Impact of destratification on the treat-ability of natural organic matter in drinking water reservoirs

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Abstract

Natural organic matter (NOM) in drinking water reservoirs affects the cost of potable water production by exerting coagulant and disinfectant demand. It also affects product water quality by acting as a disinfection by-product precursor and imparting colour and taste if not removed satisfactorily. Therefore, processes that determine the concentration and character of NOM and its transport and formation in reservoirs are of interest and concern to catchment, reservoir and water utility managers. Thermal stratification, caused by solar heating of the reservoir surface, plays a major role in determining water quality in reservoirs. A number of biological and chemical processes that result in reduced water quality, such as release of soluble metals or the growth of cyanobacteria, result after periods of persistent stratification. Artificial destratification is widely implemented to manage these water quality problems in reservoirs by breaking down thermal stratification using bubble plumes or submerged impellers. However little is known about the effect of artificial destratification on NOM. Inflow events, where increased river flow causes a riverine intrusion into the reservoir, may compromise water quality from the perspective of turbidity and pathogens. Changes in organic matter concentration and character may also occur during such an event, but has not been investigated from the perspective of potable water production.

The aim of this study was to describe the potential impact of stratification, and therefore destratification, and inflow hydrodynamics on the raw water quality in drinking water reservoirs, from the perspective of NOM. Investigations of the changes in the concentration, character and removal of NOM by conventional treatment processes during inflow hydrodynamics and thermal stratification were performed using observational and manipulative experiments and empirical and process based modelling. Further conceptual
models were developed to place NOM within the existing frameworks of reservoir management from the perspective of other water quality hazards.

The potential for short term fluctuations (hours to days) in concentration and character of NOM due to flood inflow hydrodynamics was demonstrated. A coagulant dose model (mEnCo) predicted increased coagulant dose requirements for this changed raw water quality, 40% of this increased coagulant dose was attributable to changes in the NOM. The hazard presented by NOM may co-occur or be temporarily displaced from other hazards such as pathogens and turbidity. The use of a selective withdrawal strategy at the water treatment plant (WTP) outlet would allow the avoidance of these changes in raw water quality.

The effect of the inflow on the microbial activity in the reservoir was pronounced, indicating a significant influence on the labile organic matter, especially in the particulate fraction. Community level physiological profiling, using BIOLOG™ Ecoplates, implied microbial communities imported from the catchment were able to utilise a greater number of substrates than reservoir communities indicating that catchment soil communities may be an important source of metabolic diversity.

The concentration of dissolved organic carbon (DOC) in Myponga River was predominantly described (~70% of the variance) by a nonlinear relationship with flow. Monitoring of the organic carbon concentration-flow hysteresis effects for a single winter indicated that the potential risks to water quality were greatest in the late winter due to the hydrologic and organic character parameters (catchment saturation, etc); however the hydrologic characteristics are likely to be more important in determining the risk. Therefore current hydrology monitoring systems such as online rainfall and gauge height sensors should be sufficient to inform management response to large inflow events, given sufficient understanding of the NOM dynamics. The annual allochthonous organic carbon load (240 ± 110 tonnes) was estimated to be 4 times greater than the autochthonous carbon
load (mean 1999 - 2003; 60 ± 34 tonnes). In 2002, a year of very low rainfall, the estimated autochthonous and allochthonous load were similar. Over 70% of the consumption of this organic matter could be attributed to microbial activity, and of this, 85 to 95% to the pelagic microbial population.

Changes in the apparent optical properties and molecular weight distribution (MWD) measured with high performance size exclusion chromatography (HPSEC), were observed in the field and in simulated water columns. However little change in the proportion of non-removable organic matter was observed (0.7%). The observations made during a mesocosm experiment were at least partially attributed to the pH of the sampled experimental water columns. Analysis of MWD with HPSEC with DOC detection suggested that UV transparent HMW OM had accumulated in the surface mesocosms, which was not completely removed during water treatment.

The operational response of reservoir offline management should consider organic matter to ensure the best quality raw water is supplied to WTPs. Inflow events represent the greatest potential risk for short-term fluctuations in the organic matter character and concentration. The decreased temporal variability in organic matter properties that would occur under artificially destratified conditions would probably provide a more consistent raw water quality than that from a stratified reservoir. The benefit of this consistency in raw water quality is likely to outweigh any changes in the treatability of natural organic matter under stratified conditions. The decision to employ artificial destratification should always consider system specific knowledge and conditions.