Comparative analysis of phosphorus load reduction measures

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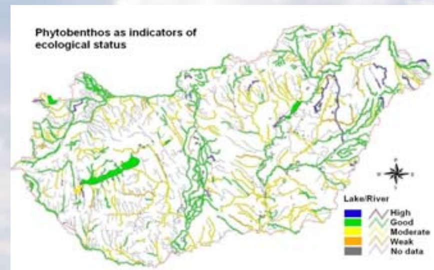
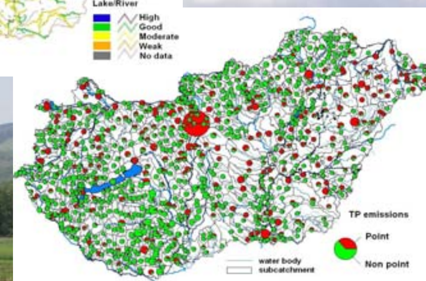
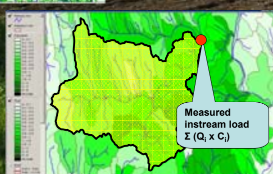
Introduction

According to the water quality assessment carried out in Hungary approximately half of the surface water bodies (rivers and lakes) do not meet the criteria of good ecological status because of different types of water pollution. Phytobenthos, phytoplankton and general physico-chemical parameters, which are supporting the biological elements, were used as indicators for nutrient pollution. Most of the cases (35% of water bodies) nutrients, principally phosphate (PO4-P) and total phosphorus (TP) concentrations exceed the WFD limit values corresponding good status. Typically, the status of smaller watercourses and ponds is significantly worse than that of the larger rivers and lakes.

Discharge of treated waste waters contributes to almost half of the total P emissions to surface waters. Major diffuse P load in the hilly areas attributable to high erosion potential. The nutrient load is significant only in those flatland agricultural fields, from which excess water is drained off, while problems are caused rather by wastewater discharges in the lowland area of the country.







PhosFate
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Objectives

The aim of this paper is to evaluate the impacts of different phosphorus (P) load reduction measures (BMP) on the water quality improvement, including:

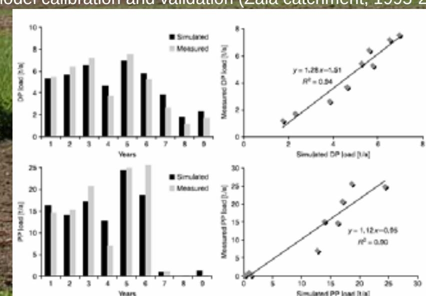
(i) supplementary P removal applied at WWTPs,

(ii) reduction of P load with change of land use and cultivation techniques (e.g. forestation, erosion control);

(iii) floodplain rehabilitation and establishment of riparian buffer zones along the riverbed.

Nutrient balances calculated from the county fertilizer statistics do not indicate such nutrient excess so that it would be realistic to suppose the further reduction of nutrient input. Therefore controlling of mineral and organic fertilizers was excluded from the evaluation of potential BMP alternatives. This assumption is adequate in the CEE region but not tolerable in many European countries with intensive agricultural production, where the application of fertilizer and manure contributes to excessive nutrient load in groundwater and surface water bodies.

Model calibration and validation (Zala catchment, 1995-2003)



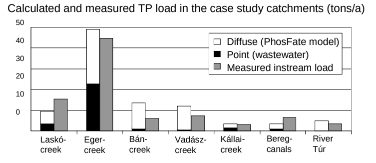
Methods

PhosFate model was developed for the estimation of annual diffuse P emissions. Model utilizes raster maps at 100 x 100 m resolution. P transport was calculated based on a relief model taking into account the 2D accumulation on cell level. Field and river retention were approximated based on the avarage travel time in the cell. These constant retention coefficients are the calibrating parameters. Combining the cell emission calculation with the transport algorithm, total annual P exports at any points within the catchment can be quantified. This enabled the observance of the impacts modifying transport routes (e.g. application of buffer zones) as well as source control (e.g. land use conversation)

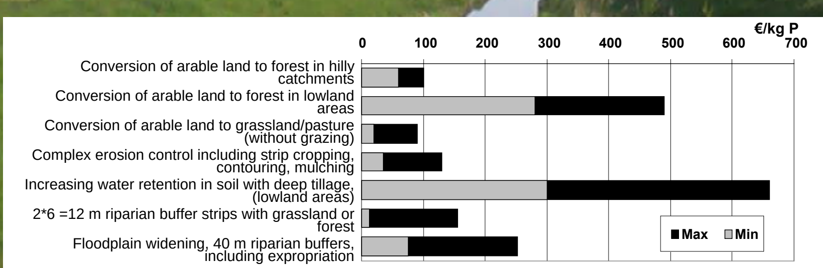
Emission and transport model was performed for the whole country. Case study catchments were selected for model calibration and validation. Some of these served as the bases for cost assessment (7 catchments, located on the Upper-Tisza river basin in Hungary). P source areas with exceeding annual soil loss of 1 mm/ha (approximately 15 kg/ha) and with total annual P emission exceeding 2 kg/ha were designated for the application of BMP measures and their possible impacts on diffuse P fluxes were simulated.

Annualized costs of applied measures were estimated. In case of agricultural cost, farming is basically determined by the subsidy system of the sector. It was assumed that the farmer enters into the corresponding agro-environment programme package. Considering this, we correlate the costs of agricultural measures to the budget position in which the farmer is carrying out the present general arable land cultivation. Costs were calculated on the basis of the Single Payment Scheme (SPS) and the Agricultural Environmental Management (AEM) payments.

Calculated and measured TP load in the case study catchments (tons/a)



Cost-efficiency of phosphorus load reduction measures (at 2007 price level)



Results and conclusions

The research covered the cost-efficiency comparison of measurements serving for phosphorus reduction. Despite the fact that P removal applied at WWTPs is more cost-effective, its unique application is usually not sufficient for achieving good status, thus comparison of measures against diffuse pollution from agricultural origin is important as well.

Among measures of changing land use the conversion of the arable land to grassland/pasture is significantly more cost effective than forestation. However its application is rather determined by the preferable ratios in land use pattern and less the costs. In hilly arable lands, load can be reduced by 50-80% with erosion control, cost-efficiency varies depending on the applied means. In flatland river basins soil erosion is negligible, even though loads are significant in the areas where drainage of excess water takes place. It follows that the most important one among the possible measures is to keep the excess water within the area in wetlands or in the soil. As a consequence of much less diffuse P emission originating from arable lands located in flatlands, the cost efficiency of P load reduction measures is generally lower than in hilly regions.

Establishment of riparian buffer strips have proved to be the most cost efficient measures for reduction of diffuse P load in hilly arable lands, but this measure reduces only loads arriving from the direct catchment area by 30-50%. However, widening of floodplain areas along the rivers has an impact on the whole catchment area by increasing retention in the riverbed.

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