THE INFLUENCE OF CLIMATE CHANGE ON THE ECOLOGICAL CONDITION OF THE OSKIL RIVER BASIN

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An intensive use of surface water and an excessive anthropogenic impact predetermine the fact that most of the Siverskyi Donets basin rivers belong to class III (polluted) (by the average performance levels) [1] and category 4 (slightly contaminated) (by the environmental assessment of surface water quality for the respective categories) [2]. Changes in the water quality depend on the anthropogenic impact, climatic conditions, landscape and ecological features, as well as physical and geographical peculiarities of the river basin.

The authors of [3] state that a multivariate nature of water quality determines the complexity of its investigation. The research problem is aggravated by an insufficient justification of the theoretical and methodological bases and an ambiguous use of instrumental methods, which complicates the attempts of disclosing the mechanisms of water quality formation that are aimed at improving the control over water protection activities.

Obvious climatic changes due to an increase in average air temperatures and an increased variability of precipitation significantly affect the formation of water quality. Numerous studies predict that climate change may have considerable effects on water quality [4, 5] and on the biotic component of aquatic ecosystems [6, 7].

Miscellaneous conditions and factors influencing the formation of groundwater quality predetermine the need to study the factors that have the biggest impact. Studies in this area are topical due the fact that contemporary climate changes and an intensive use of water resources require identifying the largest sources of pollution of surface waters for further development of a complex of environment protection measures.

The largest left tributary of the Seversky Donets River is the Oskil River. Its length is 472 km, the area of the basin - 14,800 km2 (according to other sources - 14,680 km2). The Oskil River flows into the Seversky Donets at 580 km from the mouth. [8].

The Oskil River basin is of cross-border importance because it flows within two countries - Russia and Ukraine. The total length of the river is 472 km, of which 290 km flows through the territory of Kharkiv region. The total catchment area is 14,800 km2, of which 3,830 km2 are located in the Kharkiv region (fig.1).

Figure 1.Map of the Oskil river basin in the Kharkiv region

The Oskil river is the largest (left) tributary of the Siverskyi Donets and is important for the whole river basin in Ukraine. The Oskil waters are used in the agricultural and industrial sectors and support the hydraulic system of the Siverskyi Donets-Donbas canal. The Oskil river basin has cross-border significance as it is located both in Russia and Ukraine.

The vast majority of rivers and reservoirs of the Kharkiv region degrades through an excessive human pressure that dominates over the ability of self-cleaning and self-healing. Significant river changes have been caused by failure of legislation and rules for the use of land in water protection zones and coastal strips.

When planning water protection activities and identifying priority issues, it is important to assess the actual ecological state of a selected aquatic site and obligatorily consider pool features and factors that have the greatest influence on the formation of aquatic ecosystems.

Particularly important is research on climate changes, because the analysis of long-term observations on climate changes in the Kharkiv region have showed that in recent years, namely since 1992, there has been a tendency of the average air temperature to increase. Such changes may further provoke uncontrollable effects on aquatic sites since they have significant direct and indirect impacts, especially on such important characteristics as precipitation, water consumption, as well as hydrochemical and hydrobiological indicators.

Modern concepts of water management increasingly emphasize the preventive character of the necessary measures and recognize the importance of acting now to adapt to the effects of global warming in the future [9].

Ecological assessment is a prerequisite for environmental regulation of surface water quality, its preliminary stage. According to the method [2] according to the analytical quality control of surface waters of Kharkiv region according to the average annual indicators for 2019, the ecological index was calculated (Table 1).

Table 1.

Ecological assessment of water quality of Oskil river basins according to observations in 2019

Observation point	Indices, categories, classes					
	$I_{есер}$	$К_{есер}$	$Кл_{есер}$	$I_{емакс}$	$К_{емакс}$	$Кл_{емакс}$
Oskil, village Krasny Oskil, bridge	3,75	4	3	6	6	4
Oskil, Kupyansk	3,6	4	3	5	5	3
Oskil, border with Russia	3,46	4	3	5	5	3

Assessment of the ecological condition of the watercourses of the Oskil river basin showed that they are in a very poor condition (3-4 quality class), especially small rivers, which are most sensitive to anthropogenic load.

The ranking of watercourses in the Oskil River basin in the Kharkiv region by the value of the integrated ecological index in 2019 showed that the river Solona is in the worst condition (5th grade, 7th category). In general, almost all studied watercourses have poor quality, which corresponds to quality class 4.

Analysis of the previous studies shows that many of them are devoted to the impact of climate changes on the quantitative and qualitative characteristics of water resources [10, 11]. Examples of such studies indicate heterogeneity of climate changes and ambiguity of their effects on different aquatic sites, so when planning water protection measures it is necessary to study the natural conditions of the formation of a selected aquatic site.

The long-term dynamics of climate change have been studied by means of the following parameters: an average air temperature and precipitation from 1969 to 2018; a predictive model was built by the Holt-Winters method.

We have studied the Oskil hydrological parameters such as the runoff volume and water consumption for 65 years, from 1953 to 2018, and constructed predictive models.

Models built by the Holt-Winters method are widely used to develop long-term prognoses. The chosen method has advantages as it takes into account seasonality and the general tendency and uses a three-parameter exponential smoothing

While monitoring the average temperature in the Kharkiv region according to the State Committee for Hydrometeorology from 1969 to 2018 and building a predictive model, we have revealed an expected global warming by 1.9°C – from 7.8°C to 9.7°C – in 2030 (Fig. 2). The blue colour in Fig. 5 marks the observation data on the average temperatures from 1969 to 2018, the red colour indicates the forecast for the period until 2030 by the Holt-Winters method, and the green colour marks errors. Similar designations are found in Fig. 3, Fig. 4, and Fig. 5.

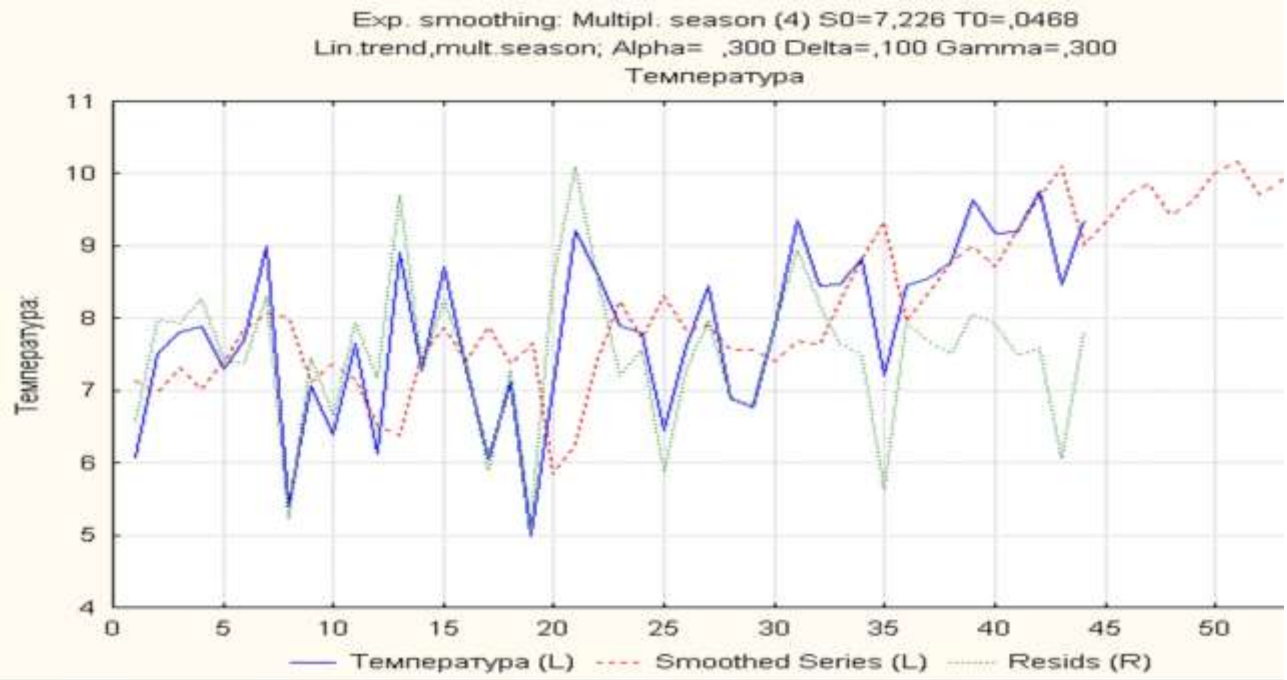

Figure 2. The forecast of an increase in the average temperature in the Kharkiv region

The monitoring of the average annual precipitation in the Kharkiv region, according to the State Committee for Hydrometeorology from 1969 to 2018, and the building of a predictive model have disclosed that there is an expected slight decrease in the amount of precipitation from 523 mm in 1969 to 504.8 mm in 2030 (Fig. 3).

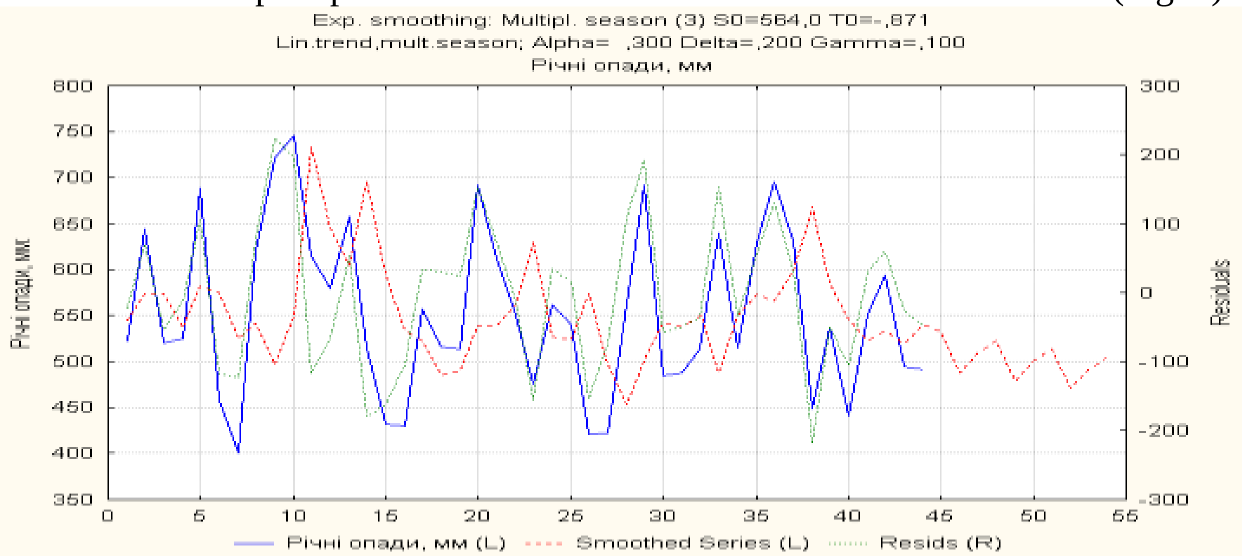

Figure 3. The forecast of a decrease in the average precipitation in the Kharkiv region

Studying the volume of the Oskil flow from 1924 to 2018 showed its considerable variability, and, according to the forecast model by the Holt-Winters method (Fig. 4), in 2030, there is an expectation of 613.8 mln $м^3$, which is well below the average volume for the years studied (1159.7 mln $м^3$)

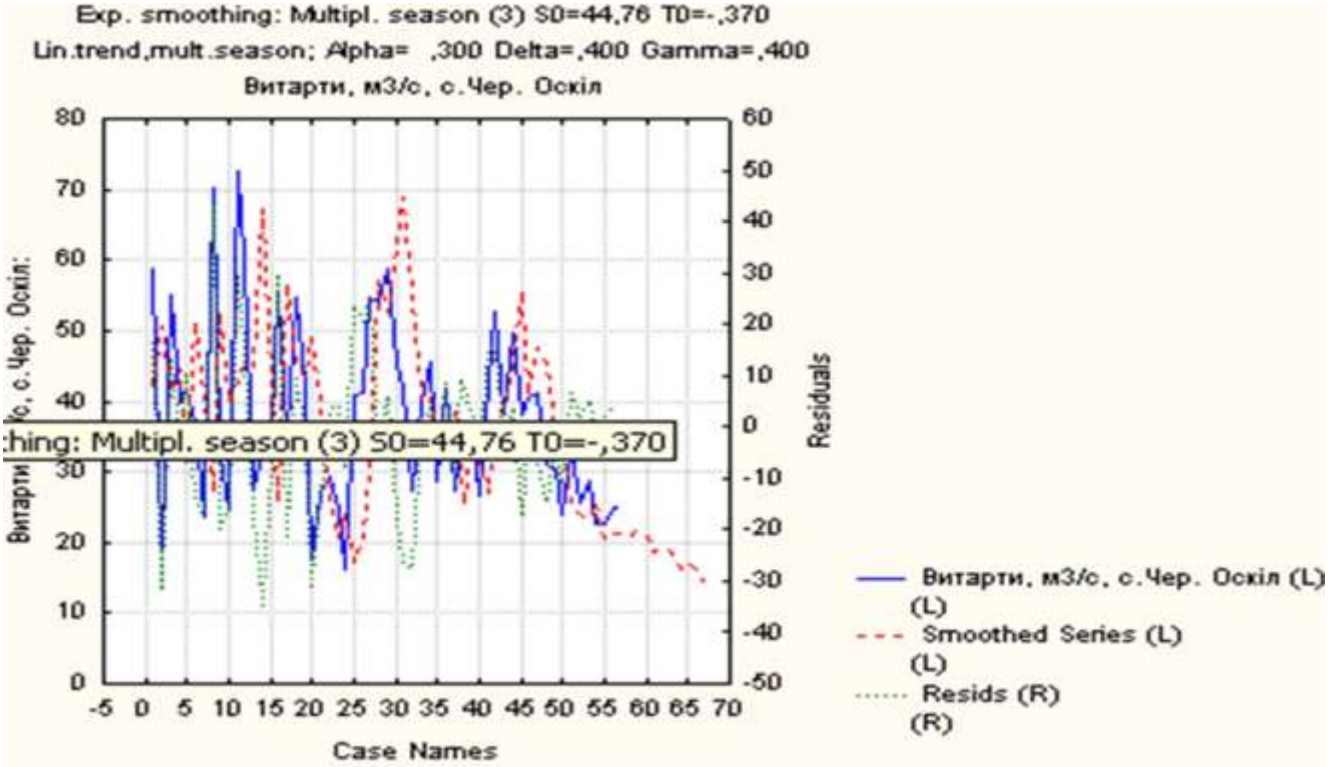

Figure 4. The forecast of changes in the average water consumption from the Oskil river

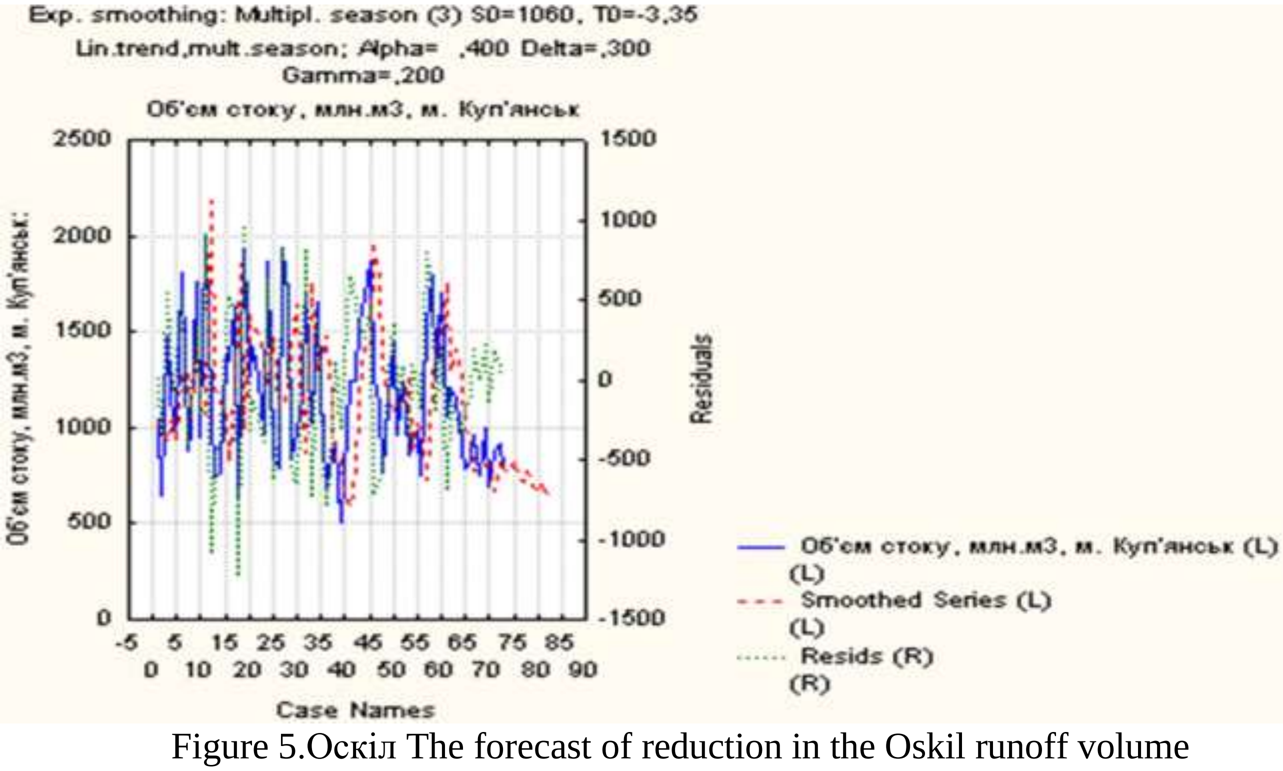

Figure 5.Оскіл The forecast of reduction in the Oskil runoff volume

The study of the fluctuations in the Oskil water flow within 61 years – from 1953 to 2018 – showed that from 1994 to 2018 the average annual water consumption significantly decreased from 56.9 m^3/s in 1994 to 25.4 m^3/s in 2018, and its further decrease is predicted for the future (Fig. 5).

The Oskil River Basin is of cross-border importance, as it flows within two countries - Russia and Ukraine, so the assessment of the ecological status of the basins and the development of measures to improve it is a very important task.

The study has specified the long-term dynamics of the climatic factors and hydrological parameters of building predictive models by the Holt-Winters method. The results indicate that the climate change tends to increase the average temperatures. Another consequence is a decrease in the average amount of precipitation. The model, which was built with using the hydrological parameters of the runoff volume and water consumption, predicts their significant reduction in the future. These trends can have negative consequences for the environmental state, create risks, and increase infestations.

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