An advancing front of monolayer film in the foreground on on cotton water storage at St George, Queensland in March 2012 shown by the smooth water surface in the image. (Photo: Guy Roth)

Evolution of polymers mitigates evaporation

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IN BRIEF…

- Development of an improved ultra-thin film (monolayer) evaporation mitigation system is well underway.
- Improvements include longevity on water surface and ability to maintain evaporation savings under wind conditions, which were limitations of previous technologies.
- Development also underway of automated application system giving users the "set and forget" option for their evaporation mitigation strategy.
- An evaporation savings of 35 per cent was demonstrated at one stage of a trial in Queensland.

EVAPORATION from water storages is a major issue affecting agricultural regions of Australia with annual losses potentially exceeding 40 per cent of water stored. Loss of this water can lead to reduced agricultural productivity. While a range of structural evaporation mitigation options (for example floating covers, suspended shade cloth) are available for small storages (less than 10 hectares), many storage dams have surface areas greater than 10 hectares and existing structural products are less applicable and require large capital outlays.

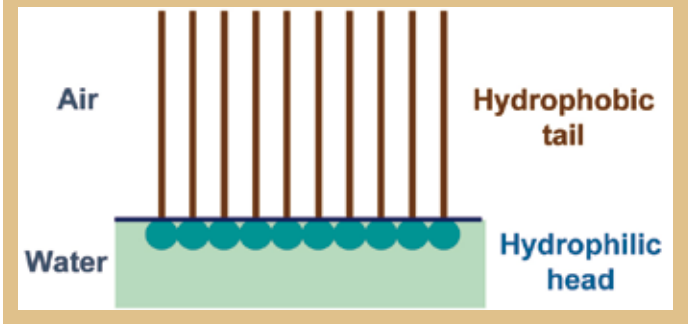
For such large storages, chemical ultra-thin films (for example chemical or polymer-based monolayers), either on their own or in combination with other systems, provide a compelling option. They offer the advantage of being applied to stored water only during periods when the evaporation rates are high and have low capital costs. However previously developed products have limitations and have not found widespread use. This research has focussed on developing improved chemical ultra-thin film products and demonstrating their effectiveness in a range of field trials.

Chemical ultra-thin films (monolayers) typically act like a detergent, very efficiently spreading out across the surface to provide a thin (often only a single molecule thick) layer that is not visible and reduces evaporation by restricting the transfer of water into the air. Due to this unique ability to form an ultra-thin layer, only a very small amount of material is needed to establish a protective film on a water body. For example, for a one hectare dam only 80–100 g of material is needed. To put this into context, the amount equivalent to three scoops of standard laundry powder would cover a 10,000 m^2 water body! A schematic diagram showing a typical monolayer on the water surface is shown in Figure 1.

Other unique properties of this ultra-thin film technology include the ability to re-form following a disturbance such as those caused by wind, birds, livestock and other animals. This means application of this technology will not detrimentally impact animal or human use of the treated water body, and use of the water body will not cause any significant disruption to the evaporation performance of the film.

A fundamental breakthrough in 2008–09 was the

FIGURE 1: Schematic diagram of a monolayer on the water surface.



development of novel ultra-thin materials which demonstrate significant improvements in performance compared to previous technologies. These included improvements in longevity on the water surface and ability to maintain evaporation savings under wind conditions, two limitations identified with the previous technologies. This breakthrough has subsequently been protected by a patent application and extensive laboratory-scale testing has identified the best performing system to progress to field trials.

A range of small and medium-scale field trial sites have been set-up across Australia including 3.7 m^2 troughs, 135 m^2 ponds and 330 m^2 dams at Dookie, Victoria and 220 m^2 sections of a lined disused (non-flowing) irrigation channel at Yanco in NSW.

A range of trials have been conducted investigating factors such as different chemical and physical formulations, different application rates and regimes, and the effect of water quality. Unfortunately recent summer seasons have been unusually wet and cool and the field trials were often interrupted by rain events making the study more challenging. Despite this, evaporation savings of 40 to 60 per cent were consistently observed throughout these small and medium-scale field trials demonstrating the effectiveness of the new technology.

The next step is to undertake larger scale field trials to further demonstrate the technology. To date a trial has been carried out on a 16 hectare dam at Forest Hill (Queensland) from which a large number of observations and understandings were obtained that were used to further improve the product. An evaporation savings of 35 per cent was demonstrated at one stage of this trial.

Over the summer of 2011–12 a field trial site was established on a cotton farm at St George in Queensland using two similar sized (approximately eight hectare) dams. Where the film was present the surface was smoother and reflected the sky. Beyond the advancing front of the film, the water was more affected by surface waves.

But heavy rain and flooding has unfortunately limited site availability and therefore limited data has been obtained to date. Despite the weather plans are still in place to conduct further large scale field trials over the coming evaporation seasons to obtain the results needed to progress development through to the next stage of commercialisation.

Concurrently, development of an automated application system that will give users the option to 'set and forget' their evaporation mitigation strategy is underway. Automated applicators can be programmed to dispense product according to specific application protocols that are currently under development, allowing users the option of deploying these applicators on their water storage with occasional refilling being the only labour required. Alternatively, users may opt to dispense the product by hand, without the use of an automated application system. Due to the uniqueness of this product, either option should produce good evaporation savings for the user.

In addition to the field trials, appropriate environmental testing is being carried out. This is necessary to ensure there is no negative environmental impact of these films on the aquatic environment, livestock, other animals, or humans. A regime has been developed in consultation with potential end users and commercial partners. This regime includes toxicity testing and a ready biodegradability study, and testing is currently underway. The contents of the current system under development are commonly used in products that have been employed in diverse uses, and in uses where there is human exposure, such as detergents and cosmetics. As such, they already have approval for use indicating they are non-toxic. Initial toxicity testing has shown that the materials are considered non-toxic, particularly at the extremely low levels that will be used.

The development of an improved ultra-thin film (monolayer) evaporation mitigation system is well underway. A breakthrough discovery in the laboratories has led to the development of a novel product which has progressed through extensive laboratory testing, small and medium-scale field trials, and is now in the process of undergoing trials in larger water bodies. An environmental testing regime has been put in place and progress so far is indicating no negative environmental impacts through use of this product. Continued large-scale trials, further development of an automated application system and finalising the environmental testing are the project aims heading into the future.

Further reading at www.crdc.com.au

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