An enzyme to protect waterways from atrazine

By Louise Lawrence and Colin Scott, CSIRO Entomology

Farmers around the world depend on herbicides as part of efficient and economic primary production. One of the most highly effective groups of herbicides is the triazines which includes the widely used atrazine. They have been used extensively to control broadleaf weeds since 1958.

But atrazine also has the potential to contaminate surface and groundwater even when used at the recommended levels. Because of this, triazine use in the sugarcane growing region of Australia and in the Great Barrier Reef catchment area has been identified as a threat to significant freshwater wetlands as well as marine ecosystems in the Great Barrier Reef World Heritage Area.

There have been attempts to use bioremediation (the use of biological agents to clean up contaminants) to remove triazine

...18 ▷

An irrigation supply channel near Clare in the Burdekin Valley, Queensland. An enzyme developed by CSIRO shows promise at removing the herbicide atrazine from irrigation run-off.

◁17…PROTECT WATERWAYS

herbicide residues from the environment which relied on the use of genetically modified organisms.

One of the attempts involved the use of the bacterium, *Escherichia coli*, and another used transgenic rice but neither approach is likely to go further because of the high level of regulation around the release of genetically modified organisms.

Alternative approach

Because of this, CSIRO Entomology scientists have been looking at an alternative, enzyme-based remediation approach, which does not involve the use of live organisms. A large scale field trial in the sugar growing areas of north Queensland has shown that an enzyme-based product developed by this group can remediate water bodies contaminated with the most common triazine herbicide, atrazine.

The CSIRO group looked for bacteria that 'feed' on atrazine then identified the enzymes in the bacteria which reduced atrazine to non-toxic products. These were the enzymes that were potentially useful for atrazine bioremediation and the group then focused on one enzyme that acts on a broad range of triazines.

While the enzyme selected was perfectly suited to the bacteria's needs, it wasn't efficient enough to use as a bioremediation product, so the group modified it to one that was suitable for large scale use and mass production.

In the trial, a holding dam on a sugarcane farm near Clare in tropical north Queensland was used to collect runoff from the irrigation of a field treated with the recommended dose of atrazine. Filling the dam with irrigation tailwater increased the atrazine concentration 10-fold.

Water samples were taken before the dam was filled with the contaminated runoff, before the enzyme was added and at various times after the addition of the enzyme. The enzyme was mixed into 20 litres of water, and evenly spread across the surface of the holding dam by hand.

After the enzyme was added, there was a short delay before the reduction in atrazine began, probably whilst the enzyme mixed with the water in the dam. Despite the lag during the mixing phase, the concentration of atrazine was reduced by more than 90 per cent in the first four hours after the enzyme was added. This result suggests that a bioremediant for triazines based on this enzyme is feasible.

It was noticed that the enzyme has a limited half-life in the environment before it is degraded, as it stopped working after 24 hours. While the short half-life ensures that the enzyme does not persist in the environment, it could also have implications for how the enzyme is applied. It would impact on when and how it is applied, whether subsequent doses are needed. It is also possible the enzyme could be further modified to extend its persistence.

The scientists also compared the atrazine enzyme with another enzyme previously developed by CSIRO for organophosphate insecticides. This enzyme reduced organophosphate insecticide concentrations by 10-fold in less than 10 minutes, 24-fold faster than the atrazine enzyme being trialled.

But this enzyme was applied to a smaller volume of flowing water, which almost certainly improved the rate of mixing of the enzyme and thus its overall performance. The scientists are now using state of the art techniques to make the atrazine-degrading enzyme work at higher efficiencies.

Examining an agar dish for bacterial colonies as part of the bioremediation project.

Wider application

When finalised, this enzyme has the potential for widespread use on contaminated surface and ground waters around the world. Further field trials will help to assess what is required to make this technically successful remediation technology commercially viable.

In Australia, the reduction of herbicide runoff from agricultural lands is a key component of the Reef Water Quality Protection Plan (RWQPP) for the Great Barrier Reef World Heritage Area and herbicide management is thus a major consideration of regionally developed Best Management Practices through Water Quality Improvement Plans in response to the RWQPP.

"Farmers will need to address the loss of herbicides from their farming systems because of their potential to harm our natural environments," says Hugh Yorkston from the Great Barrier Reef Marine Park Authority. "This new enzyme technology will allow farmers to cost-effectively treat their residual herbicides before they leave the farm."

The commercial development and application of enzyme products to remove herbicide residues before they enter waterways of the Great Barrier Reef catchment area provides an additional strategy to reduce herbicide runoff and thus reduce their potential impact. This application may also allow sugarcane growers and horticulturalists to continue using products such as atrazine on their farms.

All in all, it is essential to find a successful way of reducing the accumulation of these herbicides in the environment through a range of practices and bioremediation presents a promising, environmentally friendly option.

The next step in the research is to improve the production and application of the enzyme in order to provide farmers around the world with a cost effective bioremediation product that will address the issue of triazine contamination.

Collaborators in the trial were Queensland Primary Industries and Fisheries, James Cook University and the Great Barrier Reef Marine Park Authority and the research group was grateful to cane farmer Wayne Dal Santo for allowing his farm to be used in the trial. Orica Australia Ltd funded the research.

Further information: Colin Scott, CSIRO Entomology: Ph: 02 6246 4090
E: email colin.scott@csiro.au ■