Determining operational requirements to optimise monolayer performance on a farm dam via a 'Universal Design Framework'

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Introduction

Chemical monolayer films are potentially an economical low-impact means of reducing evaporative loss from farm water storages. However, their performance can be highly variable as they are affected by a number of complex site-specific, climatic and environmental variables. These include wind-induced effects such as surface drag, drift, volatilisation, submergence by waves and beaching on the lee shore, and biological degradation. All of which need careful consideration, simultaneously, to determine (1) what monolayer material/s to use; (2) the type of application system, its estimated performance and how to spatially arrange that system on-site; and (3) what application strategy to employ. These multiple influencing factors have been studied in detail and consolidated into a 'Universal Design Framework' (UDF) to aid decision-making in regards to the above, during planning, design and installation of a monolayer-based evaporation mitigation system.

Methods and Materials

To inform question (1), six reservoirs within South East Queensland were benchmarked with respect to water quality and biological characteristics. Qualitative assessments were made of water source/s, water colour, turbidity, catchment vegetation type and storage size. Water chemistry was also characterised using pH, EC dissolved oxygen, biochemical oxygen demand and UV absorbance. The resilience of three monolayer compounds to microbial degradation was assessed in laboratory studies using a common freshwater bacterium with a monolayer provided as the sole organic carbon source. In addition, performance of the monolayer compounds in reducing evaporative loss on clean water was compared with results from a brown water storage. These data were then ranked, given a weighting of importance, and used within a decision matrix to match suitable monolayer materials with the water quality and biological characteristics of a nominated water storage.

For questions (2) and (3), a monolayer dispersion simulation was developed to enable rapid evaluation of a range of different environmental conditions. Algorithms within this model were deduced and their parameters are being calibrated in large-scale laboratory trials; firstly from the natural spreading ability of the monolayer under zero wind conditions; and secondly from the dispersion rate of monolayer under the influence of wind. The simulation permits desktop exploration of the effect of differing spacing between applicators, applicator types (i.e. on-shore or floating) and placement of applicators to achieve optimal surface coverage under a range of wind speeds and directions.

Quantitative results from these desktop scenario explorations are used to populate decision charts within the UDF: this information then enables a specification for the optimal design and operation of a monolayer application system which is unique (but comprises only standard components) for that specific agricultural reservoir.

Results & Discussion

Monolayer performance results from experimentation, modelling and related research have been incorporated within the UDF. Key results to date indicate the following:

1. Hexadecanol (C16) will only perform on large storages with clear, good quality water, not subject to algal blooms. The related compound octadecanol (C18) will perform under

many different combinations of storage size, water colour and water quality. C18E1 will perform on storages that vary in size, and water quality, but will perform poorly on brown water storages or storages experiencing algal blooms (Table 1).

Table 1: The water quality attributes of three water storages were matched with the performance specifications of three monolayer compounds to predict which product will best perform on a given storage (Pittaway 2010).

Water Storage:	pH:	Algal Bloom:	UV Absorbance:	Water Colour:	Storage Size:	Suitable Monolayer/s:
Cooby Dam	8.4	no	0.14	clear	306ha	C16 or C18 or C18E1
USQ Ag. Plot	9.1	yes	0.31	pink	0.01ha	C18
Narda Lagoon	8.4	no	0.45	brown	2ha	C18

2. Re-application rate of monolayer is mainly driven by wind speed. For wind speed greater than 4km/hr the monolayer drifts down wind at a rate of 0.03-0.045 of the wind speed. As it drifts, the monolayer is constantly being removed by volatilisation and/or is submerged by waves or beached on the downwind shore. All of these processes of removal are exponentially enhanced by wind speed.
3. For wind speeds < 4km/hr monolayer disperses in an elliptical tear-drop shape from the point of application. However, above 4km/hr monolayer disperses in a triangular wedge shape, Figure 1. The higher the wind speed the narrower the triangular wedge. Therefore, the key factor determining optimal applicator spacing is wind speed.

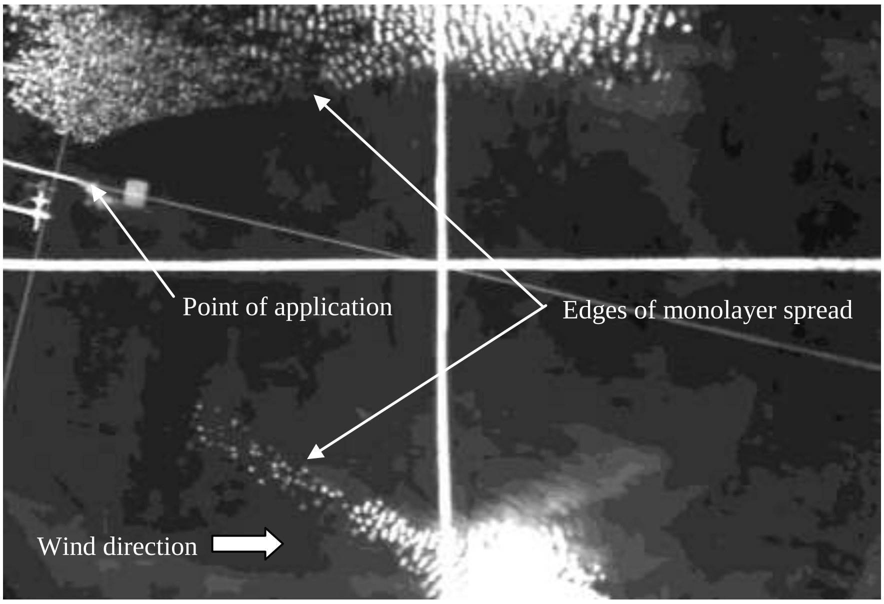

Figure 1: Image capture from a video recording of monolayer being applied continuously at 50mL/min on a 6m diameter tank (in the laboratory) and spreading in a wedge shape under an imposed uniform wind speed of 16.2km/h.

4. For large dams (>10ha), optimal surface coverage is best achieved by a number of fixed application points on-shore and also within the reservoir space (i.e. floating). With respect to the prevailing wind direction, a greater concentration of applicators is required upwind delivering higher rates of monolayer application.

Further quantitative results will be incorporated within the UDF as research progresses and new monolayer materials become available.

Reference

Pittaway, P. (2010) Water quality performance criteria for monolayer product specification: selecting the right product for the job. *IAA National Conference, Irrigation Australia Limited.* 8-10 June, Sydney, Australia.