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Extended Abstract: (see following page for extended abstract)

TOWARDS ADAPTIVE OPERATIONAL REQUIREMENTS FOR OPTIMAL APPLICATION OF EVAPORATION-SUPRESSING MONOLAYER TO RESERVOIRS VIA A 'UNIVERSAL DESIGN FRAMEWORK'

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Much of the chemical monolayer-based evaporation mitigation research was generated in the 1950s, 60s and 70s centred on the use of spreading long-chain fatty alcohols, such as hexadecanol (C_{16}) and octadecanol (C_{18}), on the water surface. Many researchers from this era have reported highly variable performance results (anywhere from 0-30% efficiency) attributing the highly variable evaporation reduction achieved to film volatilisation, drift, beaching on the lee shore and waves which can break-up or submerge the film. In summary, Mansfield (1962) stated: "It is clear that no one method of applying/spreading (monolayer) material is suitable for all locations. Factors such as storage size and shape, wind pattern, and the costs of material and labour affect both the feasibility of each technique and the details of its use". Failure to address this requirement has undoubtedly contributed to the lack of development in the use of monolayers despite some demonstration of useful evaporation suppression performance.

In addition recent studies have also indicated that all water bodies have a naturally-occurring surface film, referred to as a microlayer, which can interact with artificial (chemical) monolayers. Natural microlayers are produced by hydrophobic plant waxes, phenolic compounds and other humified material, which concentrates populations of micro-organisms capable of utilizing these materials as organic substrates. This explains why common artificial monolayers (with carbon chain lengths of up to 16) are highly susceptible to biodegradation. Studies on Australian brown water storages reveal highly concentrated microbial microlayer communities, due to the coincidence of leaf and bark fall with low rainfall (Pittaway and van den Ancker 2009). This variation in the concentration of humified organic compounds in the storages is associated with both the volume of the storage, and the riparian vegetation within the water catchment.

This paper sets out a strategic approach to the use of monolayer on a reservoir for evaporation mitigation. The approach recognises that every reservoir will have a specific set of user and environmental considerations which leads to a unique set of operational requirements. In order to capture and utilise this information a Universal Design Framework (UDF) has been developed. The UDF serves two purposes, firstly to inform the selection of monolayer material and system design for any given site ('Planning Mode'), and secondly to inform (and potentially autonomously manage) day-to-day operations, i.e. the timing and amounts of monolayer application ('Operational Mode'). The UDF takes into account the following parameters:

- **Critical water requirement periods:** These will vary from location to location and at different times of the year. Hence, this is a user determined input.
- **Economics:** The dollars-per-megalitre value of water will also vary from location to location and at different time of the year with respect to critical water requirement periods (e.g. irrigated cropping close to harvest). Included in this input is a user defined annual maximum cost outlay for the monolayer-based system.
- **Water storage factors:** Inputs differ slightly depending on storage type (i.e. ring tank versus gully dam), but generally require information of length, width, shape, bank height, freeboard, full supply volume and geographical co-ordinate points for storage orientation. This would be determined by a basic on-site analysis
- **Climate and weather factors:** Monthly average evaporation demand, rainfall and ambient air

temperature information is required, including particularly wind speed frequency and prevailing wind direction, (e.g. from a local Automatic Weather Station (AWS) or via the Bureau of Meteorology SILO database, http://www.longpaddock.qld.gov.au/silo/). In the Planning Mode mean and extreme historical climate data are used; and in the Operational Mode prevailing conditions are required.

- **Water quality and biological factors:** Assessments are made of water source/s (e.g. runoff versus bore), water colour, turbidity, water chemistry (pH, electrical conductivity and UV absorbency), plus density of local catchment vegetation and catchment area.

Once the above parameters are known, the UDF is used to determine (in Planning Mode) the most suitable monolayer material/s and optimal arrangement of application equipment, including number of applicators, their arrangement and application strategies for the particular reservoir and monolayer product. In Operational Mode the UDF will guide (or if required, fully control) operational procedures, i.e. the implementation of a unique application strategy for a specific product according to the hour-by-hour prevailing conditions.

This paper also outlines decision-making processes within the UDF. Firstly, to determine suitable monolayer materials the UDF compares water quality and biological characteristics of the particular site to those of six benchmark reservoirs in SE Queensland which have been studied in detail (Pittaway and van den Ancker 2009). The biologically-closest informs the choice of appropriate monolayer material/s. Once the selection of a monolayer is made there are a number of unique characteristics that material possesses that will substantially influence the application strategies.

Secondly, a simulation platform has been developed to determine the application strategies and operational requirements for the reservoir. The simulation enables rapid evaluation of a range of different sample water bodies to populate a decision chart similar to that for monolayer material selection. A central component of the simulation platform is a fluid-mechanical model of the dispersal of monolayer across a water surface area under the influence of environmental variables, principally wind speed and wind direction, which (in Planning Mode) determines:

- optimal spacing between application points,
- amount of monolayer applied from each applicator as well as the total amount applied,
- placement of applicators to achieve optimal surface coverage,
- number of applicator types required, and
- percentage of surface coverage under a range of wind speeds and directions.

The above simulated output information is unique to the particular reservoir and is essentially a specification for the design and operation of a monolayer application system for that specific site, and is used firstly (Planning Mode) to select appropriate application equipment capable of satisfying the monolayer application requirements; and secondly, if installed as planned, as the basis for day-to-day monolayer application (Operational Mode). Simulation results to date indicate that from large reservoirs, optimal surface coverage is best achieved by a number of fixed application points surrounding and within the reservoir spaced no further than 12 metres apart; and that a greater concentration of applicators is required upwind from the prevailing wind direction in addition to higher rates of monolayer application.

References Cited:

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Pittaway, P. and van den Ancker, T. (2009) Properties of natural microlayers on Australian freshwater storages and their potential to interact with artificial monolayers**.** Submitted to *Marine and Freshwater Research*