Research

Underground nitrogen busting is crucial

A study in south-east Queensland has confirmed the vital processing role that waterside habitat plays in reducing the amount of nitrate flowing into waterways, often from agricultural land, lessening the risk of toxic algal blooms. The findings are extending to important catchment-scale assessments, encouraging targeted management, restoration and protection of riparian areas along our rivers, streams, billabongs and wetlands.

Beneath the ribbons of vegetation that hug the contours of rivers, creeks and streams, lives a microscopic world churning with the intensity of a human city. Competition for food is fierce, but members of this microbial metropolis perform a range of complex chemical tasks that allow them to make the most of the nutrients available, and maintain healthy 'riparian' (near-stream) and aquatic ecosystems.

One task, undertaken by specialised soil bacteria, is the removal of nitrogen, in the form of nitrate, from the riparian environment. This process, known as 'denitrification', turns nitrate into nitrogen gas, which is then released into the atmosphere.

Studies in North America, Europe and New Zealand have shown that riparian zones can remove over 90% of the nitrate from the groundwater flowing through them. Some of this nitrate, which comes from fertilisers, sewage or the breakdown of organic matter, is taken up by riparian vegetation or assimilated into microbial cell proteins. But a significant proportion is permanently removed from the environment through denitrification. Because aquatic plants thrive on excess nitrate, denitrification is important in reducing the occurrence of undesirable algal blooms.

The overseas findings raise questions about the importance of soil processes, especially denitrification, in Australian riparian systems. Do they play a similar role in reducing nitrate loads in streams, for example, and if so, can denitrification be encouraged by improving the characteristics of riparian zones through better management?

Answers for Australia

The answers are essential if we are to evaluate all options for improving the health of our waterways. In south-east Queensland, for example, the flow of nitrate-rich groundwater and surface runoff from agricultural and urban areas has contributed to the formation of algal blooms in coastal and freshwater systems. In 2001, a catchment-wide survey of stream-water quality in the Sunshine Coast hinterland revealed nitrate concentrations up to 60 times higher than the guideline value (0.06 mg/L nitrogen as nitrate) recommended for protection of aquatic ecosystems in lowland sub-tropical streams.

NRM&E

The typical Coochin Creek study site: a strip of riparian vegetation beside the ephemeral stream, with a shallow sub-surface flow providing excellent conditions for denitrification.

Denitrification drivers

Now, scientists from the Department of Natural Resources, Mines and Energy (NRM&E) and Griffith University, supported by the Cooperative Research Centre (CRC) for Coastal Zone, Estuary and Waterway Management and the CRC for Catchment Hydrology, have reported the first steps towards understanding subsurface riparian zone processes in an Australian context.

Back in 2000, the team commenced a study of nitrogen and carbon dynamics in riparian buffer zones at an intermittent stream near Coochin Creek, on Queensland's Sunshine Coast.

Dr Heather Hunter, NRM&E project leader, says the site was selected because it fulfilled the requirements of the team's conceptual model, specifying three key drivers of denitrification:

- a high organic carbon content in the soil to fuel bacterial processes;
- anaerobic conditions (no oxygen) to kick start denitrification enzymes; and
- a flow of shallow, slow-moving groundwater through the riparian zone towards the stream, bringing nitrate to the denitrification hotspot and maintaining waterlogged and anaerobic conditions.

Optimising denitrification

The team laboratory-tested the denitrification potential of soils and sediments from the site and found that denitrification potential was greatest in samples containing the most organic carbon.

Subsequent field studies showed that when nitrate was injected into the soil,

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significant amounts (up to 40% in one case) were removed over a number of days, through the combination of denitrification, and assimilation by plants and microbes.

'This research demonstrates the importance of soil carbon reserves in promoting denitrification,' Hunter says.

'From a management perspective, soil carbon reserves should be protected and enhanced by minimising vegetation removal and cultivation, and by building up soil organic carbon levels with deep-rooted plant species.'

Model management

Using their laboratory and field data, the team developed a model that would estimate the denitrification potential of the site, and which could then be applied to other sites with similar hydrology. More broadly, along with their study's conceptual model, important catchment-scale estimations can be developed.

To do this, a computer-based mapping technique is being designed to identify stream reaches where shallow groundwater inflows are likely to occur. This will help target priority areas where riparian management activities can be most effective in reducing nitrogen inputs to streams. When coupled with the models, the impacts of various management options can be evaluated. These techniques will be incorporated into a larger 'catchment modelling toolkit' being developed by the CRC for Catchment Hydrology.

'Not all riparian areas transmit groundwater to streams so it is important to be able to identify those areas where this is most likely to occur,' Hunter says.

'This will be possible through ongoing research, and the development of a catchment-scale mapping technique, to be used in combination with the knowledge of local community members.'

The ephemeral stream studies are now being extended to Coochin Creek itself, to gain insights into groundwater–surface water interactions and riparian zone processes in the larger perennial stream system.

The team's research is also feeding into the comprehensive scientific program underpinning implementation of the South-east Queensland Regional Water Quality Management Strategy (*Ecos* 112), and the wetlands studies being conducted by the CRC for Coastal Zone, Estuary and Waterway Management. It is an important contribution to improving our understanding and management of Australia's vital water systems.

● **Wendy Pyper**

Project member Rob De Hayr checks a riparian water sample. The team's study has confirmed that healthy Australian waterway habitats, like those overseas, can remove over 90% of the nitrate from the groundwater.

More information
http://www.catchment.crc.org.au/programs/projects/p2_5.htm

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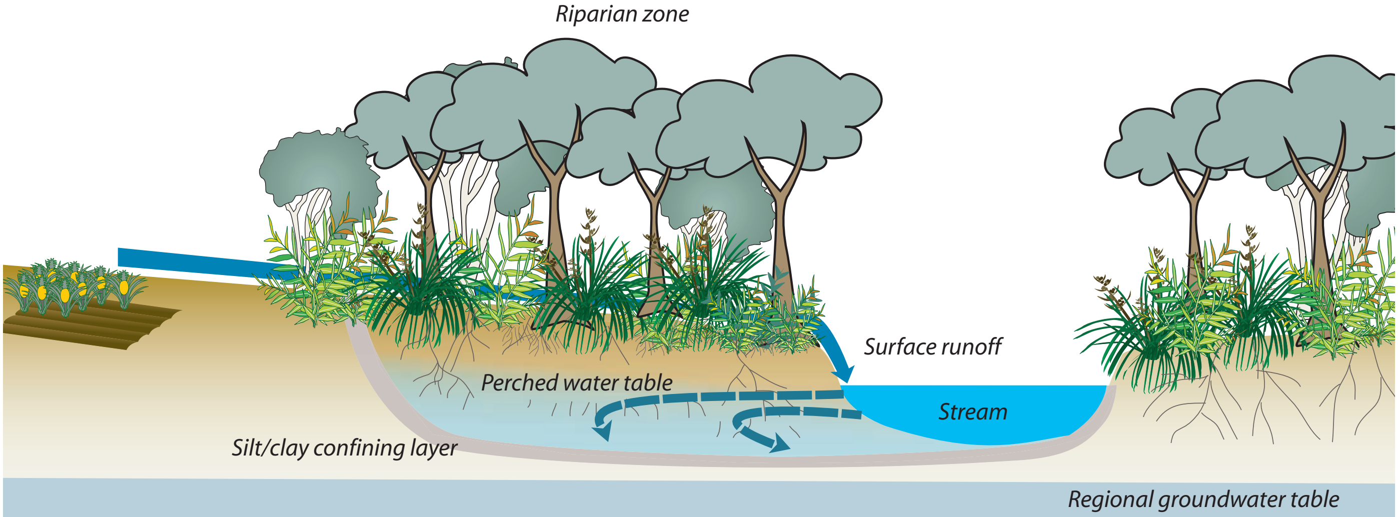

A proportion of the stream flow moves laterally to form a perched water table within the carbon-rich root zone of riparian vegetation. If conditions are suitable, soil bacteria efficiently remove nitrate from this shallow groundwater before it drains back to the stream.

Note: This page has been corrected and is different from the printed version.