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Impact of changes in rainfall intensity, land use pattern and management practice on sediment output of agricultural loess catchments

U. Scherer (1), E. Zehe (1), and K. Träbing (2)

(1) TU Munich, Institute for Water and Environment, München, Germany (u.scherer@bv.tum.de, +49 89 28923172), (2) Unger Ingenieure, Homberg, Germany

The emission of nutrients and pollutants from agricultural land via erosion is a serious threat to surface waters. For planning and managing the sustainable use of water resources information on sediment bound nutrient and pollutant emissions are required. Within the framework of a research project in a rural catchment the process based model CATFLOW-SED which permits the simulation of specific events as well as long term processes of water and sediment transport was developed. The detachment rate of sediment particles from the soil matrix is quantified using an optimized approach for loess soils, based on the correlation of the attacking forces of rainfall and surface runoff to the erosion rate. The amount of detached soil particles depends on the erosion resistance which is an empirical soil parameter. Sediment transport capacity is modelled for various grain size fractions using the equation of ENGELUND & HANSEN (1967). It is assumed, that detachment and transport on loess soils are not size selective. On the other hand, the deposition rate of a grain size fraction depends on the sinking velocity and therefore this process is highly size selective. The model results on sediment input for each grain size fraction could be coupled with nutrient and pollutant contents of the specific fractions allowing the quantification of nutrient and pollutant emissions into surface waters.
CATFLOW-SED was validated for the database of the 3.5 km^2 Weiherbach catchment located within a loess region of Southwest Germany at various scales (irrigation experiments, hillslope, catchment). The variation between modeled and observed erosion rates of the irrigation experiments was high due to the stochastic variability of natural landscapes on small scales. On the catchment scale the erosion resistance for the homogenous loess soils mainly depends on the land use category and the management practice. So for the hillslope and catchment scale the model results were in good agreement with observed sediment loads of large erosion events. Following these results, various scenarios regarding changes of rainfall intensity, land use pattern and management practice were modelled. The rainfall intensity of erosion events was increased about 1-3 % to simulate the impact of heavier thunder storms expected for the future in Southern Germany. It could be shown, that surface runoff increased about 15-22 % and sediment output of the catchment about 29-34 % due to the high non linearity of the underlying processes pointing out the increasing importance of erosion protection measures. The sediment output of the largest observed erosion event was varied by a factor of 0.6-1.3 when the given percentage of land use categories was rearranged in a “best case” and a “worst case” scenario. For the management practice scenario a reduction of 50-90 % of sediment output was achieved for reduced tillage and mulching. Each landscape is characterized by specific processes and factors of influence. These relationships can only be measured and examined at small scale. It was shown that the model CATFLOW-SED is a tool for drawing up the interrelationships within an agricultural loess catchment allowing conclusions to be drawn about comparable loess areas.