RIVER AND LAKE WATER QUALITY SIMULATION WITH GIS-INTEGRATED BASIN-SCALE MODELS

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Streamwater quality is affected by a number of natural and human processes. Major types of chemical compounds which may affect water quality include nutrients (nitrogen and phosphorus). Nutrients are of particular interest in the study of environmental quality within the Pusiano/Lambro River basin as they turn out to be critical for the water quality in the lake. This paper briefly details a methodological approach used for implementation of water quality models, with an aim of defining water quality in the lake's immissary as a result of all different pollution-generating activities within the basin. A steady-state simulation model (QUAL2E) was adopetd to predict changes in the concentration of in-stream nutrient concentrations in the Lambro River within the Lake Pusiano watershed (Northern Italy). Simulation of local hydrology as a preliminary study was conducted using the HEC-HMS model. In this study, watershed analysis is carried out with the "Soil and Water Assessment Tool" (SWAT) package. This paper describes therefore parts of an integrated hydrologic, catchment and stream nutrient modelling system. The river modelling system is designed to simulate at first, and subsequently to develop reduction plans, nutrient loads delivered to lake.

In order to fully implement the capabilities of the SWAT framework, input file organization in a Geographic Information System (GIS), as an integral part of the existing database is essential. In fact, a GIS allows to collect, store, easily manage, elaborate and display large quantities of data, necessary to run a complex simulation, associated with a watershed. Pollution-generation models in fact require input information including: land use and cover, soil data, precipitation and potential evapotranspiration, stream-reach characteristics and stream flow, and many additional informations that may be useful in determining or estimating the model parameters. Time series data, such as water quality data, are also necessary to run the QUAL2E model, seeing that all water quality models simulate changes based on a known initial condition, and thus demand a comprehensive, well organized water quality sampling program. However, conventional measurements of water quality require onsite sampling and expensive and time-consuming laboratory work. Due to these two limitations, the sample size often can not be extended

and comprehensive enough to cover the entire water body. The difficulty of overall and successive water quality sampling becomes a barrier to water quality prediction (Brown & Clark, 1998). Therefore, in this study, specific preliminary attention was paid to the outcome of an established monitoring program, which is recommended primarily to support the water quality model calibration.

Existing water quality data (two years' records on a monthly basis) of Lambro River were applied to preliminary modeling using QUAL2e. Representative events were selected to identify the governing water quality processes under low and high flow conditions. Accordingly, preliminary water quality modeling was used to assess the variability of nutrients throughout the catchment, examine data set for water quality modeling and identify potential pollution sources. An initial examination of model results lead to recognize the water processes and establishing further data collection. A new monitoring program designed on thus preliminary results was started in january 2004. This is providing a new set data to improve the modeling framework.

Concentrations of nitrogen (N) and phosphorous (P) species were determined in the main stream and tributary waters of the Lambro River system during the periods of July 2002 through December 2003. Water quality data were analyzed for five monitoring stations. Examination of the observed water quality variability was used to select the simulated events; as a criterion the ranges for flow values during the day of the selected events were taken. Changes in mean concentrations are significant: during the entire period, the total N (TN) and total P (TP) concentrations in surface waters were found to be within the ranges of 1,3 – 6,0 mg/l and 0.01–0,6 mg/L, respectively. The results of this comparative analysis can be expressed in terms of low and high flow (i.e. total nitrogen TN: minimum 1,3 mg/l, maximum 3,4 mg/l in S1, and minimum 2,4 mg/l, maximum 4,4 mg/l in S5). The events were ranked according to streamflow values observed at the gauging station Caslino. Events below and above 2.5 m^3/s were considered as 'low' and 'high' flow events respectively. Two events were arbitrary selected for presenting modelling efforts; one for low flow (November 15, 2002) and one for high flow (September 03, 2002) in order to model observed changes in concentration along the river.

Nutrients nitrogen (N) and phosphorus (P) were simulated as the chemical parameters of interest. Chlorophyll-a and dissolved oxygen will be calibrated in the next part of study, as the former had been measured since January 2004 only. Chemical calibration of the model involves determining the strength of point sources (in our case tributaries), evaluating existing conditions along the stream and water temperature as initial conditions.

The initial approach used for the Lambro River model was to use constant rates derived from QUAL2E's user manual and/or other related literature for initial model calibration. Although this option was used as a starting hypothesis, it was determined during the course of the simulations that a large number of model reaches required individual user's specification of coefficient rates. Variable rates were used mainly for nitrogen oxidation coefficient and ammonia uptake rates. Reaches 6-8 required lower rates, while reaches 13, 17 and 22 generally required higher rates. These and some other adjustments were made to the model, in order to achieve good calibration for nutrients results. Model results are plotted for each chemical parameter in river-kilometers versus chemical parameter format.

To help derive meaningful interpretations of temporal and geographical variabilities in the nutrient behavior, the entire database was evaluated under several different schemes. As mentioned earlier, the nitrogen concentration difference between low and high flow was on the average around 2,5 mg/l and as much as 4,7 mg/l. Recommendations for the

developed monitoring framework have been made to better investigate this relationship during high flow events. The new monitoring program will provide additional datasets for QUAL2E, in order to improve model calibration and understanding of the major processes impacting water quality in the Pusiano Lake watershed.

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