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Potentials of mathematical modeling and use of GIS in catchment management and the benefits for the Water Framework Directive fulfilling

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The EU Water Framework Directive (WFD) brings relatively strict demands concerning surface waters protection, soil protection and watershed management. Water quality and soil conservation are among the priorities of European environmental policy. The aims and corresponding limits are clearly and strictly formulated but the ways how to fulfill the task remain unspecified. Moreover the side effects and synergic effects are not considered. Therefore there is no recommended methodology for implementing the protection measures.

At the Faculty of Civil Engineering (Czech Technical University in Prague) we deal with development and use of various methods routinely applicable in catchment management and engineering praxis. Mainly we focus on soil conservation, sediment transport assessment, retention capacity of landscape evaluation and flood prevention. Our contribution will present overview of applicable approaches and methods useful for the WFD implementation and for Watershed management strategy defining. Very important part of the problem is use of high precision data sources available for environmental modeling. Data in similar formats and precision (considering soil properties, land use and land cover, precipitation, etc.) exist throughout Europe, but the data availability for research is very limited. In spite of the INSPIRE Directive the European coordination here is low.

Typical example can be found in Map of soil loss and sediment transport within Czech Republic. Methodically simple approach (using USLE – Wischmeier et al., 1978) was applied to whole Czech territory in coordination with GIS already in 2001 (Dostal et al.,2001). The map was consistently updated and in 2007 the LPIS database allowed us to estimate soil erosion rates in scale of individual parcels (Dostal et al., 2007). Each agricultural field block was assessed in 25m resolution raster (484 835 individual parcels, 35 301 km2). The data were then used for preparing Watershed management strategy – to estimate phosphorus loads from non-point sources and to define potential prevention measures in most endangered areas. The map is nowadays accessible for any Czech region at the internet as a WMS link. It can be easily downloaded from national metadata portal http://mis.cenia.cz using a key word „eroze“to search for the map. This map can be easily updated using high precision soil map (1:5000 scale) existing for the whole Czech territory. Unfortunately the soil map was not available for the recent assessment.

Next example of application, generation of the map of rainfall-runoff conditions for sub catchments with area of ca 5 – 10 km2 can be mentioned. This Map classifies individual sub catchments according to their surface runoff production as response to causal rainfall event (Vrana et al, 2004). This material helps since 2004 for decision making related to state financial subsidy policy for flood control prevention in upper parts of the catchments.

Related example are also Assessments of retention capacity of riverine floodplains or urban areas flood risk by surface runoff from agricultural land, which are recently processed for entire territory of The Czech Republic.

One of the basic obstructions for wider implementation of simulation models and other mathematic-based tools in practice and especially for decision making support is relatively weak coordination within EU countries. There exist valid and relatively strict regulative on entire EU level on one hand, but the methods, which should be used to determine fixed values and limits are not specified properly. The approach within individual countries is very different regarding to both of methodologies recommended or accepted and input data availability for desired calculations and designs. The third problem is insufficient foreknowledge of important decision makers (local governments and state authorities) about current state of the art in mathematical modeling and GIS application in watershed and water quality management. The above mentioned calculations and mathematical simulations are still assumed mostly being a domain of science and it is not accepted that many analysis and models were already finished to the level of practical routine applicability.

Another important problem is missing relation and cooperation between environmental field (where for instance Water Framework Directive is also assumed to be included) and economical and social fields. The regulative and limits are set up in the area of agriculture on one hand, to reach economic goals in food production, but on the other hand, side effects of those measures to water quality protection are not assumed and vice-versa, watershed management measures are mostly not assessed from point of view of the effects on a desired economic field. Already (Van Rompaey et al., 2000) examined the effect of conversion of arable land into peace (conversion mostly to grassland) in agreement with European agricultural policy of food overproduction prevention, on sediment transport into water reservoirs. Based on mathematical simulations and survey between farmers he approved that unimportant increasing of proportion of converted land in certain regions can significantly influence sediment transport and water quality in given catchment.
Proposed presentation tends to invoke support of international and interdepartmental cooperation in given fields and to present various possibilities of application of mathematical modeling and GIS assisted analyses on the level of practical and routine applicability for watershed management in various scales.

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