Measuring the effects of landuse and land management on river water quality

P.S. Cornish[1], B. Baginska[1], G. Kuczera[2] and D. Jones[3]

[1]University of Western Sydney (Hawkesbury), Bourke St, Richmond, NSW 2753
[2] University of Newcastle, Newcastle, NSW 2038
[3]CSIRO, PO Box 136, North Ryde, NSW 2113

Summary. After years of research evaluating the on-site effects of land degradation, scientists are now turning their attention to understanding and managing the off-site impacts of agriculture. As in most catchments, the key issue in the Nepean-Hawkesbury is the nutrient loading in runoff water, in particular phosphorus. Whilst nutrient runoff is the key issue for most catchments, the Nepean-Hawkesbury is distinguished by the frequency of farm dams and rapidly changing patterns of landuse. This paper describes the methodology developed to quantify the contribution of agriculture to diffuse sources of nutrient runoff. A nested arrangement of monitoring points with flow gauging and automatic sampling for chemical analysis was chosen to meet the goals of:

(i) disaggregating total loads into the contributions made by different land uses,

(ii) providing process-based, event-related estimates of nutrient runoff in lieu of empirically- derived average annual loads,

(iii) evaluating the attenuation in nutrient concentration between the boundary of a land use (or farm) on the hillslope and the receiving water, and

(iv) understanding the effects of farm dams on both nutrient transport through the catchment and catchment hydrology.

A sample of data is presented, showing the importance of scale for nutrient transport and suggesting that export of soluble P can be higher than normally expected.

INTRODUCTION

Since early this century, soil conservationists and agronomists have rightly focused on the on-farm impacts of soil structural degradation and soil erosion. More recently, attention has turned to the off-farm impacts of agriculture, not just the familiar physical effects of soil erosion, but on the movement of nutrients and pesticides into rivers and lakes.

In the Nepean-Hawkesbury catchment, an area of 25,000 km2 with agricultural production of $1 billion annually, the main concern has been nutrient runoff, in particular phosphorus. Quantification of diffuse sources of nutrient runoff, such as crop and pasture land, is much more difficult than from point sources, such as the discharge from sewage treatment plants. Not surprisingly, there are no detailed data for nutrient runoff in the Nepean-Hawkesbury catchment. Nevertheless, estimates from the program CMSS (Catchment Management Support System) suggest that agriculture contributes about half of the total annual loading of phosphorus to the rivers. These estimates use no local data for nutrient runoff from rural land, and are surprising in view of the discharge of sewage effluent from 1.5 million people into catchment waters.

There is clearly an urgent need to quantify the real impacts of agriculture on water quality so that appropriate catchment management strategies can be developed. This task is complicated in the Nepean-Hawkesbury by the heterogeneity of land uses, the numerous farm dams and rapid changes in land use because of the proximity to Sydney.

This paper outlines the problems associated with the meaningful measurement of nutrient runoff and describes the methodology developed for the Nepean Hawkesbury study.

METHODS

The Catchment.

Figure 1 shows the Nepean Hawkesbury catchment and the sites for monitoring. These sites are Currency Creek and Mangrove Mountain where nested monitoring stations in subcatchments are being installed, and Camden and Robertson where single sites are planned. At present, equipment has been installed at Currency Creek and Camden.

Figure 1. The Nepean-Hawkesbury catchment

The Need for Nesting.

Land use in the catchment is very heterogeneous. It is generally not feasible to monitor a stream on the up and down stream boundaries of a landuse to quantify its contribution to pollution. The only option is to monitor single landuses where they occur in the landscape, and this is best done by monitoring all major landuses in an appropriately sized and representative subcatchment. This raises the question of scale. The movement of both water and nutrients will be affected by the terrain between the point of generation and the receiving water. This is well known for sediments, where the delivery from site of entrainment to receiving water is inversely related to the distance between them. Functional relationships between scale and nutrient transport are needed, and nesting will provide the data from which to develop such a relationship.

The Place of Farm Dams.

Dams have always been a feature of the catchment. Part of the project will be to quantify changes in the number and size of dams in the catchment, and evaluate the importance of dams as both nutrient traps and for catchment hydrology. Anecdotal evidence suggests that rural residential development is leading to the loss of a few large dams and construction of large numbers of nested dams. Dams fall into two broad groupings depending upon their use for irrigation or for stock water and amenity. The two groups differ in rates of water use. Dams are a major feature of our study, not only because of their likely importance outlined already, but they also provide a low-cost way of gauging flow.

A Typical Nested Subcatchment.

Each monitoring station consists of a DataTaker 50 logger which controls the system and records data. The DataTaker was chosen for its strong programming capability. Water level is measured with Greenspan pressure transducers, chosen for their stability and precision. Gamet autosamplers were tested and proved to be cost effective and reliable. Each dam needs a topographic survey, so that dam volume can be related to water height.

Figure 2. Landscape features at the Currency Creek study site

System Operation.

Catchment discharge into dams or through culverts is calculated from water height measurements and using detailed survey data of dams, dam spillways and channels as required. Spillway discharge is calculated after Henderson (1). Discharge data are corrected for rainfall, logged to provide the hydrograph and used to trigger autosampler operation. Three sampling strategies were compared (Fig. 3) and the variable discharge-increment approach was chosen to provide the best spread of sampling through a runoff event: small increments for low flows, increasing fourfold moving to large flows. The pollutograph is calculated following sample analysis for soluble and total nitrogen and phosphorus.

Figure 3. Alternative sampling strategies

RESULTS AND DISCUSSION

The hydrograph and data for soluble and particulate P are shown for site 1, at the top of the catchment, during an event in May, 1995 (Fig. 4). Although the results are preliminary and represent only one event which occurred after a long period of drought, the detected concentrations of phosphorus are greater than expected from pasture, and soluble P is the dominant form. This is contrary to the general assumption that runoff of P from agricultural land is primarily particulate.

The elevated concentrations of soluble P, reaching 8.37 mg/L, were found in the uppermost part of the catchment and they are comparable with the concentration of phosphorus in the Hawkesbury River caused by effluent from sewage treatment plants (2). The high concentration of soluble P may be attributed to the land use in the catchment, which included irrigation with dairy effluent, and proximity to the source of pollution. Further down the catchment, at site 4, maximum P concentration recorded during this event was 1.2 mg/L (soluble) and 0.1 mg/L (particulate). This reduction in concentration between site 1 and 4 occurred despite the fact that market gardens, a rich source of P, separated the two sites. This demonstrates the importance of scale, and in particular the importance of the dam at site 2.

Total export of P from the 250 ha of this catchment was 108 kg P in this one event.

REFERENCES

1. Henderson, F.M. 1966. Open Channel Hydraulics, MacMillan.

2. Kerr, R.J. 1994. EPA Report. pp. 22-31.

Figure 4. Distribution of soluble and particulate phosphorus in relation to runoff

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