Biological Monitoring of Cotton Pesticides used in Northwest New South Wales

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Introduction

In Australia the primary pesticide for control of heliothis in cotton is the organochlorine, endosulfan. In recent years it has been supplemented by a variety of other pesticides including organophosphates, carbamates, pyrethroids and insect growth regulators in an effort to reduce the level of pesticide resistance. Endosulfan is toxic to aquatic life (either as the two parent isomers or as the breakdown product, endosulfan sulfate), with fish being reported as highly sensitive to the chemical. Concern over the environmental fate of cotton pesticides in the late 1980s, led the New South Wales Department of Land and Water Conservation (DLWC) to undertake in 1992 biological monitoring of aquatic macroinvertebrates to assess the impact of irrigated agriculture on the rivers in the north west region of New South Wales (Figure 1). The work forms part of the Central and North West Regions Water Quality Program (CNWRWQP) which is jointly funded by the DLWC and the water users of the Gwydir, Macquarie, Namoi and Border Rivers valleys. The other major components of the CNWRWQP focus on pesticide, physico-chemical and nutrient monitoring.

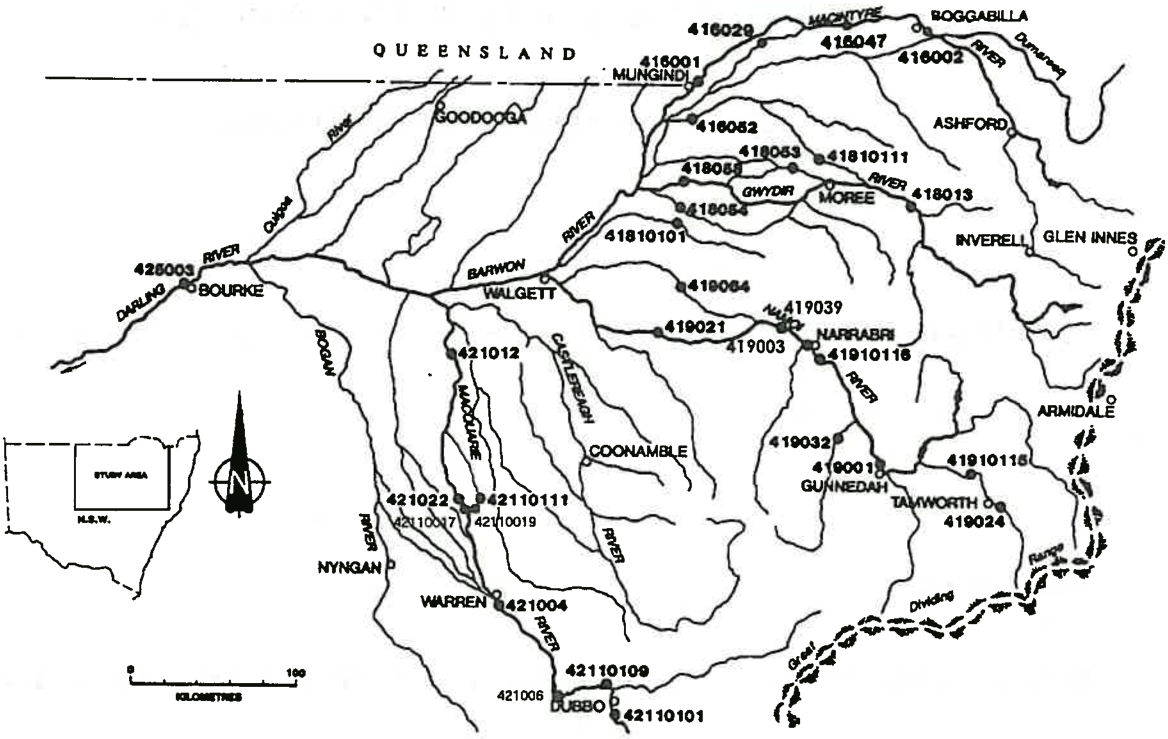


Figure 1. Location of study area in New South Wales and sampling sites for the Central and North West Regions Water Quality Program.

Results of Biological Monitoring

A range of different biota can be used in a biological monitoring program. The most commonly used groups are fish, zooplankton, macroinvertebrates and algae. Macroinvertebrates were considered the most suitable group to use in these studies as they are:

- easily sampled without complex equipment;
- they are widely distributed and abundant throughout these river systems;
- there are a range of different species/types which are likely to be responsive to a range of environmental conditions;
- their basically sedentary nature allows effective spatial analyses of pollutants or disturbance effects; and

- they hold a key position within the food web.

In general, the results of previous years have shown the rivers studied have low to moderately diverse macroinvertebrate communities. Many taxa present however are pollution tolerant and these dominate at several sites. In the 1994/95 irrigation season there was also a substantial drop in the number of macroinvertebrates throughout the river systems monitored during January and April compared with October. Similarly the number of taxa were reduced in January compared to October and April. The drop in January coincides with the period of highest pesticide use. However these results were similar for river sites both upstream and within irrigated cotton developments, indicating natural seasonal patterns are the major determinants of abundance and taxonomic richness and not the use or presence of pesticides (Figures 2 & 3). Statistical techniques confirmed these temporal changes in macroinvertebrate community structure, abundances and taxonomic richness.

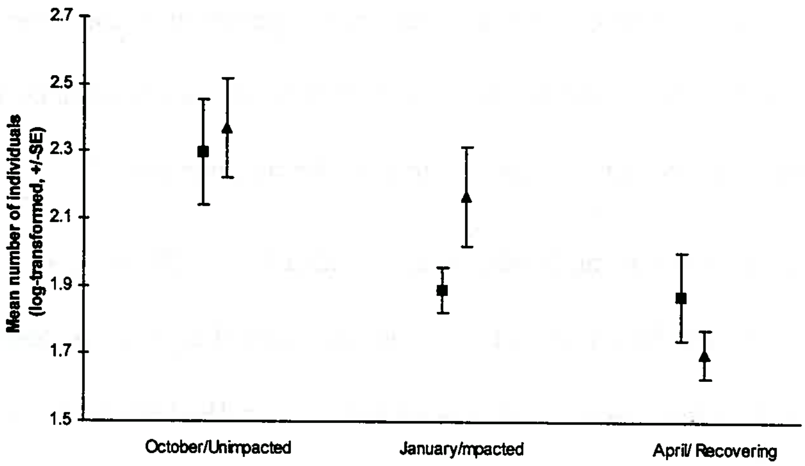


Figure 2. Mean numbers of macroinvertebrate individuals for sites upstream and adjacent to irrigated agriculture within the Border Rivers, Macquarie River, Darling River, Gwydir River and Namoi River basins. Squares indicate sites upstream of irrigated agriculture (n=9) and triangles indicate sites possibly impacted (n=14). Error bars are standard error.

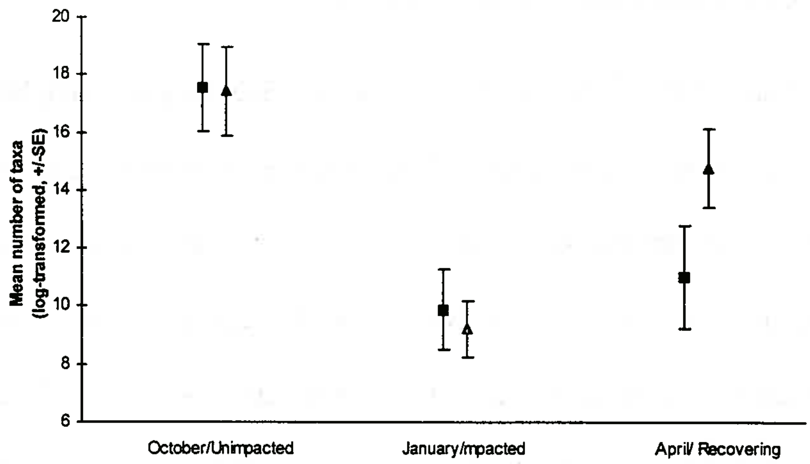


Figure 3. Mean numbers of macroinvertebrate taxa for sites upstream and adjacent to irrigated agriculture within the Border Rivers, Macquarie River, Darling River, Gwydir River and Namoi River basins. Squares indicate sites upstream of irrigated agriculture (n=9) and triangles indicate sites possibly impacted (n=14). Error bars are standard error.

There were however some results which suggest pesticides from irrigated cotton may have some impact. There was evidence of suppression of the recolonisation of *Micronecta* sp. in April at sites within irrigated cotton areas compared with those upstream of irrigated agriculture.

Although examination of potential impacts on a broad geographic and time scale have not shown pesticides to be detrimental to macroinvertebrate communities, effects that may occur over smaller geographic and time scales are currently being investigated.

The Subcatchment Biomonitoring Study, jointly funded by the DLWC and Land and Water Resources Research and Development Corporation, was designed to determine possible impacts over smaller spatial scales. It was carried out in 1994/95 within a section of the lower Macquarie River, near Carinda. The results showed that the major differences in macroinvertebrate communities were not between areas upstream (Location 1), adjacent (Location 2) and downstream (Location 3) of a cluster of cotton farms, but between month of sampling (Figures 4 & 5). As there were no pesticides detected in the water throughout the study, due to reduced cotton planting and a consequent reduction in pesicide usage, conclusions regarding the impacts of cotton pesticides on aquatic biota could not be made.

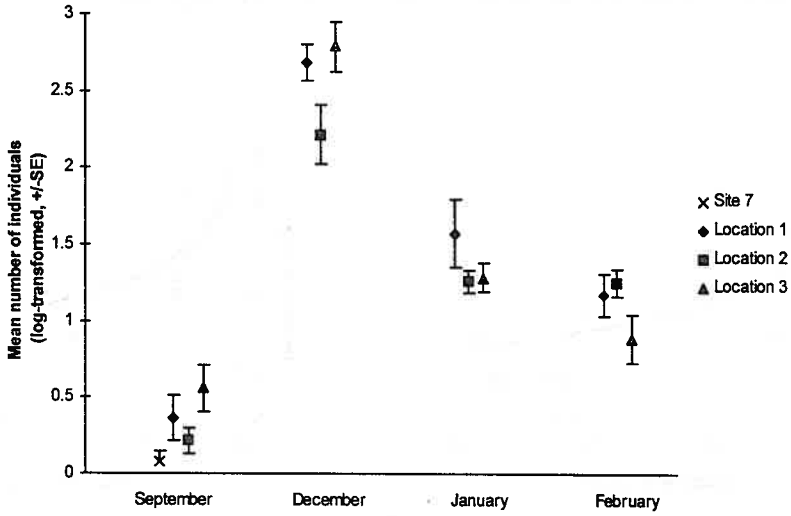


Figure 4. Mean number of log-transformed macroinvertebrate individuals sampled from edge habitats at each Location throughout the study period. Site 7 was sampled in September only. Error bars are standard errors (n=8).

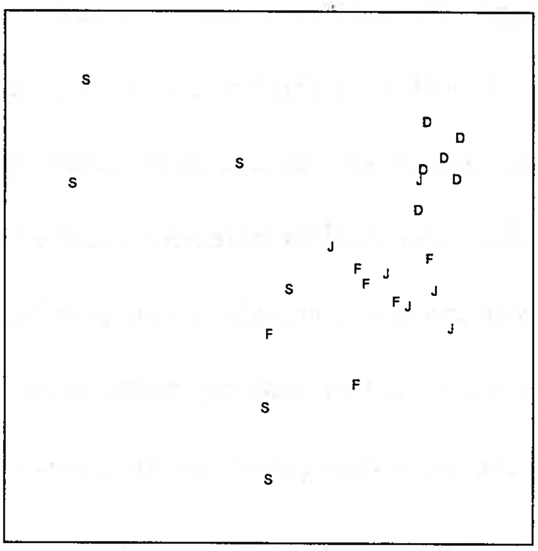
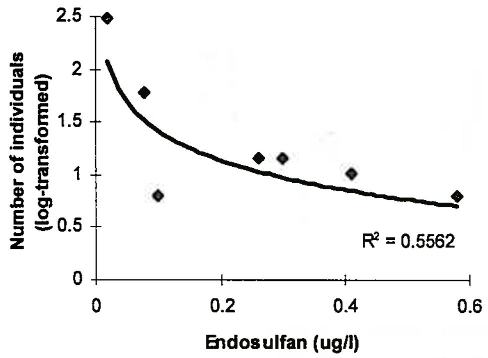


Figure 5. Non-metric multidimensional scaling (NMDS) ordination of log-transformed macroinvertebrate communities sampled from edge habitats displaying a. site and month sampled and b. month of sample. Numbers correspond to sites and S=September, D=December, J=January and F=February. Stress=0.14

However, a study of aquatic macroinvertebrates within the irrigation channels of "Lochinvar" cotton farm in 1994/95 showed that at high endosulfan concentrations, decreases of invertebrate abundances and diversity were observed (Figure 6).



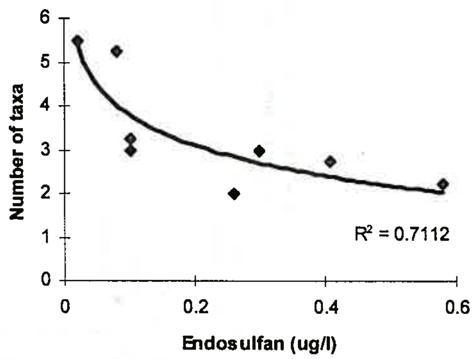


Figure 6. Relationship between total endosulfan concentration in water and aquatic macroinvertebrates from the irrigation channels within Lochinvar cotton farm. a. and b. represent number of individuals and taxa from sweep samples respectively.

To continue to investigate the possible impacts at smaller spatial and temporal scales, an intensive study of the sites within the Macquarie valley was carried out as part of the 1995/96 CNWRWQP. This area was chosen because of the reliability of water supply for 1995/96. Chemical monitoring showed endosulfan increased in surface waters after the pesticide spray season began at sites both upstream and within cotton growing areas (Figure 7). The greatest increase was at sites within cotton growing areas, where median levels exceeded the ANZECC (1992) aquatic ecosystem guidelines for endosulfan (0.01 µg/L). Endosulfan concentrations in the sediment also increased at all sites after pesticide spraying began, with the greatest increase at sites within cotton growing areas. At the time of writing results from macroinvertebrate sampling at these sites are not available, but will be presented in the corresponding poster.

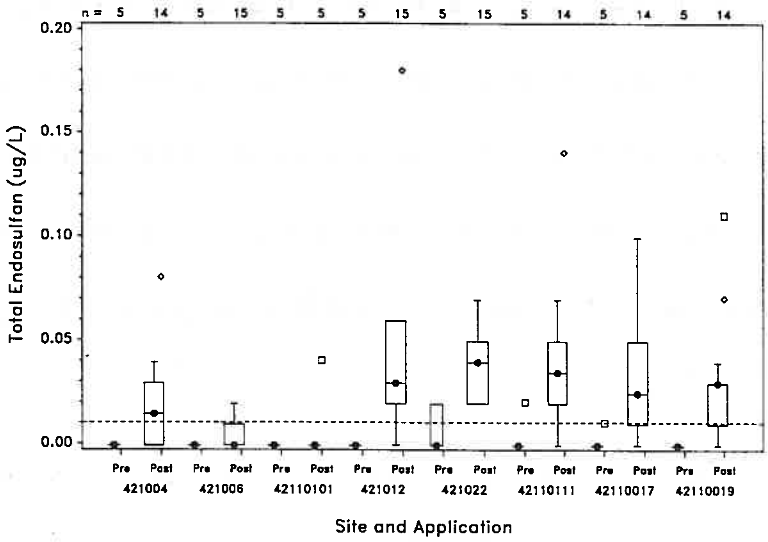


Figure 7. Comparison of endosulfan concentrations in surface waters of the Macquarie valley pre- and post-pesticide spraying.

Discussion and Conclusions

The studies have shown that riverine macroinvertebrate communities in areas of intensive irrigated agriculture, have varying and difficult to quantify responses to the presence of these pesticide residues in river water and sediments. There are many other confounding factors which to have an impact on these communities such as river flow, drying of rivers, water temperature, habitat availability and season. Until such time as we are able to distinguish impacts caused by pesticides from those caused by these confounding factors, the precautionary principle will continue to be used in setting water quality objectives and guidelines and community attitudes.

Increased community pressure on the cotton industry is widespread through media reporting of fish and wildlife deaths being attributed to cotton pesticide use and the export of beef contaminated with residues of Helix® from the feeding of cotton gin trash to drought-affected stock. It is not inconceivable that as a result of these pressures, more stringent environmental guidelines covering pesticides will be developed. Government regulation of the industry on the basis of such a guideline for endosulfan, would severely affect the industry's productivity.

Without associated biological data on the affects of endosulfan and other pesticides on the aquatic environment, debate will always exist over the appropriateness of environmental guidelines set at or close to the limit of analytical detection. Information being collected and assessed on the distribution of aquatic macroinvertebrates as part of the Central and North West Regions Water Quality Program will need to be used by regulatory agencies involved with the guideline setting process.

Continued support of the cotton industry in developing and implementing best management practices covering the use of agrochemicals is pivotal to ensuring that reductions in off-target transport are minimised, thereby reducing the potential for adverse environmental impacts. The continued use of biological monitoring programs such as the ones discussed will provide a means of assessing the degree of success in the implementation of best management practices in reducing off-target environmental contamination.