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Assessing algal bloom risks from purified recycled water addition to Lake Wivenhoe

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Abstract: As the population of Southeast Queensland continues to grow, and climate becomes warmer and rainfall more variable under the influence of climate change, there is an increasing need for risk mitigation of drinking water supplies by using alternative water sources. The Millennium drought in the 2000s was the impetus for construction and implementation of an advanced water treatment system to provide purified recycled water (PRW) to augment the water supply in Lake Wivenhoe. One of the concerns in previous studies of the impact of PRW to Wivenhoe reservoir was the potential role of the nutrients in PRW in initiating algal blooms.

In this study, we developed a modelling framework to examine the potential impact of nutrients added with PRW on algal blooms in Logan's Inlet. The modelling framework included a Logan's Inlet water quality model nested within a hydrodynamic model for the whole lake. The method involved first applying a three-dimensional hydrodynamic model (AEM3D) to the whole lake. The boundary conditions (water velocity and temperature) of this model, where Logan's Inlet connected with the main lake basin, were used as input to a nested Logan's Inlet model. The Logan's Inlet model also used AEM3D, combined with a water quality module, to simulate the major biogeochemical processes in the Inlet. The scenarios were formed as different combinations of reservoir water level (30%, 50% Full Supply Level), PRW discharge volume (23, 160, and 180 ML/d), and operation of a pumped-hydro storage (standard operation on/off). Two groups of phytoplankton were simulated corresponding to a 'background' of greens/diatoms and the toxic cyanobacterium *Raphidiopsis raciborskii*.

The modelling results demonstrated the importance of water level for the distribution and concentration of PRW in Logan's Inlet. At low water levels, Logan's Inlet is almost entirely disconnected, so most of the inlet water would be comprised of PRW. The PRW resulted in a moderate additional biomass of *R. raciborskii*, but low phosphorus inputs from the PRW appeared to limit the formation of large blooms. At higher water levels, the modelling results showed a larger volume of the bottom waters may become hypoxic (< 2 mg/L dissolved oxygen), inducing conditions suitable for phosphorus transport into the overlying water from the bottom sediments. This is also a risk from blooms and production of toxins, which can be mitigated to some extent by exchanges with the main lake basin at the higher water levels.

This study predicts that: 1) while PRW addition alone does not appear to create major issues with algal blooms, blooms may appear when moderate to major inflow discharges also occur due to rainfall events; 2) the risks to algal bloom formation from PRW addition are reduced when the water levels in Wivenhoe are higher because this allows greater exchange of PRW with the main basin. Therefore, adding PRW at higher water levels (50% or more) is preferable. This would also extend the period of higher water levels and reduce the risk of algal blooms.

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