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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Water resource management

Managing human-induced salinization in the Berg River catchment

A completed WRC-funded study investigated how best to manage human-induced salinisation in the Berg River catchment, Western Cape, and developed criteria for regulating agricultural land use.

Background

From previous WRC-funded work in the Berg River catchment by the project team, comprising Stellenbosch University, CSIR and Friedrich Schiller University, in Germany, various needs were identified. One was to examine the effects a range of land uses may have on the production of salinity from the Sandspruit catchment.

This project set out to establish if the range of agricultural practise in the region could be related to the differences in salt production in any way. In so doing, the team had to analyse the whole drainage path towards the river, make sure that this was duly represented in the models that were used and then test the effect that land use change had on the salinity and water levels that reached the Berg River.

By implication the study did not focus on hydrological modelling only, but also on the understanding of the system through research aimed at determining the origin of salt, the behaviour of soils in this landscape, and the effect different cultivation practices had on the water flow path. Subsequently, it had to be ascertained whether the hydrological models assessed these flows in an appropriate manner.

The main aims of this project were thus to:

- Quantify the water and salt balances for a variety of land uses and on-farm management practices
- Set up and develop a hydrological model of the Sandspruit catchment for predictions of salt load contributions to the Berg River from different land uses and management practices, and finding the best practice to accommodate land use change in hydrological modelling
- Develop guidelines for regulating land use in terms of salt generation capacity based on the knowledge gained from on-farm experiments and hydrological modelling.

Methodology followed

Continuation of monitoring since a previous study published in 2010 helped to establish fairly long-term trends in salinity, soil water and groundwater trends for this region. These were necessary to establish a pattern of behaviour related to specific land use practices.

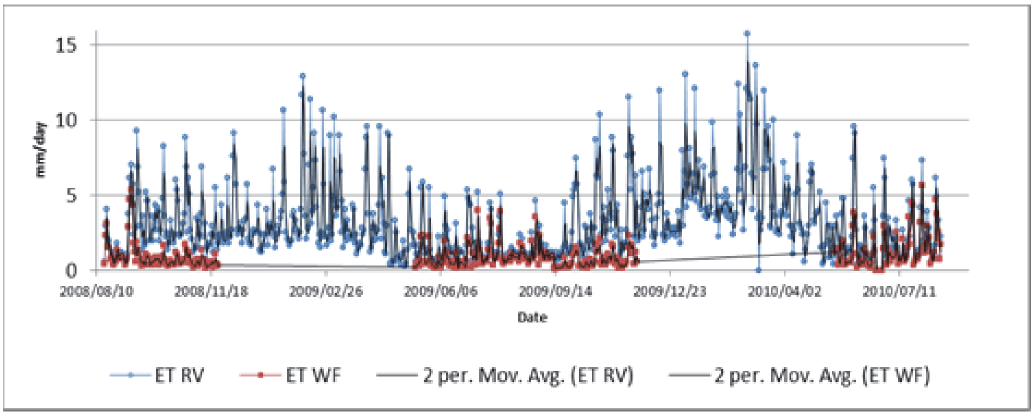
Defining the land use differences and land use change were therefore done by describing the differences in water movement through the different land use sites indicated for specific regions in this study.

A direct comparison in terms of water relations was done on the Voëlvlei/Schoongezicht site between the Renosterveld and a wheat production system. they were compared in respect of their seasonal soil water status, the perched water table levels and the deep water tables. The data were modelled using Hydrus-1D.

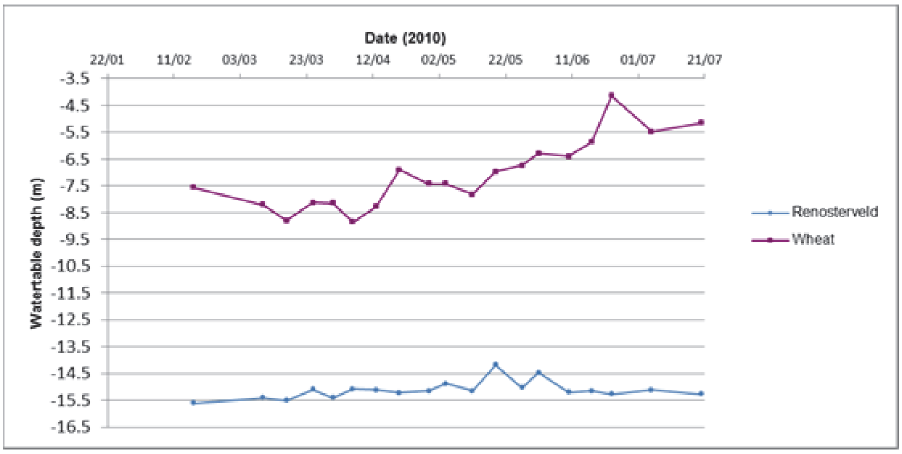
Specific land use scenarios were also studied on the Langgewens experimental farm where the impacts of cultivation practices on the water flowpaths were investigated.

Results and discussion

The water usage (evapotranspiration) in the Renosterveld system by far exceeded that of the wheat system. this explains the lower water table experienced in the Renosterveld when compared to that in the wheatfield regions.



The estimated ET for the Renosterveld and wheatfield respectively.



Groundwater depth measured from boreholes in the what and Renosterveld respectively.

Tracer studies were done on the Goedertrou farm and in the Sandspruit catchment. On Goedertrou, the idea was to test the role which salts in the soil played in the salt production from an area.

During 2005, potassium iodide (KI) was introduced on the farm in an infiltration study. During 2012, the locations where KI was introduced were re-visited and the reductions in iodine at these locations were measured. It was found that the iodine, which resembles chlorine to a large extent in terms of behaviour and reactions, was reduced significantly, and the manner in which the reduction took place is highly significant to this project.

In the Sandspruit all results indicated that groundwater is possibly affected to a larger extent by *in situ* deep drainage than by lateral flow in the system.

In the Langewens cultivation practice the study was performed on an old but still continuing experiment where four different tillage practices were applied since 1975. Of these, conventional till and no-till were the most extreme in terms of rainwater uptake. The study therefore focused mainly on these two practices.

It was indicated that the rooting depth, soil salinity, soil structure and soil density were all affected negatively by conventional tillage practices, while with no- and minimum till practices all these factors tended to return to their natural state. The no- and minimum till practise therefore presented soils with lower salinity, deeper rooting volumes and less compaction, generating conditions that allowed faster water uptake and deeper infiltration of rainwater.

These sites also indicated a lower risk for the farmer during dry spells in winter. The major concerns is that the better practice therefore seems to be that where less tillage is practiced. Less disturbance of the soil implies more winter water that enters the soils and feeds into the water table.

Larger disturbance of the soil implies more overland flow. The project team's concern therefore is that the agricultural practices of no- or minimum till have been shown to be the preferred practice for farmers and conservation farming. In terms of water and salinity in the catchment, it is apparent that more infiltration into the soils also implies more winter water that enters the system. This presented a larger saline seep problem until late in summer. The extra winter water in these systems is therefore not utilised by the crop production system and the removal of unwanted (alien or indigenous) perennials is therefore not advisable if saline seep needs to be limited.

The Langgewens overland flow and hill slope study was done measuring overland flow in the crop production landscapes on the farm looking at a range of terrain types. For all the measuring points, the ratios between surface runoff, sub-surface flow and deep drainage was monitored. It was indicated that a considerable component of the water reached the water table as deep drainage.

Remote sensing of salinity was done to take stock of the salinity in the catchment. It was also done to develop methods through which better input could be generated for hydrological and salinity modelling. These results further had to contribute to our understanding of the surface processes and to the defining of the hydrological response units in this area.

The occurrence of salinity in the catchment was therefore mapped based on measurements and the team's experience in terms of where soil salinity occurs. Saline prone areas were mapped.

The hydrology of the Sandspruit was tested with a J2000/JAMS model using a number of model set-up scenarios. Land use and land use change for the Sandspruit catchment are extensively linked to winter crop production systems. The measurements and models were therefore prepared to be sensitive to all possible situations in a complex matrix of crop rotation in the catchment. Testing of the models was therefore done in a real-life situation and extremes where all land use in the catchment was modelled for grazing and a total wheat cover.

The land use was mapped using satellite data. The reason for using satellite data were that one could utilise the Landsat database which spans the last 30 years. However, the development of historic database of land se from Landsat information fell outside the scope of the research.

An analysis of the effect scale had on the parameterisation of a model for the Sandspruit catchment brought to light that running a model for the Sandspruit scale implied that variation in soil physical parameters and small changes in land use related to the scale of the elevation model did not affect the model significantly enough.
Setting up of the J2000/JAMS model was done implementing a new salinity routine and implementing the first contour bank routine used in any hydrological model of the world. For the benefit of this research, the model was calibrated using a timespan for which good data existed.

This calibration was used to simulate the balance of the available data to calibrate the model. After calibration, the model was used to predict the normal mix of land uses, a change in land use towards a single land use of grazing only, and a single land use of wheat only.

Guidelines for regulating land use were defined then by five criteria:
- The crop area, and most importantly the total surface area, covered by perennials and annuals and the ratio of these areas to the total landscape area of a region
- The cultivation practice – affecting the soil and water flow paths and the contribution to stored water in the system
- The presence of contour banks and their role in water flow paths, as well as their role in water retention (slowing of runoff), thereby increasing deep drainage and recharge
- The occurrence of salinity in the landscape
- Accumulation of water in the landscape and the routes water use to reach the river

Conclusions

The project achieved more than the aims set for this research programme. The models chosen for the purpose of predicting water and salinity during land use change were even more applicable after the models were adapted.

The J2000 model was adapted to be a useful tool in the evaluation of land use practices for this region. The lessons learnt will also help to improve the ACRU model. The Hydrus-1D model was used to help the project team understand the accumulation of water in the landscape as well as the role played by cultivation practices.

Regarding the hydrological model input it was necessary to make absolutely certain that the models used would be sensitive enough to be able to reflect the effects of land use change in the differences between measured and predicted runoff from the Sandspruit. This research consequently focused largely on understanding of the systems and to make certain that the modelling output could be presented with confidence.

A broad understanding of how these agricultural systems operate and the influence on the environment was developed. This understanding, which includes the soils, the crops, the weathering zone, the water table, among others, guided the modelling done for the research.

The following key findings were indicated by this research:

- That land use, with specific emphasis non cultivation practices, determines the ratio between water infiltration and overland flow, also the subsurface lateral flow response and consequently the amount of water that will reach the water table.
- That land use is in fact a key factor to salt and water responses in this environment.
- That minimum tillage and no-till increased the total water and salt response measured in this region.
- That it is possible for farmers to contribute to the reduction of summer saline seep that reaches the Berg River.
- That the use of contour banks needs to be considered in modelling.
- That the crop production systems, compared to perennial plants, indicated that low utilisation of water in the crop production systems, is the major cause of the saline seep problem.
- That through hydrological modelling we can design agricultural land use practices that could assist salinity management in this region so that the negative impact of dry-land salinity on our freshwater resources is lowered.
- That deep-rooted natural vegetation in the major drainage pathways could stop summer seep sufficiently to reduce or stop saline seep from the low lands to reach the river.

This research will not stop the region from being a crop production area. The knowledge gained from this research could, however, change the ***modus operandi*** of the Working for Water programme for this region.

The project team cannot condone the removal of trees and shrubs to allow more water to reach the streams. This results in elevated saline water tables that also have a much worse environmental impact.

Recommendations

Since the removal of trees and shrubs allow more water, and accompanying salt load, to reach the streams, this practice needs to be suspended in this region.

There should be focus on the implementation of management tools for farmers and catchment managers.

Long-term monitoring of the current research infrastructure should be maintained. The total set of boreholes were sunk with a total cost of around R4-million could over time become increasingly important in the quest to adapt to the effects of climate change.

Further reading:
To order the report, *Management of human-induced salinisation in the Berg River catchment and development of criteria for regulating agricultural land use in terms of salt generating capacity* (**Report No. 1849/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.