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Reconstructing the small river basin sediment budget and associated particle-bound contaminants redistribution (Chern River, European Russia)

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Reconstruction of the basin-scale sediment budget and associated particle-bound pollutants redistribution was carried out within the upper part of the Chern River basin (133 km2). It involved application of integrated approach based on use of several independent techniques. The study river basin is located on the border between the Orel and Kursk Regions of the Central European Russia nearby the Mikhailovskiy opencast iron ore mine and processing plant, which are believed to be the main local sources of air-borne pollutants. In addition, the basin was contaminated by radionuclide fallout after the Chernobyl accident in 1986. Combination of geomorphic, geochemical, soil survey and geodetic methods has allowed authors to evaluate dynamics of sediment and contaminants redistribution for the last 50 years (since the beginning of a mining activity) within the upper part of the basin upstream from the reservoir, located in the middle reach of the main valley. Main techniques applied were field description of soil or sediment sections, the 137Cs radioactive tracer (for estimation average soil loss rates from eroding cultivated hillslopes and for reconstruction of accumulation rates and sediment microstratigraphy for deposition locations such as main river floodplain and bottoms of small dry valleys), chemical analysis (content of selected heavy metals and As – both in mobile forms by atomic absorption spectroscopy and total by X-ray fluorescence spectrometry, organic C content, pH), geomorphic and detailed geodetic survey of selected key sections of the Chern River floodplain, calculation of average soil erosion rates for cultivated area of the studied part of the basin by the empirical model. In addition, two detailed bottom sediment cores were taken from the reservoir bottom which intercepts practically all the sediment delivered from the upper part of the basin. Integrating the obtained data, it has been found out that substantial changes of the sediment budget took place within the studied part of the Chern River basin between periods before and after 1986 (as the main time mark was indicated by the Chernobyl-associated 137Cs peak detected in almost all sampled sections in deposition zones). These involved significant decrease of sedimentation in the reservoir (from 29% to 6.3% of basin-scale sediment production from cultivated hillslopes) and on the main river floodplain (from 14% to 4.5%) and consequent increase of deposition in small dry valleys (from 27-32% to 60-65%). This can be explained by combination of anthropogenic impact (dramatic decrease of cultivated area after the Soviet Union collapse and gradual recovery of local agriculture until the present time) and climate change (significant decrease of spring snowmelt runoff with increase of frequency of intensive runoff-generating rainstorms during the warm season). In terms of the contaminants redistribution, it was found that practically simultaneous commencement of the mining and industrial activity and sharp increase in application of chemical fertilizers in agriculture caused detectable heavy metal pollution within the basin only during the late 1950s – early 1960s. As a result concentrations of Zn and As in the floodplain sediment layers dated to that period increased dramatically, exceeding the maximum allowable levels.