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TECHNICAL BRIEF

Mine-water treatment

Determining the evaporation rate of brine solutions during treatment of mine-water with membrane technology

A WRC-funded study used field tests to determine the evaporation rate of brine solutions formed during the membrane treatment of mine-water.

Water treatment using membranes

Improvements in membrane processes have made it economically feasible to treat reclaimed water to drinking water quality. Reverse osmosis or other membrane processes are often selected for the treatment of water from a variety of sources, including mine-water. Membrane treatment results in a brine, or concentrated saline stream, which has to be managed as a waste. For example, current mine-water reverse osmosis treatment results in brine with total dissolved solids (TDS) concentrations of 17.5 g/ℓ to 51.0 g/ℓ.

Evaporation ponds for brine disposal

Disposal options for brine include treatment and/or authorisation for disposal to surface water resources, authorisation to discharge to sewer, deep well injection, spray irrigation, mechanical or thermal evaporation, and evaporation ponds. Evaporation ponds have been the preferred disposal option for the coal mining operations that were considered in this project.

One of the key factors influencing the design of evaporation ponds is the evaporation rate – the correct sizing of a pond depends on an accurate evaporation rate. Typically, the larger the surface area, the greater the rate of evaporation from the pond, however the relationship is not linear and a number of other factors also play a role. The evaporation rates for water are readily available for most areas in South Africa. However, the high salinity in the brine lowers this rate.

This project obtained the reported evaporation rates of saline solutions and carried out field investigations to measure the evaporation rates of real and synthetic brines and compare them against that of potable water and the standard published rates.

Field investigations

Field investigations were carried out in order to obtain a comparison between evaporation on synthetic solutions composed to represent various brine concentrations and potable water. Evaporation of actual brine was compared to the synthetic solution at the eMalahleni Water Reclamation Plant, in Witbank, Mpumalanga, in order to verify that the synthetic solutions are a reasonable representation of the evaporation rate on actual brines.

A weather station was purchased to understand the impact of climatic conditions on evaporation rates. The weather station had the ability to monitor temperature, humidity, rainfall, wind speed, wind direction, and solar intensity

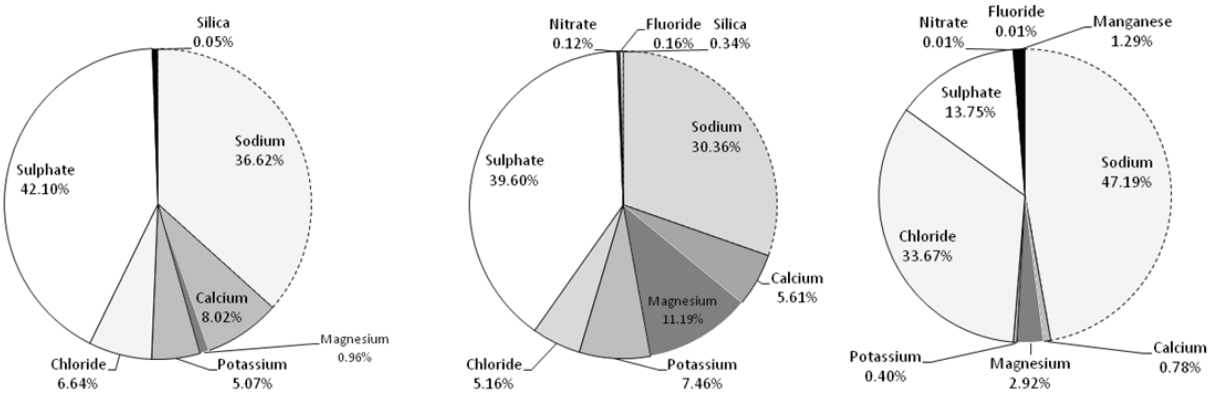
It was necessary to use standard equipment **i**n order to be able to replicate data at various sites requiring evaporation ponds, thus standard A-Pans were used to measure the evaporation rates.

Brine characterisation

Three brines from different coal mining operations were assessed and their characterisation showed that brines from apparently similar operations can differ considerably in nature.

Using the characterisation results, synthetic brine solution was created and used in Apans set up at eMalahleni. It displayed similar results to the evaporation of real brine. This confirmed that synthetic solutions can be used during the design phase of a project in order to determine a salinity factor, prior to the construction of a pond.

An average salinity factor of 74% was calculated for eMalahleni and Kilbarchan synthetic solutions and 65% for



Brine compositions from left to right: eMalahleni, Optimum and Kilbarchan coal mine-water treatment retentate.

the Optimum synthetic solution. This indicated that the salinity factor is influenced by both the concentration and the composition of the brine and that TDS alone is insufficient for pond design.

Stratification in ponds

Initial results indicated that stratification occurred in the evaporation pans, impacting on the results obtained. The experimental procedure was modified to include daily mixing in the pans.

The evaporation of the brine from unmixed ponds was faster than the predicted rate, and the effect of mixing was to slow evaporation down. The implications of this observation are that the standard procedure of mixing evaporation ponds may impede the removal of the water from the pond. Stratification allowed the less dense, less saline water to form a layer at the top of the pond and for the evaporation rate to be closer to the clean water rate than was anticipated.

Impact on future research and practice

When designing evaporation ponds, samples of the brine to be disposed of must be used to empirically determine the specific evaporation rate, or to design a recipe for a synthetic brine to be used to determine the rate.

Further research should be undertaken in a controlled environment in order to better understand the impact of various climatic conditions on the evaporation rate and salinity factor.

The widely accepted need for mixing evaporation ponds needs to be revised.

Further reading:
To obtain the report, *Field testing to determine the evaporation rate of brine solutions formed during the membrane treatment of mine-water* (**Report No. 1895/1/12**), contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.