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DEGRADATION, REHABILITATION, AND CONSERVATION OF SOILS

Assessment of the Trend of Degradation of Arable Soils on the Basis of Data on the Rate of Stratozem Development Obtained with the Use of ^{137}Cs as a Chronomarker

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Abstract—A new approach for determining the trend of changes in the rate of degradation of arable soils is suggested. It is based on the assessment of volumes of soil material eroded from arable fields and accumulated on the bottoms of first-order valleys during two time intervals: 1954(1963)–1986 and 1986–2015. For dating of this material, ^{137}Cs of global fallout and Chernobyl fallout are used. This approach in combination with a detailed morphometric characterization of the valley bottoms, the pathways of sediment transport from the fields, and the morphology and composition of the sediments accumulated on the bottoms makes it possible to give reliable estimates of the volumes of soil loss from tilled slopes. The benchmarks of 1963 and 1986 are related to maximum ^{137}Cs fallout during nuclear bomb testing and immediately after the Chernobyl accident. As an example, the rates of formation of stratozems (stratified aggraded soils formed due to accumulation of eroded sediments) within the first-order catchment of the Veduga River basin (Voronezh oblast, Russia) are analyzed. The results of the study indicate that the mean annual rate of soil loss from arable fields of the catchment in 1986–2015 was at least two times lower than that in the preceding period from 1954 (the beginning of the global fallout) to 1986 (the Chernobyl accident).

Keywords: soil degradation, erosion, Stratozems, sedimentation, chronomarker ^{137}Cs, first-order catchment, Voronezh oblast

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INTRODUCTION

Water erosion and accumulation of sediments on arable lands are the major processes of the soil cover transformation on plain territories of the European part of Russia (EPR). The manifestation of these processes is highly sensitive to hydrological and climatic changes, including those related to the global climate change. In the EPR, the global climate warming has been clearly pronounced in the recent decades [19]. Since the mid-1990s, river discharges during spring floods have become lower because of warmer and less snowy winters in comparison with those in the previous decades [24]. Economic conditions after the breakdown of the Soviet Union led to considerable changes in the land use with a sharp reduction in the cropland area, especially in 1991–2005 [15]. The abandoning of former plowlands mainly affected the forest zone of the EPR; however, this was also observed in the forest-steppe and steppe zones. In recent years, cropland area in the steppe and forest-steppe zone has been partially restored. However, it remains lower than that in the 1980s. These changes in the climatic characteristics and land use could not but affect the intensity of erosion on tilled slopes, which largely controls the degree of soil degradation. However, no direct observations over the rate of soil loss from arable fields on slopes have been conducted in the past decades. At present, soil-erosional surveys that were performed on the regular basis in the earlier years are no more conducted. As a result, it is difficult to give a quantitative estimate of the impact of climatic and economic factors on the intensity of soil degradation caused by erosion.

The aim of this study is to develop a new approach toward quantitative assessment of current trends in erosion-induced soil degradation on arable lands of small catchments on the basis of data on ^{137}Cs chronomarkers making it possible to date sediment sequences accumulated in the bottoms of first-order valleys adjacent to cultivated fields. These sediment sequences represent stratozems (Stratozems)—layered soils with a well-developed aggraded part consisting of soil materials washed off from the fields.

GENERAL METHODOLOGICAL PRINCIPLES

The erosion of soil material from arable fields is accompanied by the redistribution of sediments. Some