Minimising groundwater contamination using vegetation

NATIONAL CENTRE FOR GROUNDWATER RESEARCH AND TRAINING

This resource introduces store-release covers, which are layers of soil and plants used to prevent contaminants in landfill or mining waste leeching into the groundwater below. It describes work done by NCGRT researchers into the best design for these covers. It is designed for a general audience.

THE PROBLEM OF WASTE

Globally, mining produces millions of tons of waste rock (rock which is removed for access to valuable ore) and tailings (materials left over after the ore is processed). These waste products are often stored above ground in large elevated mounds.

Also, as we know, the municipal waste disposal industry tends to bury industrial and domestic waste as landfill. In 2007, Australia buried over 21 million tonnes of landfill.

A problem in both scenarios is that when it rains, the rain water percolates through the piles of waste, and as it travels, picks up acids and heavy metals that can end up in our groundwater systems.

The cost of transporting waste is so large that choosing where it is best stored is usually uneconomic – the best that we can do is try to minimise groundwater contamination.

USING VEGETATION TO MINIMISE GROUNDWATER CONTAMINATION

One of the common solutions to this problem is to put a layer of 'soil' (made up of low grade clay, sand, gravel and other materials) above the waste and grow trees and plants in it. These are called 'store-release covers', or SRCs.

The idea is that the soil will soak up rainfall and the vegetation will use that water and transpire it back to the atmosphere, effectively acting as a barrier to the rainwater percolating through the waste, and therefore removing the opportunity for chemicals and heavy metals to leech out from the waste.

One of the challenges of this strategy is knowing what's a good design for these store release covers; that is, how thick the soil layer should be, what the composition of the soil should be, what plants to use and so on.

Testing SRC design experimentally is extremely difficult, as each site has a different climate, different vegetation, different soil and so forth, and waste is stored for many years – decades to centuries. Experimental testing necessitates hundreds and hundreds of different test sites to account for the variability – all in all, it's just way too expensive and slow.

MODELLING TO FIND OUT WHAT WORKS BEST

Researchers from the NCGRT decided to tackle this problem with computer modelling.

Plant researchers often use a soil–plant–atmosphere model (SPA) to test different variables in different ecosystems.

The research team started with the SPA model developed by Matt Williams at the University of Edinburgh, which has previously been used to model various ecosystems from Brazilian tropical rainforests to the Arctic tundra to temperate and tropical Australian woodlands.

This model is highly mechanistic, meaning that it can help us understand the way in which different variables interact, and the processes that drive patterns.

The researchers looked at the influences of a number of different variables – the depth of the soil layer, the composition of the soil (which affects how much water it can hold), the leaf area index (which indicates how much water a plant will use), and the volume of rain. Once they had set up these parameters,

Want to know more?

The research described in this factsheet was led by Professor Derek Eamus at the University of Technology, Sydney. For more information, the following paper may prove useful:

Eamus, D, Yunusa, I, Taylor, D, Whitley, R 2012, 'Design of store-release covers to minimize deep drainage in the mining and waste-disposal industries: results from a modelling analyses based on ecophysiological principles', Hydrological Processes, DOI: 10.1002/hyp.9482

they could model any location in the world, providing meteorological data were available.

By varying the parameters, the researchers were able to find out which covers worked well – that is, they could find out which composition of soil and plants led to evapotranspiration equalling rainfall, in a given location. When evapotranspiration equals rainfall, it means that the plants are using all available water, and therefore there is no excess rain travelling down to the water table.

The researchers then applied this model to three contrasting climates: Darwin, which is in the wet–dry tropics, and has very high rainfall; Perth, which has a Mediterranean climate; and Sydney, which has a fairly even distribution of rainfall across the year. By looking at these specific locations under particular scenarios (for example, average annual rainfall, the highest rainfall on record, or the longest period without rain), they were able to find out how a particular store-release cover would perform, and whether they could gather any additional information about the best design for store-release covers in general.

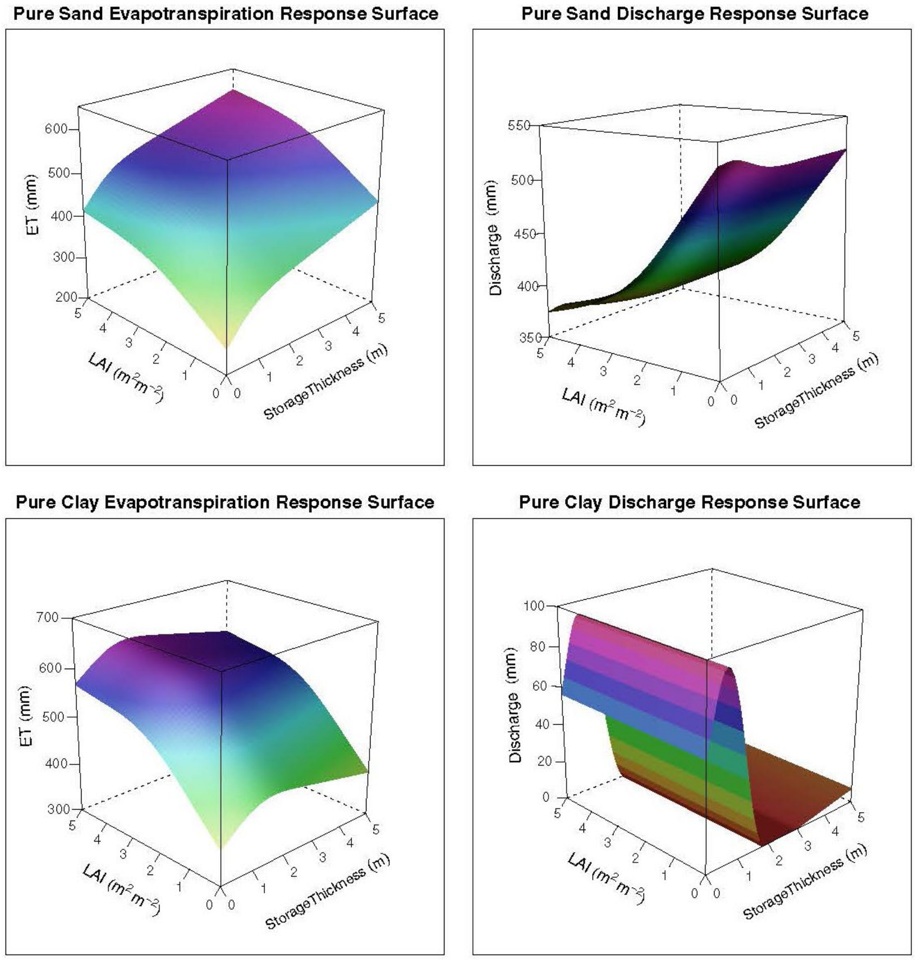

Figure 1. The four figures above are a 3-dimensional representation of how evapotranspiration (ET – or how much water plants return to the atmosphere – shown in the left two panels) and deep drainage (discharge – or water trickling down past the root zone – shown in the right two panels) are affected by leaf area index (LAI) and soil depth (storage thickness) for store release covers that are composed either of pure sand (the top two panels) or pure clay (the lower two panels). These four images show that the amount of water escaping down through store release covers to the waste below is least when there is a high leaf area index and when soil thickness is largest.

THE BOTTOM LINE

The outcome of this study was that researchers found that applying this approach could be really useful for designing the most effective store-release covers to minimise groundwater contamination from mining waste and landfill.

Furthermore, they found that working from generalised information, or rainfall averages, can lead to very ineffective store-release covers indeed!

In general the researchers found that effective store-release covers need to be able to store the rain that falls in wetter than usual years; use plants whose root systems reach right to the bottom of the cover, and which have enough leaves year round to transpire rainfall; and need to take into account rainfall variability and other climatic variables.

This research means that in future, engineers will be able to make more informed decisions about how to design store-release covers, tailored to the location that they're in.

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