

# Systems to control the air–water interface to reduce evaporation from water storages

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## Key findings

- » Applying a monolayer of ethylene glycol mono-octadecyl ether polymer reduced evaporation by 50%–60% under small scale, controlled environmental conditions.
- » Under field situations its efficacy is significantly reduced and produces inconsistent results with evaporation savings of less than 10%.
- » Windy conditions and/or a decrease in the polymer's longevity on the water surface under field situations probably cause this reduced effectiveness.

## Introduction

On- and off-farm storages are an integral part of Australian agriculture and the environment. Evaporation and seepage are known to significantly reduce the efficiency of water storage systems. Until now, seepage had been considered important; however, evaporative loss has not been given due scientific attention as it has been considered inevitable in the natural hydrologic cycle.

The impacts of frequent drought and related increased prices of dwindling water supplies for domestic and agricultural uses have led to investigations into methods of saving water lost through stored water evaporation. This is a national problem currently causing potential reducible losses of more than 23,000 GL/year, or 120% of all water used in Australia (18,767 GL/year). This is comprised of 22,123 GL/year from larger storages (>1000 ML storage capacity) and 1,320 GL/year from farm dams.

Relatively expensive mechanical structures such as floating covers and suspended shade cloths are deemed unsuitable for commercial or large sized storages (>10 ha) due to the high initial capital investment and maintenance costs. Using mono- and micro-layers of certain chemicals, in spite of their variable performance, for larger storages is promising. These products, which self-spread across the water surface to provide a thin layer (often called a monolayer due to its thickness of one molecule) that lowers water vapour transfer into the air, are potentially cost effective and practical. Monolayers applied to water bodies with a surface area greater than 1 km<sup>2</sup> have reportedly reduced evaporation by 8%–37%.

More than 95% of water storages are currently uncovered and untreated. There is an urgent need to develop new chemical-film technology, including new environmentally benign and biodegradable products with monitoring capabilities. Research reported here highlights results from a series of experiments that evaluated polymer-based evaporation control systems under various environmental scales.

## Site details

Evaluating common evaporation mitigation (EM) products started several years ago at the Yanco Agricultural Research Institute. Early experiments used a polymethyl silicone solution, a mixture of cetyl (hexadecanol) and stearyl (octadecanol) alcohols, and two polymer-based products (E10 and E100) under the following controlled environments (figures 1 and 2):

- temperature-controlled glass chambers
- exterior fly-screen house
- lined shallow concrete tanks
- two 20 m long lined channel storages with 110 m<sup>2</sup> water surface area when filled to maximum capacity.



Figure 1. Set-up for evaporation experiments conducted in temperature-controlled glass house (left); exterior fly-screen house (centre); and lined, shallow, concrete tanks (right).

In all experiments, available untreated irrigation water was used. A series of experiments were conducted for evaluating EM products for their application rates and frequency of application on reducing evaporation. A field experiment was also undertaken to evaluate polymethyl silicone solution, and a mixture of the two alcohols.

A commercial irrigation channel was used to prepare five lined channel storages in 2010 for the field scale evaluations of polymer based evaporation mitigation products. Each of the five storage channels had a water surface area 42 m long and 5 m wide when full. Researchers from the University of Melbourne and Cooperative Research Centre for Polymers collaborated in the experiment. This site is maintained for conducting experiments during the summer season, including pre-season testing and post-season care. Since then trials of 3–5 weeks duration have been conducted annually to evaluate different polymer formulations, their

application rates, forms (solutions, suspensions and solid powders) and application frequencies. Available water from the irrigation canal used in these experiments was analysed for pH, electrical conductivity (EC), dissolved oxygen, turbidity and ionic chemistry before and after each experiment. Evaporation was measured using pressure sensors linked to an automated data logger and a weather station. Odyssey capacitance meters were also used to measure water levels in the lined channel storages for measuring evaporative water losses.

## Results

### Glass house

Experimental results showed significant reduction and variation in evaporation due to different temperatures, application rates and re-application frequencies of the alcohol mixture, polymethyl silicone, and the two experimental polymers. Comparison of water savings indicate superiority of polymers X and Y (Table 1).

Table 1. Impact of applying evaporation mitigation products on reducing evaporative losses of water.

Product and application rate	Application frequency	Evaporation reduction (%) at 20 °C	Evaporation reduction (%) at 30 °C	Evaporation reduction (%) at 40 °C
Polymer X @12 monolayer concentration	2-day intervals	40–61	39–47	36–43
Polymer Y @12 monolayer concentration	2-day intervals	42–58	38–48	35–45
Polymethyl silicone solution at 12–18 L/ha	10-day intervals	28–34	24–29	18–26
Cetyl and stearyl alcohols mixture applied at 1500–3000 g/ha	Alternate days	18–26	14–21	12–18

### Exterior fly-screen house

Using polymers showed significantly improved efficacy by almost halving evaporative losses. Polymer application of 12 monolayer concentration at two- or four-day intervals reduced evaporation by 40%–60%. Results also showed that application at a 36 monolayer concentration at two-day intervals was significantly superior to the 12 monolayer concentration. Application frequencies of two- or four-day intervals were mostly on par, but significantly better than application at seven-day intervals.

### Shallow concrete tanks in the open

Results indicated water savings of 3.1% by applying the alcohol mixture (1000 g/ha on alternate days) whereas polymethyl silicon (6.0 L/ha at 10-day intervals) saved just 7.1%. Application of polymer E10 and E100 at a 12 monolayer concentration at four-day intervals reduced evaporation by 12.1% and 10.3% respectively. Water savings were found to increase to 12.5%, 20.5%, 30.3% and 27.2% with a three-fold increase in application rates of the alcohol mixture, polymethyl silicone, polymers E10 and E100. Relatively lower savings in the open environment highlight the probable role of solar radiation and/or wind in reducing the effectiveness of EM products.

### Field evaluation

Results from experiments conducted in the lined storages under field situations indicated the significant role climatic variability plays, especially wind. Results have been variable so far, notwithstanding their satisfactory efficacy under controlled environmental conditions. Visual observations indicate that a wind velocity of more than 6–8 km/hour pushes the applied monolayer to the end of storage channels.



Figure 2. Field setup of lined storages on a commercial irrigation channel.

Polymer scientists at Melbourne University are working to improve polymer compound effectiveness by changing from a monolayer to a duo-layer

approach to enhance bonding at the water surface for increased resistance to movement of monolayer by wind. It has also been noted that wind tends to pick up its flow velocity at noon, probably due to the convective flow of energy. Considering this, appropriately timing polymer compound applications are also being reviewed and evaluated.

### Summary

Research into use of EM products (especially polymers) is of significant interest to the Australian agricultural industry. A monolayer polymer called ethylene glycol mono-octadecyl ether (C18E1) has been developed. It reduces evaporation consistently by 50%–60% under controlled conditions. However, research is still in progress to improve its desired effectiveness under field situations.

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