Commercial production of crops irrigated with gypsiferous mine water

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Abstract

The use of gypsiferous mine water for irrigation of agricultural crops is a promising technology that could add value through agricultural production and utilise mine effluent. Crop response to irrigation with gypsiferous mine water, as well as the impact on soil and groundwater resources were investigated in a three-year field trial set up at Kleinkopje Colliery (Witbank, Mpumalanga Province, South Africa). Sugar-beans, maize and wheat were irrigated with four centre pivots on virgin and rehabilitated land, under three irrigation management regimes using two qualities of mine water. Good crop yields were obtained compared to dry-land cropping. Waterlogging in certain areas of the fields indicated that especially rehabilitated land should be properly prepared and, where necessary, waterways built to prevent yield reduction. Soil salinity increased over the duration of the trial due to high concentrations of Ca^{2+}, SO_4^{2-} and Mg^{2+} in the irrigation water, but this never reached levels critical to yields of most crops. Exchangeable Ca^{2+} and Mg^{2+} in the soil increased with time, whilst K^+ decreased. Plant analyses indicated possible nutrient deficiencies, which should be easily managed through corrective fertilisation. The groundwater impact was limited based on borehole measurements, indicating the presence of a buffer zone between the cropped soil profile and groundwater, but this should be monitored over a longer period. Commercial production of crops under irrigation with gypsiferous mine water is feasible and the resulting environmental impact is limited, but further research is required to confirm these findings over a longer period.

Introduction

The mining industry is one of the most important endeavours in South Africa, both from the point of view of gross national product and job creation. In the mining of mineral resources, pollution problems are created with adverse effects on the already scarce water resources. Disposal of mine wastewater is a world-wide problem occurring wherever operating coal- and gold-mines, as well as closed underground and open-cast workings are found (Pulles et al., 1995). The type of water emanating from mines depends largely on the geological properties of the coal, gold ore and other geological material with which waters come into contact. The concentrations of salts and other constituents frequently render such waters unsuitable for direct discharge to the river systems except in periods of high rainfall when an adequate dilution capacity is present and controlled release is permitted. Current measures to prevent pollution of the environment were reviewed by Pulles et al. (1996).

Gypsiferous mine water can be regarded either as one of mining's greatest problems, or as a potential asset. Large amounts of wastewater could possibly be made available to the farming community and utilised for the irrigation of highly productive soils in the coal-fields of the Mpumalanga Province in South Africa, where water resources for irrigation are already under extreme pressure. In this summer rainfall region, dry-land winter cropping is not feasible and mine water is often the only source of water for irrigation. Moreover, concentrating the gypsiferous soil solution through evapotranspiration, thereby precipitating gypsum in the soil profile, will reduce environmental pollution as these salts are removed from the water system. Contamination of downstream water supplies for other users could therefore be reduced, and additional income could be achieved through farming. The high capital expense and operational cost of effluent treatment by mines could also be offset to some extent by farming income. Aluminium toxicity, often occurring in these soils, could be reduced through irrigation with gypsiferous mine water (Barnard et al., 1998). A surplus water problem for the coal-mining industry could also be significantly reduced, as the irrigation option (mine-water utilisation during dry spells) could complement the controlled release into river systems during rainy spells.

The potential for use of gypsiferous mine water for crop irrigation was first evaluated in South Africa by Du Plessis (1983). In previous work, Barnard et al. (1998) carried out field and laboratory screening trials, where a wide range of crop and pasture species were irrigated with lime-treated acid mine drainage. They proved that irrigation with this water should not present a soil salinity or crop production problem within a relatively short time period of three years, provided careful fertilisation management was applied (Jovanovic et al., 1998). The long-term effect, 50 years of irrigation with gypsiferous water on soil and water resources was assessed by Annandale et al. (1999a), using the Soil Water Balance (SWB) model (Annandale et al., 1999b) in combination with the CLIMGEN weather data generator (Campbell, 1990). They simulated the long-term soil-water and salt balance, and concluded that irrigation with gypsiferous mine water should not cause irreparable damage to soil and groundwater resources.

In this study, the general objective was to evaluate the environmental sustainability of irrigation with gypsiferous mine water under commercial crop production at Kleinkopje Colliery

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