THE FATE OF AMMONIA AND NITRATE FROM THE LOWER MOLONGLO WATER QUALITY CONTROL CENTRE IN THE MOLONGLO AND MURRUMBIDGEE RIVERS

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This thesis is dedicated to Aspi Baria.

He was my mentor, my guide and then my best friend.

It is also dedicated to my family, Leigh, Stephanie and Brennan de Wit

without their love and understanding I would not have persisted.

STATEMENT OF ORIGINALITY

This thesis is my original work and has not been submitted, in whole or in part, for a degree at this or any other university. Nor does it contain, to the best of my knowledge and belief, any material published or written by another person, except as acknowledged in the text.

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ABSTRACT

The Lower Molonglo Water Quality Control Centre (LMWQCC) is a tertiary sewage treatment plant that services the Australian Capital Territory (ACT). During the treatment process at LMWQCC, ammonia is biologically converted to nitrite and then nitrate during the nitrification process. Under normal operating conditions, the ammonia concentrations leaving the treatment plant are low but nitrate, the by-product of the nitrification process, is high and therefore river water downstream of the discharge is low in ammonia and high in nitrate. A lack of knowledge about the importance of biogeochemical cycling within this river system resulted in this study having a number of aims. These aims were to:

1) determine the location and conditions for nitrification, nitrate depletion and calculated nitrate depletion
2) determine the rate coefficients for nitrification, nitrate depletion and calculated nitrate depletion downstream of the discharge
3) measure the actual reductions in loads within the Molonglo and Murrumbidgee Rivers downstream of the discharge
4) trace the transport of nitrogen via nitrogen isotope techniques and determine the fate of the discharged nitrogen within the Molonglo and Murrumbidgee River system.

From the analysis of flow data, effluent travel time was determined within the river system and found to be sufficient under certain flow conditions to be adequate for nitrification and denitrification to occur downstream. Sediments in the river systems also have sites for both nitrification and denitrification where oxygen concentrations vary enough to enable both processes to occur simultaneously.

Experiments carried out to determine the nitrification and denitrification potential of the Murrumbidgee River showed that rates were influenced by the following:

- Nitrification and denitrification were microbially driven.
- Sediment was required for these processes to substantially occur.
- Not influenced by oxygen concentration per se but that rate of exchange of oxygen across the sediment interface is more important.
- An increase in the substrate ammonia increased the rates of nitrification.

- The addition of a carbon source did not affect the rate of nitrification but the rate of nitrate depletion and calculated nitrate depletion increased. Increased rates of nitrate depletion occurred since reactive carbon was critical in the denitrification. However, denitrification was not only affected by carbon content but by nitrate availability.
- Generally there was an increase in the rates of nitrification, nitrate depletion, calculated nitrate depletion and denitrification as temperatures increased.

During interruption of the nitrification system within the LMWQCC, there were significant loads of nitrogen species lost from the Molonglo River system within a1 km stretch downstream of the discharge in the order of 3,290 kg/day for the ammonia load; 10,450 kg/day for the nitrate load and 14,570 kg/day for the total nitrogen load.

$\delta^{15}N$ analyses in benthic algae confirmed the sewage derived nitrogen species were present approximately 15km downstream of the effluent input and nitrogen is moving through the nitrogen biogeochemical cycle.

The experiments show that the biogeochemical processes occurring in the Molonglo and Murrumbidgee during normal operation of the LMWQCC treatment plant would reduce the nitrate and thereby nitrogen loads on the river system. When plant performance decreases and ammonia is present in the discharge there is the potential for both increased nitrification and denitrification processes to take effect and reduce the ammonia loads over a wide range of temperatures. Generally an increase in temperature results in an increased rate of both nitrification and denitrification. Therefore the Molonglo and Murrumbidgee rivers are nitrogen sinks and have the potential to remove much of the ammonia and nitrate added.

This investigation has demonstrated that both nitrification of ammonia and denitrification of nitrate can occur in the sediments of the Murrumbidgee River both *in vitro* and in the actual "real-world" system. Measurements made, albeit over a short time scale, during a full scale release of a high ammonia concentration pulse typical of what would occur during a loss of nitrifying capacity at the LMWQCC, also show that a substantial portion of this material is both nitrified and then denitrified within a short distance of the plant.

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