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Distinguishing spatiotemporal variability of sediment sources in small urbanized catchment as a response to urban expansion

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Understanding hydrological response and geomorphic behavior of small catchments in urban environments, especially those experiencing urban expansion, represents serious and important problem which has not yet been given an adequate research attention. Urbanization exerts profound and diverse impacts on catchment characteristics, particularly by increasing surface runoff coefficients, peak flow discharges and rates of flash flood waves propagation as a result of widespread appearance of buildings and paved surfaces with practically zero infiltration capacities. Another essential influence of urbanization on small catchment hydrological regimes is associated with significant changes of natural topography (from relatively minor modifications such as grading of steeper slopes to complete transformations including total filling of gullies and small valleys, transfer of small streams from surface into underground pipes or collectors, etc.) combined with creation of systems of concrete-protected surface drainages and underground storm flow sewages. Such activities can result in substantial changes of runoff- and sediment-contributing areas for the remaining gullies and small valleys in comparison to the pre-urbanization conditions, causing dramatic increase of fluvial activity in some of those and much lower flow discharges in others. In addition, gullies and small valleys in urban settlements often become sites of dumping for both dry and liquid domestic and industrial wastes, thus being major pathways for dissolved and particle-bound pollutant transfer into perennial streams and rivers. All the problems listed require detailed hydrological and geomorphic investigations in order to provide sound basis for developing appropriate measures aimed to control and decrease urban erosion, sediment redistribution, pollution of water bodies, damage to constructions and communications.
Recent advances in sediment tracing and fingerprinting techniques provide promising opportunities for distinguishing contributions of different sediment sources into catchment sediment budgets on a reliable quantitative basis. In combination with microstratigraphic differentiation and dating of sediment in continuous deposition zones by 137Cs depth distribution curves and available land use records, spatial and temporal variability of sediment sources and sinks can be reconstructed for the last several decades. That is especially important for catchments which experienced profound land use changes such as transition from pristine or agriculture-dominated to urbanized environment. The example presented here describes the results of reconstruction of changing sediment source types, contributions and spatial patterns for small reservoir catchment within the city of Kursk (Sredenerusskaya Upland, Central European Russia). Combination of compound specific stable isotopes, 137Cs, sediment grain size composition, land use information for several time intervals and daily rainfall record for the Kursk meteorological station (conveniently located within the study catchment) have been employed in order to evaluate major sediment sources within the catchment, their spatial pattern and temporal changes and compare those to history of reservoir sedimentation. The reservoir is situated on the Kur River – small river which gave its name to the city itself. The dam and reservoir were constructed and put into operation in 1969, thus the beginning of its infill is located stratigraphically later than the main peak of the global 137Cs fallout. It has been found that transition from dominantly agricultural land use to urbanized conditions caused decrease of contribution of soil erosion from cultivated land and increase of that of the active gullies into reservoir sedimentation. However, it is important to note that during extreme runoff events contribution of sediment originated from soil erosion on arable land still remains dominant, even though its area within the catchment recently became very limited.