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Simulating water and salt movement in tile-drained fields irrigated with saline water under a Serial Biological Concentration management scenario

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Abstract

We report on the analysis of water and salt balance data collected at a tile-drained experimental site irrigated with saline groundwater. Saline groundwater (EC = 8.4 dS/m) was applied to an area planted to replicated blocks of redgums (*Eucalyptus camaldulensis*) and tall wheat grass (*Lophopyrum elongatum*). The intercepted drainage effluent was disposed off-site to an evaporation pond. The experiment applied the concept of Serial Biological Concentration (SBC) of salt, which aims to reduce drainage effluent volumes from irrigated land. Data collected during the 2002–2003 irrigation season were used to calibrate the soil–water–atmosphere–plant (SWAP) model. SWAP satisfactorily simulated components of the water and salt balance when compared to the collected hydrologic data. The simulation results show that the soil EC resulting from the high applied-irrigation EC reduced crop evapotranspiration ETc and that the redgum trees produced (marginally) smaller drainage volumes of a higher salinity than tall wheat grass pasture and thus can be considered as better crops for SBC design. Simulations over a 10-year period highlight that a large proportion of the applied saline drainage water escapes below the level of the tile drains, thus reducing the concentration effect

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of the trees and pasture. Much of the water intercepted by the tile drains under the site was resident groundwater, rather than leachate from underneath the crops. The paper also discusses site characteristics and management options that would be favourable to more effective SBC designs.

Keywords: Irrigation; Drainage; Serial Biological Concentration; Tile drainage; SWAP model; Salt balance; Red gum trees; Tall wheat grass; Regional groundwater

1. Introduction

Salinity is a major threat to irrigated landscapes and waterways in many parts of the world (van Schilfgaarde, 1974; Ritzema, 1994; Ghassemi et al., 1995; Tanji and Kielen, 2002). Salinity impacts on soil and water quality and crop production and causes serious off-site environmental degradation (van Hoorn and van Alphen, 1994). Consequently, salinity is one of the most challenging environmental problems facing irrigation landscapes around the world, including Australia.

A range of methods are available to manage salinity and rehabilitate saline soils in irrigated regions of which sub-surface drainage is the most commonly applied, both in Australia (Christen and Hornbuckle, 2002) and other parts of the world (Westcot, 1988). However, sub-surface drainage schemes generate large volumes of saline water that must be appropriately managed to prevent production losses and harmful off-site environmental impacts. Community concern over the health of riverine ecosystems is putting pressure on the irrigation industry to minimise saline drainage water entering natural watercourses (Crabb, 1997). Consequently, there is limited capacity to export saline drainage water from inland irrigation regions (Blackmore et al., 1999). This situation necessitates containment and local management of saline drainage water within the irrigated regions. The two main options for local management of saline drainage water are (1) the reuse for irrigation and (2) pumping to evaporation basins for regional storage.

Serial Biological Concentration (SBC) is a relatively new option for the management of saline drainage water, combining both irrigation reuse and disposal to an evaporation basin. The SBC concept was initially proposed to minimise the size of evaporation basins needed for the disposal of drainage water with high selenium contents in the San Joaquin Valley, California (Cervinka, 1990). SBC involves the process of irrigating crops in series of increasing crop salt tolerance (Oron, 1993; Tanji and Karajeh, 1993). Drainage water collected from beneath one crop is used to irrigate the next more salt tolerant crop in the series, with the final highly saline drainage pumped into a small evaporation basin (Fig. 1). This concentration process aims to significantly reduce the volume of drainage water and therefore the size of the evaporation basin needed for final disposal. The number of stages used in the design of SBC systems would vary according to the soil and irrigation water salinity, as well as the salt tolerance of the plants used in the system. More information is needed on the capacity of such systems to concentrate drainage water to evaluate the cost effectiveness and irrigation efficiency benefits of this approach to the management of drainage water.

An SBC site has been operational for the past 8 years at Undera in northern Victoria (Heuperman et al., 2002; Anon, 2003). The objective of this study is to quantify water and