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Modelling soil erosion and associated sediment yield for small headwater catchments of the Daugava spillway valley, Latvia

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The accelerated soil erosion by water and associated fine sediment transfer in river catchments has various negative environmental as well as economic implications in many EU countries. Hence, the scientific community had recognized and ranked soil erosion among other environmental problems. Moreover, these matters might worsen in the near future in the countries of the Baltic Region, e.g. Latvia considering the predicted climate changes – more precisely, the increase in precipitation and shortening of return periods of extreme rainfall events, which in their turn will enable formation of surface runoff, erosion and increase of sediment delivery to receiving streams.

Thereby it is essential to carry out studies focused on these issues in order to obtain reliable data in terms of both scientific and applied aims, e.g. environmental protection and sustainable management of soils as well as water resources.

During the past decades, many of such studies of soil erosion had focused on the application of modelling techniques implemented in a GIS environment, allowing indirectly to estimate the potential soil losses and to quantify related sediment yield. According to research results published in the scientific literature, this approach currently is widely used all over the world, and most of these studies are based on the USLE model and its revised and modified versions.

Considering that, the aim of this research was to estimate soil erosion rates and sediment transport under different hydro-climatic conditions in south-eastern Latvia by application of GIS-based modelling. For research purposes, empirical RUSLE model and ArcGIS software were applied, and five headwater catchments were chosen as model territories. The selected catchments with different land use are located in the Daugava spillway valley, which belongs to the upper Daugava River drainage basin.

Considering lithological diversity of Quaternary deposits, a variety of soils can be identified, i.e., Stagnic Albeluvisols, Albic Rubic Arenosols and Albic Stagnic Podzols with stony loamy – clayey diamicton to coarse sand textures prevail in the selected catchments.

The results of modelling were validated through obtaining data on suspended sediment load directly during episodic runoff events caused by different scenarios of runoff formation. In order to get comparable values of suspended sediment load from gully catchments that differ in size, an area-specific daily suspended sediment yield was derived.

The obtained results indicate that modelled area-specific sediment yield from the catchments to river greatly varies from 0.001 to 97.2 t ha^{-1} yr^{-1}; the average soil loss predicted by RUSLE for the each of five catchments calculated for a 1×1 m cell grid totals 0.81; 1.36; 0.96; 1.05 and 1.55 t ha^{-1} yr^{-1} respectively. Notably, despite the presence of forest vegetation that cover more than 40% of area of three of these catchments, sizable plots of soils are potentially prone to erosion rates above the tolerable threshold, i.e. 0.3 t ha^{-1} yr^{-1}.

Comparison of modelled vs. measured values indicates that the applied RUSLE model underestimates real sediment delivery, which shortly can reach values 213.75 kg ha^{-1} day^{-1} during intense snow melting in spring. Nevertheless, results of GIS modelling can be reasonably used to estimate the spatial distribution of soil erosion risk and to identify potential erosion hotspots.