Bioscience Biotechnology Research Communications Vol 15 No (4) Oct-Nov-Dec 2022
P-ISSN: 0974-6455 E-ISSN: 2321-4007

Editorial Communication

Water Resources of Rivers and Erosion-Accumulation Processes

Fedor Lisetskii
Kazan Federal University, Kazan, 420008 Russia

ABSTRACT

Basin territorial structures are defined as unified natural and anthropogenic systems, since the movement of matter, energy and information occurs naturally from the divide to the valley line of the river valley within them. Considering the global issues of soil degradation in watersheds and depletion of water resources, some regional experience in the design and implementation of soil and water protection of cultivated lands as part of the concept of the basin nature management and implementation of the program for environmental rehabilitation of rivers and water bodies is presented. The statement that it is necessary to develop a long-term strategy for the consistent arrangement of basin geosystems from a divide of catchments to valley lines of a fluvial network in the conditions of a crisis situation with the use of soil, land and water resources is justified.

KEY WORDS: RIVER BASIN, SOIL EROSION, WATERSHEDS, ENVIRONMENTAL FLOW, ENVIRONMENTAL REHABILITATION.

INTRODUCTION

European news resources are full of information about weather anomalies that have affected the shortage of water resources this year. On August 23, experts from the Joint Research Center (European Commission's science and knowledge service) believe that Europe is experiencing probably the worst drought in the last 500 years. The Danube River, which flows through the territory or is the border of ten states of Central and South-Eastern Europe, is the second (after the Volga) river in Europe in terms of its length and catchment area. The Danube basin (817 thousand km2) is the most international river basin in the world and it provides drinking water for 20 million people. As WWF notes, as of August 17, 2022, in recent weeks, the Danube River has been setting daily records for its lowest level since 1941. While back in early February, the Rhine river overflowed its banks due to melting snow and torrential rains, which resulted in many settlements being flooded, it was noted on 13 August 2022 that the dropped water level in the Rhine had become a threat to navigation. Countries such as France, Spain, Italy and the Netherlands are facing water shortages this year.

Water resources and their use have some features that require managing them as a whole. A river flow intended for use is a space and time category: it has intra-annual and interannual fluctuations and is unevenly distributed over the entire territory. Natural features of the water flow dynamics change with the global climate changes. Another feature is that rivers that are used as a source of water supply can simultaneously be used as a wastewater receiver. However, it is important to emphasize that river flow is a key zonal factor for understanding territorial patterns of sediment yield formation (Yermolaev et al. 2021).

A conceptually new agriculture that is dynamically progressing economically resilience (adaptation), and removes greenhouse gases (mitigation), should not only be justified in terms of its feasibility, but also implemented in practice, which is especially important for such an agriculturally important country like India where over 600 million people are directly dependent on agriculture (Singh, 2013). And it is those densely populated countries with developed agriculture that soil erosion is most intense in. Annual global irreplaceable soil waste due to erosion reach 23 billion tons, of which the United States accounts for 6.5%, China - 14.3%, India - 20.4%. Since 1945, soil degradation has affected about 11% of the land free of ice from land mass of Earth (i.e. an area that, in total, exceeds the area of India and China). Innovative estimates for Earth (Borrelli et al. 2017) showed that on 9% of land and more, soil erosion is characterized as moderate and high intense, with the share of the latter class being 5.1%.

Selective nature of effects of the water erosion leads to the fact that silt particles enriched more in organic carbon (by an average of 40%) are carried out of watersheds, which leads to decarbonisation of arable soils and siltation of water

Article Information:*Corresponding Author: fnliset@mail.ru
Received 15/10/2022 Accepted after revision 25/11/2022
Published: Dec 2022 Pp- 480-482

Available at: https://bbrc.in/ DOI: http://dx.doi.org/10.21786/bbrc/15.4.1

bodies. Sediments on slopes with variable steepness are redeposited with the formation of pollutant accumulation zones. The use of fertilizers and plant protection products in cultivated lands determines the need to develop a priority list of pollutants in the soil-ecological monitoring system, as is shown e.g. for the regional conditions of the black earth zone: Cu, Cd, Cs, Pb, Zn (Zelenskaya et al. 2019). Monitoring is necessary both to control the translocation of heavy metals in the soil–plant system and to predict the zones of their accumulation in subordinate landscape positions. Excessive use of agrochemicals and in particular pesticides on watersheds leads to accumulation of their residues in the water and fishes (Hasan et al. 2021).

Suppression of the self-purification process and a decrease in the self-purification ability of an aquatic environment occurs as a result of a rupture in individual links of the food chain and turnover disturbances due to the toxic effect of individual pollution components (heavy metals, pesticides, surfactants, biogenic elements in case of their excessive concentration).The FAO compiled Global Soil Partnership reports (GSP, 2017), noting that 75 billion tons of soil are eroded every year from arable lands worldwide, which equates to an estimated financial loss of US $400 billion per year. Although there is disagreement among different authors that soil erosion costs for the US economy range from US$30 billion to US$44 billion annually, however, it can be assumed that the ratio of the total annual losses from erosion due to decreased productivity to the losses from water pollution as a result of erosion, but with dispersed sources (in the form of suspensions, soluble substances, nitrogen, phosphorus, bacteria), is 1:4.6 (Alt, Putman, 1987). Indirect and environmental consequences of water erosion are diverse (Borrelli et al. 2022).

In addition to damage to water supply sources from pollution with fertilizers, pesticides, and heavy metals, reduced fish stocks due to eutrophication of water bodies, changes in the composition of aquatic organisms, reduced recreational potential of coastal zones, it also includes siltation of navigable rivers and harbours, inflow of solid runoff into water intake facilities of the main canals, sediment deposition in roadside ditches, at spillways, etc.

Various criteria and indicators are used to assess the state of water resources in terms of quality and sufficiency of the volume for water use. The hydrological concept of the “minimum river flow” has at least two dimensions: a resource and an environmental one. The former is important for assessing the self-purification ability of the water flow to move sediments, which directly affects the water quality, as well as the balance of sediments in the aquatic environment and in case of accumulation in the bed. Turbidity of water of lowland and mountain rivers differs by 20–50 times, which is due to their river flow velocity differences. The environmental dimension of the minimum flow is determined by its potential for transporting ionic runoff and pollutants. Environmental runoff is an important tool for management of water resources.

Disruptions to environmental flows, which are widespread and occur in half of the sub-basins of the world, have become twice as common as in the pre-industrial period (Virkki et al. 2022). From the point of view of the theory, the environmental flow and the hydroecological safety of water use increase in those situations when the flow characteristics of the summer and autumn low-water season increase, while the risks of hydroecological emergencies are reduced due to a decrease in the extremes of the flow volumes in the spring flood (Dmitrieva, Zhigulina, 2020).

The concept of basin nature management involves the development of a strategy for consistent development of basin geoecosystems from the divide of catchments to the valley lines of the fluvial network. Informational parameterisation of river basins is reasonable within the framework of a dedicated geoportal for large regions, as it is done for the East European Plain (Yermolaev et al. 2018), while the development and implementation of soil and water protection projects in watersheds within the framework of the basin nature management concept (Yermolaev et al. 2015).

At the national level, the Belgorod Oblast has become the territory of the pilot project of soil and water protection development of cultivated lands on the basis of the basin principles. The choice of this region is in no way accidental. Belgorod Oblast is a part of the Central Black Earth Economic Region (CBEER), which is part of the Eurasian Black Earth Zone, with a total area of 168,000 km2, with its arable land occupying 60% is a large agricultural region, which provides the national agricultural industry with 40% of sugar beet, 25% of sunflower, and 10% of grain. Located on the south-western slopes of the Central Russian Upland, Belgorod Oblast has a large many slopes (72%, of which 34% of arable land exceed 3°), and is the region among the five regions of the Central Black Earth Region that is most prone to soil erosion (the share of eroded soils is about 50%). According to various estimates, the average annual rate of soil erosion in Belgorod Oblast ranges from 4 to 11 t ha-1.

As shown in a large body of evidence (Yermolaev et al. 2022), changes in land use and climate (i.e. meltwater runoff and rainfall erosivity) can act as specific triggers in the transformation of the fluvial system on hillslopes. Small rivers and their hydrological regime, as shown in many studies (Lisetskii, 2021, Lykov, Melenchuk, 2022), are the most sensitive to anthropogenic transformations compared to watercourses of higher orders. For example, siltation of river beds on the territory of the Central Black Earth Region for 200–250 years of agrarian development of watersheds (on average it 1 mm yr−1) has led to a change in the water regime on the floodplains and often leads to flooding of settlements. Compared to late 18th century, drainage density in the region has decreased 1.6-fold. Total length of small rivers (up to 100 km) has reduced by 40%. As a result of a decrease in water flow in small rivers and an increase in the amount of sediment, many tributaries have become non-perennial ones since they were separated from the main river bed.

Environmental rehabilitation of the surface water bodies now becomes a logical continuation of the basin nature management projects for 52 river basins completed in 2015 and subsequent implementation of comprehensive soil protection measures at watersheds in each river basin (optimization of the structure of agricultural land, differentiated crop rotation depending on the erosion hazard, depression resting on arable land, creation of new forest strips and afforestation zones at the peaks ravines, etc.). Belgorod Oblast is one of the first constituent entities of the Russian Federation to launch a large-scale water rehabilitation program. To reduce the ingress of suspended sediment into a water body, it is required to arrange for protective forest belts or waterworks (water-retaining walls, drainage channels and flow diffusers) in the areas of the flow accumulation.

Water protection zones near a water body should include three zones: sanitary protection, moderate and partial restrictions. In addition to the damage caused by gullies to soils, land use and infrastructure (Yermolaev et al. 2022) active erosional forms that open as mouths on narrow floodplains into the river bed serve as powerful providers of sediments. Therefore, it is necessary to create silt filtrating plantations on the fans of gullies, on their bottom, as well as on the bottom of water supply troughs. The urgent need for comprehensive water management and environmental protection measures for small rivers has caused the commencement of development of the "Preservation of Unique Water Bodies project (Belgorod Oblast)", including the water protection reconstruction of 72 water bodies back in 2022 (33 rivers and 39 ponds or reservoirs). It is planned to clear sections of river beds with a length of at least 260 km and lakes with an area of at least 730 ha by 2024.

Thus, the critical environmental situation in most rivers and water bodies requires a long-term rehabilitation strategy based on a deep understanding of hydrological, hydrodynamic, hydrochemical, and other processes in watersheds and in river beds. The results of said study will establish a scientific basis for implementation of comprehensive systems for environmental rehabilitation and protection of rivers and water bodies. The work is carried out in accordance with the Strategic Academic Leadership Program "Priority 2030" of the Kazan Federal University of the Government of the Russian Federation.

REFERENCES

Alt, K., Putman, J. (1987). Soil erosion: dramatic in places, but not a serious threat to productivity. Agricultural outlook AO-United States Department of Agriculture, Economic Research Service (USA).129, 28-33.

Borrelli, P., Ballabio, C., Yang, J. E. et al. (2022). GloSEM: High-resolution global estimates of present and future soil displacement in croplands by water erosion. Sci Data, 9, 406. -https://doi.org/10.1038/s41597-022-01489-x

Borrelli, P., Robinson, D. A., Fleischer, L. R. et al. (2017). An assessment of the global impact of 21st century land use change on soil erosion. Nat Commun., 8, 2013. https://doi.org/10.1038/s41467-017-02142-7

Dmitrieva, V. A., Zhigulina, E. V. (2020). Water dynamics of small water currents of the Upper Don basin and its role in the structural-dynamic organization of landscapes. Regional Geosystems, 44(4): 404–414. (in Russian). DOI: 10.18413/2712-7443-2020-44-4-404-414

GSP. Global Soil Partnership Endorses Guidelines on Sustainable Soil Management. (2017). http://www.fao.org/global-soil-partnership/resources/highlights/detail/en/c/416516/

Hasan, M. A, Das, A. K, Satter, M. A. (2021). Human Health Risk Surveillance through Organochlorine Pesticides in River Water and Fish from Bangladesh. Bioscience Biotechnology Research Communications Bioscience Biotechnology Research Communications, 14(4), 1777-1785. http://dx.doi.org/10.21786/bbrc/14.4.59

Lisetskii, F. (2021). Rivers in the focus of natural-anthropogenic situations at catchments. Geosciences (Switzerland), 11(2), Art. 63, 1-6. https://doi.org/10.3390/geosciences11020063

Lykov, I. N., Melenchuk, V. I. (2022). Environmental problems of small rivers in the Volga and Dneprovsky basin in the territory of the Kaluga region. IOP Conf. Ser.: Earth Environ. Sci., 981, 042046. https://doi.org/10.1088/1755-1315/981/4/042046

Singh, R. B. (2013). Climate change and abiotic stress management in India. Book Editor(s): Narendra Tuteja, Sarvajeet S. Gill. Chapter 3. pp. 57-78. https://doi.org/10.1002/9783527675265.ch03

Virkki, V., Alanärä, E., Porkka, M., et al. (2022). Globally widespread and increasing violations of environmental flow envelopes. Hydrology and Earth System Sciences, 26(12), 3315-3336.

Yermolaev, O. P., Lisetskii, F. N., Marinina, O. A., Buryak, Zh. A. (2015). Basin and eco-regional approach to optimize the use of water and land resources. Biosciences, Biotechnology Research Asia, 12, 145-158.

Yermolaev, O. P., Mukharamova, S. S., Maltsev, K. A. et al. (2018). Geographic Information System and Geoportal «River basins of the European Russia». IOP Conf. Series: Earth and Environmental Science, 107(1), 012108. https://doi.org/10.1088/1755-1315/107/1/012108

Yermolaev, O., Medvedeva, R., Poesen, J. (2022). Spatial and temporal dynamics of gully erosion in anthropogenically modified forest and forest-steppe landscapes of the European part of Russia. Earth Surface Processes and Landforms. https://doi:10.1002/esp.5433

Yermolaev, O., Mukharamova, S., Vedeneeva, E. (2021). River runoff modeling in the European territory of Russia. Catena, 203, 105327, https://doi.org/10.1016/j.catena.2021.105327.

Zelenskaya, E. Y., Kukharuk, S. A., Naroznyaya, A. G., et al. (2019). Bioecological Assessment of Arable Soils Pollution: A Case Study of Belgorod Region. Bioscience Biotechnology Research Communications, 12(3), 548-555.