Multiobjective optimization for the allocation of cost-effective BMPs at the watershed scale

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The mitigation of non-point Phosphorus (P) losses to surface waters is currently a major issue for the implementation of Environmental Directives in Europe. These losses are often driven by location specific factors in catchments, such as climate, topography, soils and management practices. The identification of the agricultural areas that pollute most, is also very crucial for the implementation of cost-effective Best Management Practices (BMPs). The difficulty in the selection and placement of BMPs increases with catchment size and the number of BMPs available for implementation. Additionally, cost is always a restricting factor that limits the number of possible combinations as well as targets to reduce P losses may sometimes negatively impact on other environmental objectives such as the reductions of nitrates concentrations in surface waters. Thus, success of conservation programs for water protection highly depends on planning tools that can assist the watershed management process. Herein a novel optimization methodology is presented for deriving catchment-scale phosphorus control plans that incorporate multiple, and conflicting, objectives. For the development of this method the watershed non-point pollution tool SWAT (Arnold et al., 1998) that is highly capable in representing BMPs was combined with a MATLAB Genetic Algorithm - spatial search procedure. A database that provides the different BMP implementation costs was developed with site-specific information from the medium-sized (940 km^2) Arachtos catchment in Northwestern Greece (Panagopoulos et al., 2007). The tool applies different kinds of nutrient, crop, soil and livestock management practices on corn, alfalfa and pastureland and tries to find solutions that are both economically and environmentally effective. Optimization was done by setting each time two conflicting objectives and using the third as constraint. Phosphorus loads were first optimized against total cost of implementation with an upper acceptable value of nitrates concentration being the constraint. Subsequently P loads were optimized against loads of N-NO3 by putting constraint on the total cost. The results of both multi-objective optimizations resulted in potential reductions of more than 25% for P from the catchment with affordable cost of non-structural BMPs implementation. Of high interest is that the tool achieved to satisfy the objectives by considering a significant part of the agricultural land under no BMP implementation and suggested solutions that would be impossible to be planned otherwise.

Arnold, J.G., R. Srinivasan, R.S. Muttiah, and J.R. Williams. 1998. Large area hydrologic modeling and assessment part I: model development. *J Amer Water Res Assoc* 34(1), 73-89.

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