The impact of water quality on monolayer performance in reducing evaporative loss from water storages

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Introduction

During the 1950s and 60s, scientists developed flexible, biodegradable, mono-molecular compounds that could be applied to the surface of water storages to reduce evaporative loss (Barnes 2008). In clean water trials, the three most commonly used monolayer compounds (hexadecanol, octadecanol, ethylene glycol mono-octadecyl ether), effectively reduced evaporative loss by as much as 40%. However, the technology was not widely adopted, due to the extreme variability in monolayer performance encountered in field trials.

To be effective, monolayer compounds must have a long, hydrophobic carbon chain terminating in a hydrophilic head (an amphiphile). The chains must spontaneously spread and re-form, to produce a condensed surface film with a high surface pressure (Barnes 2008). The compound must be resistant to ultraviolet light (UV), and must biodegrade at a rate that is sufficiently slow to reduce the frequency of repeat applications. The three monolayers fulfilled these criteria, yet still failed to perform on all water storages. Unfortunately, water quality was not documented when these monolayer field trials were undertaken.

Water quality is an important parameter, as all water storages have a natural microlayer comprised of humified organic compounds which, like monolayers, are amphiphilic (Norkrans 1980). All of the published information on microlayers is from brown holoarctic lakes, documenting the increase in chemical and microbial activity as the concentration of humified compounds increases. The reactivity of the microlayer environment may well explain the variability of monolayer performance in field trials.

The objectives of this study were 1) to compare the water quality characteristics of six surface water storages located in southeast Queensland, to investigate how naturally occurring microlayers might adversely affect monolayer performance, and 2) to develop the minimum suite of water quality tests required for a water manager to select the monolayer product best suited for a specific water storage.

Methods and Materials

Six water storages varying in volume, soil type, water source and catchment vegetation were sampled for microlayer and subsurface water samples using a Larssen plate (Kostrzewska-Szlakowska 2005) and a glass bottle respectively. The samples were analysed for biochemical oxygen demand (BOD), permanganate chemical oxygen demand (COD), UV absorbance, pH, electrical conductivity (EC) and dissolved oxygen (DO). Microlayer enrichment was calculated by dividing results for the microlayer by the corresponding subsurface result. The relationship between the water quality parameters was investigated using Pearson correlation.

Results & Discussion

Microlayers were evident on all six water storages. Visually, the microlayer was most obvious as a film of particles concentrated within emergent vegetation or within the protection of a headland on the lee shore. Microlayer enrichment was greatest for water storages that had a wooded catchment and a relatively small volume. Microlayer enrichment was most evident in the BOD, COD (Figure 1) and UV results. Results for the permanganate COD indicate that the chemical reactivity of humified organics in Queensland water storages is much greater than that of Norwegian holoarctic lakes (Hessen 1985, Figure 1).

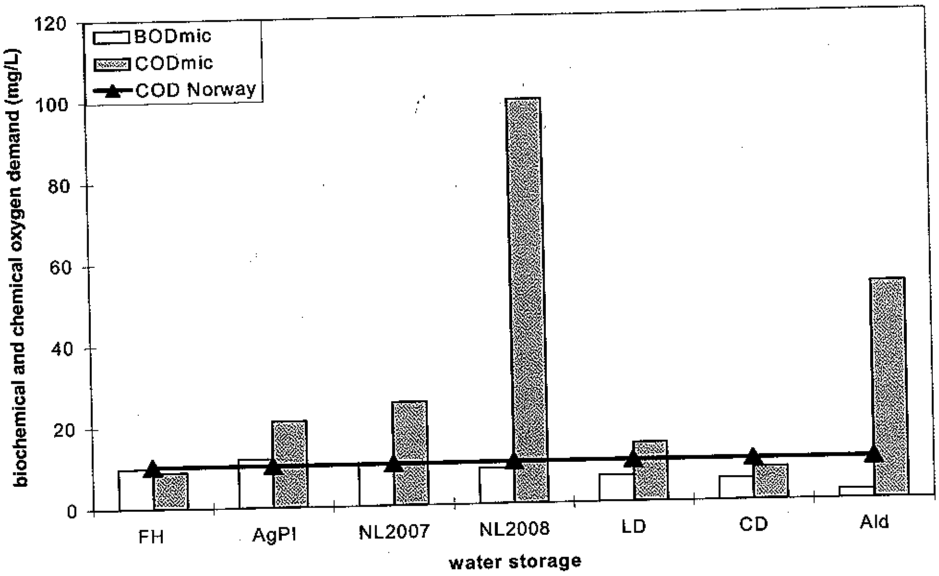

Figure 1: Microlayer BOD and COD results for SE Qld water storages sampled during the 2007 drought, and the highest Norwegian microlayer COD results (Hessen 1985). Narda Lagoon (NL, also sampled after breaking rains in 2008), Alderton (Ald) and Cooby Dam (CD) had wooded catchments, whilst Alderton (ALD) and Cooby Dam (CD) had the largest storage capacity (45 and 306 ha respectively).

The BOD was not correlated with either UV absorbance or permanganate COD. However, the COD was positively correlated with UV absorbance (Mrkva 1983). This implies that the humified organic compounds in the microlayer are photochemically reactive, but are not necessarily available for microbial degradation. For the Alderton storage, the organics may have been adsorbed onto suspended bentonite particles, further reducing their availability for microbial degradation. The humified organics are derived from leaf and bark litter within the water catchment, with levels increasing after peak summer storms (Figure 1). Therefore, monolayers applied to brown water storages with a well developed microlayer, will need to resist both photochemical and microbial degradation and must maintain the high surface pressure required to resist evaporative loss.

The permanganate COD is not routinely undertaken by commercial laboratories. However, UV absorbance (253.7 nm) can be undertaken by most commercial labs. Testing for pH, BOD, EC, DO and UV absorbance should be sufficient to indicate the potential for adverse interactions between natural microlayers and artificial monolayers. As part of the CRCIF Evaporation Mitigation Project, we have characterised the resilience of three monolayer compounds to microbial degradation and to film disruption when the compounds are applied to a brown water storage (Narda Lagoon water). We are developing testing protocols for product performance that can be integrated into a decision support system (Brink *et al.* this proceedings).

In summary, to achieve reliable, effective performance, the performance specifications of a monolayer formulation must be matched with the water quality attributes of a water storage.

References

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