Application of models for evaluating non-point source water pollution in agricultural catchments.

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Summary This paper reports on the application of the SOILOSS and AGNPS models together with GIS technology for use in identifying the sources of nutrients in catchments of the Namoi River and for determining best management practices.

1. INTRODUCTION

In the Namoi River major blue-green algae outbreaks are associated with high nutrient levels, especially phosphorus. The Murray Darling Basin Commission [MDBC, 1993] has estimated the relative contribution of point sources and diffuse or non-point sources. In dry years, most nutrients come from point sources, particularly sewage treatment plants. In wet years most nutrients come from non-point sources such as agricultural lands. Sources of such nutrients are soil erosion and sedimentation on rural and urban lands and eroding stream banks, nutrients and organic materials from livestock wastes and agricultural land, and storm water from urban areas.

According to Young et al. [1989] managing non-point sources of nutrients, in addition to being politically, economically and socially difficult, is technically complex. Nutrient sources often are located over a large geographic area and are not readily identifiable. By locating and targeting specific areas within a catchment that have high potential for soil and nutrient losses, available resources can be used more efficiently to alleviate nutrient pollution problems and protect water quality.

2. THE MODELS

2.1 AGNPS

Agricultural Nonpoint Source Pollution (AGNPS) as described by Young et al. [1989] is a computer simulation model developed to analyse the water quality of runoff from agricultural catchments in Minnesota, USA. The model predicts runoff volume and peak rate, eroded and delivered sediment, and nitrogen, phosphorus, and chemical oxygen demand concentrations in the runoff and on the sediment for single storm events for all points in the catchment. The model is intended for catchments up to about 50,000 ha in size. The model has been adopted for use throughout the United States by the Natural Resource Conservation Service.

AGNPS provides a means of objectively evaluating non-point source pollution from agricultural catchments and is one of the few available that provides output that is site and management specific. The model works on a cell basis. These cells are uniform square areas which divide up the catchment into units ranging from 0.4 to 16 ha to represent upland and channel conditions. The basic components of the model are hydrology; erosion; sediment transport; and transport of pesticides, nitrogen, phosphorus and chemical oxygen demand. In the hydrology portion of the model, calculations are made for runoff volume and peak flow based on the US Curve Number method. Erosion for each cell is estimated using a modified form of the Universal Soil Loss Equation (USLE), Wischmeier and Smith [1978]. Total upland erosion, total channel erosion and a breakdown of these sources into five particle size classes for each of the cells are calculated. Sediment transport is also calculated for each of the cells, in the five particle size classes as well as the total. The pollutant transport portion handles soluble and sediment attached pollutants as well as pesticides.

At present the model (V4.03) only accepts input in US standard units and operates on single storm events. An annualised version with SI units is under development. Considerable work is underway in the US to link AGNPS with a GIS such as GRASS, pc-ARC/INFO, IDRISI etc.

2.2 SOILOSS

SOILOSS [Rosewell and Edwards, 1988; Rosewell, 1993] is a computer program designed to apply the USLE and to assist in the selection of land and crop management practices to reduce erosion. SOILOSS has been validated for use on agricultural land in NSW, Rosewell [1992]. It contains procedures to facilitate the estimation of the soil erodibility factor (K) as decribed by Loch and Rosewell [1992], support practice factor (P) and cover and crop management factor (C) for use in AGNPS. In AGNPS, what is referred to as the the C factor is actually the Soil Loss Ratio (SLR) [Wischmeier and Smith, 1978] which applies at the time of the event. SOILOSS contains procedures to estimate the SLRs applicable to a range of crops for 15 day periods throughout a year. The SLRs for pasture, woodland and forests may be estimated given information on the percentage of ground cover at the time of an event.

3. THE AGNPS PROJECT.

The purpose of the study is to assess the capability of AGNPS for use in the planning and management of catchments with respect to nutrient export. AGNPS will be used demonstrate the relative effects on nutrient generation based on alternative land and crop management practices and to identify and focus attention on hot spots in the catchment and to estimate the export rates and coefficients required by decision support systems such as CMSS and in-stream models such as AQUALM.

3.1 Stage 1

This work was reported by Foerster [1994] and Foerster and Milne-Home [1994] and involved the application of SOILOSS/AGNPS to 1 ha catchments at the Gunnedah Research Centre which were subject to different management practices. Data was available and used to calibrate the hydrologic sub model. AGNPS predicted total runoff and peak flow rates with good accuracy. For the one event where sediment yield data was available, AGNPS, was able to differentiate between, and appropriately rank, management practices in respect to sediment production. AGNPS was also applied to the total catchment (214 ha) of the Research Centre. Foerster [1994] concluded that AGNPS can be used to propose best management practices for catchments and can focus the implementation of these BMP to areas where they will be most effective. However, it would be essential to automate the compilation of the necessary input data using GIS technology.

3.2 Stage 2

The use of distributed parameter models such as AGNPS requires the processing of large amounts of data. If geographically distributed model parameters can be obtained from GIS data layers, considerable effort can be saved in the development of data files for simulation. This second stage involves the adaptation or development of GIS/AGNPS interface tools for the application of SOILOSS and AGNPS to the catchment of Chaffey Dam on the Peel River. This catchment was selected because of the current interest in nutrient inputs into Chaffey Dam, the availability of some sediment and nutrient yield data which might be used for model validation and because the catchment is covered by Department of Conservation and Land Management Multi-Attribute mapping on a GIS.

The following discussion refers specifically to the 10 km^2 Back Creek catchment which serves as a test case for the remaining 400 km^2 catchment to Chaffey Dam. At the time of writing, the work on stage 2 has only just commenced.

The Land Information Centre produced a raster based digital terrain model (DTM) for the Back Creek catchment with a 100m x 100m grid. This level of detail is necessary in order to account for the topographic complexity of the catchment. For each of the 1053 cells, the DTM provides cell number, receiving cell number, flow direction, land slope, slope shape and slope length.

The Multi-Attribute mapping includes soil type, land use and land management practice layers stored in GENAMAP format. The development of appropriate AGNPS input layers has been explored using the IDRISI GIS [John Foerster, pers. comm, 1995]. The soil type layer was reclassified to provide soil texture and soil erodibility layers. For each land use an appropriate SLR value was estimated using SOILOSS. Similarly, SOILOSS was used to estimate P factors from the land management and land slope combinations.

Further work will proceed using the GRASS (Geographic Resources Analysis Support System) GIS and a suite of interface tools as described by Srinivasan and Engel [1994]. An important hydrological tool is the curve number procedure which generates a curve number map for a catchment based on the four layers of hydrological soil group, hydrological condition, management practice and land use. The first two layers can be derived from the soil type. The AGNPS-GRASS input interface developed by Srinivasan and Engel [op. cit.] minimises the user interaction in preparing the input data for the AGNPS model and minimises the number of GIS database layers. The GIS approach provides flexibility, data analysis capability, data preparation capability, potential for reuse and ease of updating when compared with a manual approach.

4. CONCLUSION

At this time the AGNPS model appears promising in its ability to identify potential nutrient pollution sources in a catchment. Obviously, the model would be greatly enhanced if it were adequately validated but the scarcity of suitable event sediment and nutrient load data creates a major problem. However, the work so far indicates that the combination of SOILOSS and AGNPS models is capable of showing the relative differences in nutrient generation between alternative land and crop management practices. The models can, therefore, provide useful guidelines for the implementation of best management practices. The work underway on interfacing the models with a GIS will enhance the user's ability to quickly try various "what if?" scenarios at a catchment scale.

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