Reducing water evaporation on farm dams: A new approach

By Professor Greg Qiao, University of Melbourne

EVAPORATION from water storages on farms remains a significant issue for farmers in many regions of Australia and around the world. For example across the Australian northern cropping region on average a quarter – and as high as half – the water from irrigation dams is lost due to evaporation. In other words, a 30 hectare (1000 megalitres) storage can lose 800 millimetres of water during summer due to evaporation. This equates to a loss of 240 megalitres over this period or 2.7 megalitres a day.

Over the past few decades, there have been several technologies investigated to tackle this issue. One of the most well-known examples is the 96 million "shade balls" (black plastic balls) covering the entire Los Angeles Reservoir. According to the local authority, these shade balls have shown evaporation savings as high as 90 per cent.

But similar to other solutions which use physical materials to cover the entire water surface, the cost of materials and instillation have been significant and are limited by the size of the water storage.

Natural solutions which utilise trees and vegetation planted around the banks of the dams to reduce wind evaporation and provide shading, have shown relatively low water savings and are impractical on larger scale water bodies.

Lastly, there are chemical materials that spread over the entire water surface and are applied in either a powder or liquid form to form a thin molecular layer at the water surface. The main advantage of these monolayers is that they can be added to the water surface from the bank and will spread across the dam. The film is very thin, 30 times thinner than a human hair, which only requires a small amount to add for the full coverage.

These materials offer a solution with a simple deployment, that requires minimal amount of material, and have previously shown promising evaporation savings in lab trials.

One of the first field trial sites looking at reducing water evaporation.

Typical monolayer films are formed using organic materials that are not toxic and are biodegradable, preventing any accumulation in the environment. These materials are a promising option for effectively reducing water evaporation, but previous field trials on dams have discovered that these monolayers are susceptible to water surface disruptions from medium wind speeds, reducing their evaporation saving rates and coverage area.

An improved approach is required to overcome this challenge with monolayers and is being developed as part of the Smarter Irrigation for Profit Phase 2 (SIP2) project.

A cost-effective solution

To address the loss due to water evaporation, a team at the University of Melbourne has been working to develop a cost-effective solution to mitigate evaporation in open water storages. The current project is a collaboration between the Chemical Engineering and Mechanical Engineering Departments.

The team based in the Chemical Engineering Department has more than 10 years of experience in working with monolayers, including running large scale field trials on-farm using the monolayer technology. They have been working with the Mechanical Engineering Department for the past five years to develop a solution.

The mechanical engineering team has a strong research background in studying fundamental fluid mechanics problems, especially areas related to turbulent flows and air-water interactions. To achieve better performances from the monolayers, the team is investigating a combined approach where monolayers are used alongside a cost-effective physical barrier device.

The introduction of a physical structure effectively reduces the water surface disruptions caused by wind and the subsequent

A droneshot of the Dookie control dam.

Over an Australian summer, evaporation losses from dams can be typically 25 per cent, and up to 50 per cent in some areas.

waves. This physical barrier device provides protection to the monolayer as well as reducing evaporation itself by mitigating moisture exchange across the air-water interface.

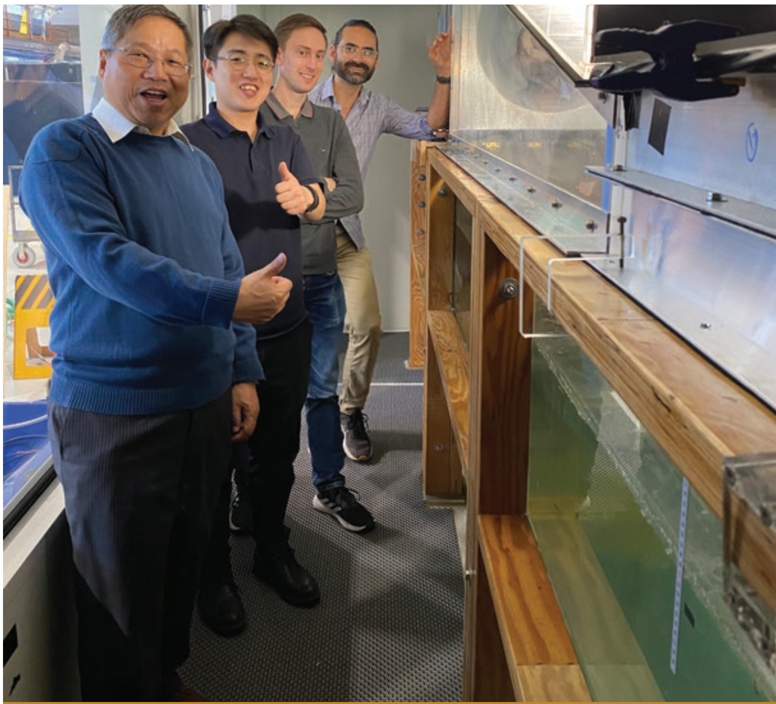
Compared with existing physical solutions, this newly developed physical barrier only needs to cover a small section of the water surface, which reduces the amount of material used as well as the cost.

These barriers were initially developed and tested in laboratory-scale trials using specially designed wind-wave tanks before scaling up to field trials. The technology was initially tested in the wind-wave tank prior to the start of the SIP2 program, which started in 2019.

The trials were designed to give information on combined monolayer and barrier performance under a range of wind and wave conditions. During the first year of the SIP2 project, a range of materials and conditions (such as wind speeds) were tested to find the optimal design for the barriers and measure their performance in combination with the monolayer.

The choice of these materials significantly reduced initial costs (including material and installation costs) and provided structural stability under various environmental conditions. The main advantage of these large laboratory-scaled trials was the ability to carefully control the surrounding environmental conditions and measure the impacts of changing parameters such as wind speed. The small scale trial was ideal for testing a range of barrier designs and materials, which was a crucial step in finding the optimal parameters for the barrier design for larger scale field trials.

Testing in a wind-wave tank was the first step in the project.



Professor Greg Qiao with some of the research team.

First field trials

The first field trails utilised identical 40 m long irrigation channels to measure evaporation where controls and variations could easily be made. After optimising the barrier designs, promising results were achieved when combining monolayer and barriers, consistent with the laboratory trials with water savings as high as up to 40 per cent.

In 2021, larger barrier designs were developed for implementation on open irrigation dams. A full scale deployment of the barrier prototype was conducted on a 0.2 hectare dam over the 2021–22 summer period. These trials were conducted at the University of Melbourne Dookie campus where these water storages are often used as water sources for livestock. Ultimately, these trials had successful outcomes with results matching the lab and channel trials and achieved average daily savings of at least 40 per cent when barriers were combined with the monolayer.

When scaled up further, this new technology is expected to result in significant water savings. For example, on a 30 hectare dam, these savings would reduce evaporation from 240 megalitres to 144 megalitres or a saving of 1.6 megalitres per day for the whole dam. Given that seasonal in-field water use for fully irrigated crops is typically between 6 to 8 megalitres per hectare irrigated over a cropping season, these savings can be quite significant.

This project is supported by funding from the Australian Government, Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program, CRDC and University of Melbourne.

If you would like more information about our evaporation research or any of the other projects in the Smarter irrigation for profit – phase 2 program, head over to *https://smarterirrigation.com.au/* and be sure to subscribe to the Smarter Irrigation YouTube channel, and follow us on Twitter @Irrigation4P or Facebook @smarterirrigation. If you would like to know more about the research we are conducting at the University of Melbourne, head to Polymer Science Group and Fluid Mechanics Research Group pages. Polymer Science Group (*https://chemical.eng.unimelb.edu.au/polymer-science/*), Fluid Mechanics Research Group (*https://fluids.eng.unimelb.edu.au/*). ■