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## More alcohol with your water could cut evaporation

By Gary Alcorn

Every irrigator knows water costs money and evaporation probably costs growers over 1000 gegalitres per year lost from small dams. That's \$1 billion worth of water at \$1000 per megalitre.

But Australian investigators could have the answer to cutting these huge losses. University of Southern Queensland (USQ) researcher Dr Ian Craig sums up the current situation.

"Currently we need more research to enhance the chemical monolayer option to control evaporation.

"Our best lead is based on work done by Professor Geoff Barnes (University of Queensland) and Professor David Solomon (University of Melbourne) in developing new molecules.

"Dr Emma Prime (UoM) is also currently completing some very promising research in this area," Ian said.

### BACKGROUND

A multidiscipline team of 23 researchers led by Ian conducted a review of evaporation research methods.

Their 2007 paper – *Evaporation, Seepage and Water Quality Management in Storage Dams: A Review of Research Methods* is a comprehensive investigation of the various agencies used to monitor and control stored water losses.

Previous studies funded by the Queensland Department of Natural Resources and Water (NRW) included:

- Evaluating computer models;
- Formulae and measurement devices and comparing the effectiveness of shade cloth;
- Floating covers; and,
- A cetyl alcohol monolayer on dam water surfaces.

During the 2002–05 NRW study, the National Centre for Engineering in Agriculture (NCEA) at USQ evaluated the performance of various different types of commercially-available dam covers.

The principal outcomes from this investigation comprised:

- Important new knowledge regarding the field performance of various different types of cover;
- Technology required to accurately assess evaporation and seepage losses; and,
- Increased public awareness of the potential for evaporation reduction on water storages.

The study revealed evaporation was reduced by approximately 75 per cent for

shadecloth-covered dams, up to 95 per cent with dams covered with a properly functioning floating cover, and approximately five to 30 per cent with dams covered with a cetyl alcohol-based chemical monolayer.

But physical covers are still too expensive for many Australian farmers.

So ongoing research led by NCEA director Erik Schmidt is focusing on the future for a cetyl alcohol-based chemical monolayer as a cost-effective solution to dam surface evaporation.

Economic analyses conducted by Erik indicates that for larger dams, chemical monolayers represent potentially the best

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Water\$avr (cetyl alcohol) monolayer seen spreading across the surface of a dam (courtesy of Nylex Water Solutions). Visual observation of monolayers in this way is only possible under conditions of light wind.

option for protection of agricultural water in Australia.

“Chemical covers offer a potentially very attractive prospect of an economical cover to reduce evaporation from large agricultural dams,” he said.

Such chemicals have traditionally been monolayers – long single chain molecules with one hydrophilic (moisture loving) and one hydrophobic (moisture repelling) end.

This structure enables the molecules to sit at the water surface and pack closely together forming a film that is only one molecule thick (approximately two nm). It is the close packing of these molecules that provides the resistance to water evaporation.

Traditionally, the monolayer materials have been the higher alcohols – linear hydrocarbon chains with 16 or 18 carbons

and with an alcohol (-OH) group at one end.

UQ’s Dr Geoff Barnes explains: “The longer the carbon chain, the more effective the monolayer is at retarding water loss.

“But at the same time a longer chain decreases the affinity of the monolayer for water, retarding the rate at which the monolayer will spread on a water surface, and increasing the brittleness of the monolayer,” he said.

C16-18 alcohols have been selected in the past because they offer high resistance to water evaporation and small flakes of the solid alcohol spread spontaneously to form monolayers with a high molecular packing density.

Fortunately monolayers of cetyl alcohol (a mixture of C16 and C18 alcohols) are biodegradable and have been cleared for use on drinking water storages by national regulatory agencies.

They have a minimal effect on the transport of oxygen through the air/water interface, and so a minimal impact on aquatic biota, but can significantly retard the loss of water by evaporation.

New products for evaporation control based on silicone chemical films are also now being used in Australia for evaporation control.

So why are these monolayers not universally adopted?

Monolayers suffer from several problems that have restricted their use including loss by evaporation, bacterial action, and wind dispersal by wind. Their useful lifetime on a natural water surface is thought to be between two and 10 days.

So, although the material cost is low, there are significant costs in monitoring and reapplying the monolayer.

Optimising the performance of monolayers with a full investigation of degradation mechanisms and also improved application methods is currently the focus of CRC-IF funded research efforts at USQ, UQ, UoM and UNE, Ian said.

### FUTURE DIRECTIONS

- There is a potential for monolayer enhancement. Monolayers based on cetyl or stearyl alcohol are permeable to oxygen and need only be present in a layer one molecule thick, enabling large surface areas to be covered with minimal environmental disturbance.

Some preliminary investigations have indicated that the performance of cetyl alcohol-based monolayers may be significantly enhanced with the addition of other chemicals.

For example, polyvinyl stearate (PVS), a polymer with a comb-like structure may enhance the resistance of the monolayer to stress.

Selection of food-grade compounds, or compounds chemically similar to naturally occurring plant waxes will minimise any adverse environmental impacts associated with the application of artificial monolayers.

- The chemicals used for monolayers must be able to withstand the harsh solar radiation and wind environments of Australia. Wind tunnel investigations by Prof Nigel Hancock (USQ) and his students have demonstrated most surface films are affected by wind – but it appears that cetyl alcohol is not affected by high levels of ultraviolet radiation.
- The performance of chemical monolayers may also be affected by the presence of bacteria or microlayer impurities in the water.
- Research by Dr Pam Pittaway (USQ) is underway to explore other molecules with longer chain lengths which may be more resistant to microbial attack. It is known that certain hydrophobic surface films form naturally on impounded waters such as lakes and stagnant pools. Model systems such as the biochemistry of the animal rumen may provide insights into likely candidate molecules
- A number of techniques show promise for assessing the degree of monolayer coverage and the nature of the monolayer (ordered or disordered) in field measurements. These include laser reflection from the water surface and the use of horizontal transducers to measure surface tension (UNE, Armidale)
- Work being done at the Department of Chemical and Biomolecular Engineering, UoM by Prof Solomon and Dr Emma Prime may soon lead to very promising and patentable new polymer chemistry which will help significantly in the battle against evaporative loss.

The authors are grateful to the Cooperative Research Centre for Irrigation Futures (CRC-IF), CRC for Polymers, Cotton Catchment Communities CRC, Queensland Department of Natural Resources and Water (QNRW), and the Australian Centre for Sustainable Catchments (ACSC) at USQ for funding the various aspects of this work.

This article, based on the research paper - *Evaporation, Seepage and Water Quality Management in Storage Dams: A Review of Research Methods (2007)* by Craig, I et al is available via USQ Eprint.

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