out of 13 samples having values >40%. There was little difference between the water content at saturation and 0.l bar, and thus plant growth on the ashes could be affected by poor aeration. Saturation hydraulic conductivities were low (<0.l cm min^{-l}), and this was related to the volume of non-capillary pores being generally <10%.

Amelioration of most fly ashes by leaching of salts, reduction of pH by acidification, addition of N,K and to a lesser extent P and the use of B tolerant species should permit the establishment of stabilizing vegetative covers on these materials. Preliminary studies on the addition of fly ash to soils indicated that potential exists for utilizing the materials to improve the water holding capacity of coarse textured soils and the drainage and aeration characteristics of clays.