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The Role Water Content in the Forming of the Ecological Condition of the Rivers of Siverskyi Donets Basin

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Authors' contributions

This work was carried out in collaboration between both authors. Author OVS designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the literature searches. Author NSL managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of the study is to determine the impact of the water content in the forming of the ecological condition of the rivers of Siverskyi Donets Basin (Ukraine) based on chemical and physico-chemical observations.
Study Design: The ecological condition of rivers is determined by their water contents and anthropogenic loading. Therefore, this study focused on the identification of the main trends in the changes of the quality of river water in the conditions of global warming impact.
Place and Duration of Study: The study addressed the industrial Chuhuiv, Zmiiv, Lysychansk cities located along the main river, the Udy River (discharges of municipal and industrial wastewater of the Kharkiv City), Kazennyi Torets, Kryvyi Torets, Bakhmutka (discharges of mine water from Donetsk coal basin) and Luhan (industrial and agricultural waste water) for 26 years from 1990 to 2015.
Methodology: Relationships between the indicators of water quality and the characteristics of water content were established from regression analysis. Determination of the ecological condition

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of the rivers was in the form estimated as a complex index of the ecological condition of their water, that based on the chemical and physico-chemical variations generated from many years of observations for them in the water.
Results: The study findings show that the indices of mineralization block and sanitary-toxicological block are increasing as the water content decreases, and the indices of toxicological and fishery blocks are increasing. The relationship between the indices of the ecological-sanitary block and water content was not found to be statistically significant. The overall index of the ecological condition of the rivers water steadily increases as the water content increases.
Conclusion: The water quality the rivers of the Siverskyi Donets Basin puts them into the categories of "polluted" and "very polluted" rivers. The analysis of the block indices of water quality generated in this study revealed that the substances of toxicological block (ammonium, nitrites, SSAS, heavy metals) and fishery block (petroleum products, phenols) are the most impacting on the water quality of the rivers of the Siverskyi Donets Catchment.

Keywords: Siverskyi Donets Basin; water content; water quality; regression analysis.

1. INTRODUCTION

Water resources are one of the most important factors in the development and deployment of productive forces in Ukraine. The Siverskyi Donets River is one of the largest river of the East of Ukraine and it is the main source of fresh water supply in the region. The river is transboundary [1].

During the existence of the Union of Soviet Socialist Republics, industrialization of the study area was a priority among the economic sectors, due to its abundance of mineral deposits. Donetsk Coal Basin (Donbas) has been a focus of industrial development for many decades. The agglomeration of industrial facilities are located along the tributaries of the Udy River (Kharkiv region), Kazennyi Torets, Kryvyi Torets, Bakhmutka (Donbas), Luhan (Luhansk region). Wastewater discharges into the rivers of Donbas (Ukraine-controlled territory) decreased since 2013 [2]. At the uncontrolled government of Ukraine, wastewater discharge continues at the level of 2013 year [3]. In part about assessment of water bodies in the non-government controlled areas (NGCA) showed the analysis of the monitoring data and the water management balance from 2013 to 2017. Results of the expert assessment of the main human-induced loads and their impact on the status of the rivers in the Siverskiy Donets River Basin located in the NGCA showed that wastewater discharge continues after 2013 and remains unchanged at the level of ecological status “predominantly under risk” [3].

The decrease of industrial production is accompanied with unauthorized discharges of wastewater from enterprises and agglomerations, flooding of coal mines, and unrepaired sewage treatment plants.

The catchment area of the Siverskyi Donets River is located in two geographical zones - forest steppe and steppe. In the conditions of global and regional climate changes that are associated with increasing aridity and corresponding river runoff in the East of Ukraine, the issues of rational use, conservation and protection of the Siverskyi Donets water resources should be adressed seriously [4].

The relevance of this study includes in the need to understand the impact of the variations of the water content of the rivers of the Siverskyi Donets Basin on their ecological condition. The object of the study is the water quality of the rivers of Severskyi Donets Basin. The objective of the study is to establish the existence of links between the water content (discharge) of rivers and the quantitative indicators of their ecological condition.

The water supply of the eastern region of Ukraine is low and the intensity of river runoff utilization here is twice the average level of its utilization in Ukraine. The water resources of the Siverskyi Donets River determine the current state and economic development of the whole region. The discharge of Siverskyi Donets River is a transformed anthropogenic activity. Considerable use of water begins within Russia. The Severskyi Donets River and the upstream of the Oskil River receive the water pumped off the iron ore mines of the Kursk magnetic anomaly. There are 128 reservoirs within the catchment area. Belgorod reservoir is located in the territory Russia, near the border with Ukraine. The Pechenizke Reservoir is located downstream, in

Ukraine. It is the main water source for the Kharkiv City. The Udy River, which flows into the Siverskyi Donets River downstream from Kharkiv, is the main collector of urban sewage.

The Chervonooskilske reservoir is located on the Oskil tributary of the Siverskyi Donets River. The Chervonooskilske reservoir replenishes the main river with water in the dry months to cover the needs of the Siverskyi Donets - Donbas Channel. The Dnipro - Donbas Channel also flows into the Siverskyi Donets River.

In the forest-steppe zone, the surface water with hydrocarbonate-calcium composition and moderate mineralization is formed under the influence of carbonate soils. The soil salted with sulfates and chlorides is cause of the formation of hydrocarbonate-sulfate and sulfate water with dominant calcium and sodium cations in the steppe zone. The high mineralization of rivers Kazennyi Torets, Kryvyi Torets and Bakhmutka (Donbas) originates from the systematic discharge of heavily mineralized mine water into the rivers. The mineralization amount is within the rangeof2000-5000mg / dm^3 [5].

The industrial cities of Kharkiv, Chuhuiv, Zmiiv, Balakleia, Izium and others are significantly impacting on the chemical composition of waters in the rivers they pollute. Kharkiv water discharges into the Udy and Lopan tributaries of the Siverskyi Donets exceed the volumes of annual runoff of this tributaries [6].

Tributaries in the downstream Izium City flow with the discharge mine water into the Siverskyi Donets, characterized as a high mineralization and concentration of petroleum products, SSAS, heavy metals and other anthropogenic substances [5]. Over the last decade, the pollution of the Siverskyi Donets by petroleum products has decreased significantly in some of its constituent rivers. However, the petroleum refinery within the city Lysychansk continues to discharge petroleum products contaminated waters into the river constantly. The dynamics of SSAS concentration are increasing, that is indicating insufficient wastewater treatment. The highest concentration of SSAS is recorded in the river Luhan within the downstream of where the Luhansk City is located, and in the river Borova within the downstream of where Sievierodonetsk City is located. The highest concentrations of heavy metals were observed in the Siverskyi Donets: Lysychansk (the iron), Kryvyi Torets - Druzhkivka (the copper), and Luhansk - Kirovsk (the manganese). Leaching of mineral and organic substances from farm lands is enabling them to be flown into the rivers of the Siverskyi Donets Basin they would pollute [7].

The main source of the polluting of river beds with organic substances are the rural households that are not unequipped with sewerage collectors. "74% of the total load of the generated organic substances flow into the Luhanka, Luhanchyk, Kazennyi Torets, the main riverbed of Siverskyi Donets, Udy and Borova." According by this literary source, the nitrogenous substances originate from arable lands(80%), and the phosphorus from agricultural and eroded lands (57%).

A study of the impact of water content on the water quality of the catchment of Siverskyi Donets was revealed that the mineralization of river water reaches the lowest values during the period of spring flood, and that depends on the intensiveness of snowmelt and height of the water flood [8].

The findings of a related study reported here [9] noted that when slightly mineralized snows are melting during the hydrological season of Spring, channel water is diluting, and concentrations of main ions in the area of sufficient moisture are decreasing. The degree of dilution depends on the intensity of snowmelt and autumn moisture. For the autumn without rain, salt could accumulate on the soil surface, and later get flushed into main river and it's tributaries during the Spring floods. For autumn is without rain possible the accumulate salt on the soil surface and this is flushing in during spring floods. Most accumulations of salt on the upper layer would be found where there's insufficient moisture due to considerable evaporation from the soil surface. In this case, the role of spring water flood as a source of water dilution is decreasing. The concentration of mineralization would be hampered with the decrease of river water.

Significant fluctuations of the qualitative characteristics of the water of rivers due to fluctuations of water content during the year were noted here [10].

And, the findings of a previous study reported here [11] also show that in high-water years the water quality is degrades.

The literature review reported above focused on the assessment of the water quality of the

Siverskyi Donets River Basin. The assessment is challenging mainly due to the significant change of water content and the factors of anthropogenic impact on tributaries and along length of the main river. A main unresolved aspect of the problem of establishing the ecological condition of the Siverskyi Donets River is the assessment of surface water quality which considers the variations of water content going on as a result of the increasing aridity arising from global warming caused climate change. As a rule, the effects of anthropogenic impact are amplified by the reduction of the water content of rivers. This pattern is due to a decrease in the degree of dilution of the pollutant in the volume of water. A separate aspect is created by the cessation of operation and further destruction of industrial enterprises, treatment facilities in the anti-terrorist operation zone(Donetsk and Luhansk regions). For a more accurate assessment of surface water quality, it is necessary to take into account the overall impact of all available pollutants entering the Siverskyi Donets River Basin, as well as the changes of water content both in time and space.

The aim of the study is to assess the impact of river water content on the ecological condition of the rivers.

2. MATERIALS AND METHODS

2.1 The Main Research of Siverskyi Donets River Basin

The catchment area of this river is 989.000 km². Ukraine owns 55% of the total catchment area, Russia - 45% [12]. In the territory of Ukraine, Siverskyi Donets River Basin is located within the Kharkiv, Donetsk and Luhansk regions and it is an urbanized region with a high level development of industry and agriculture (Fig. 1) [13].

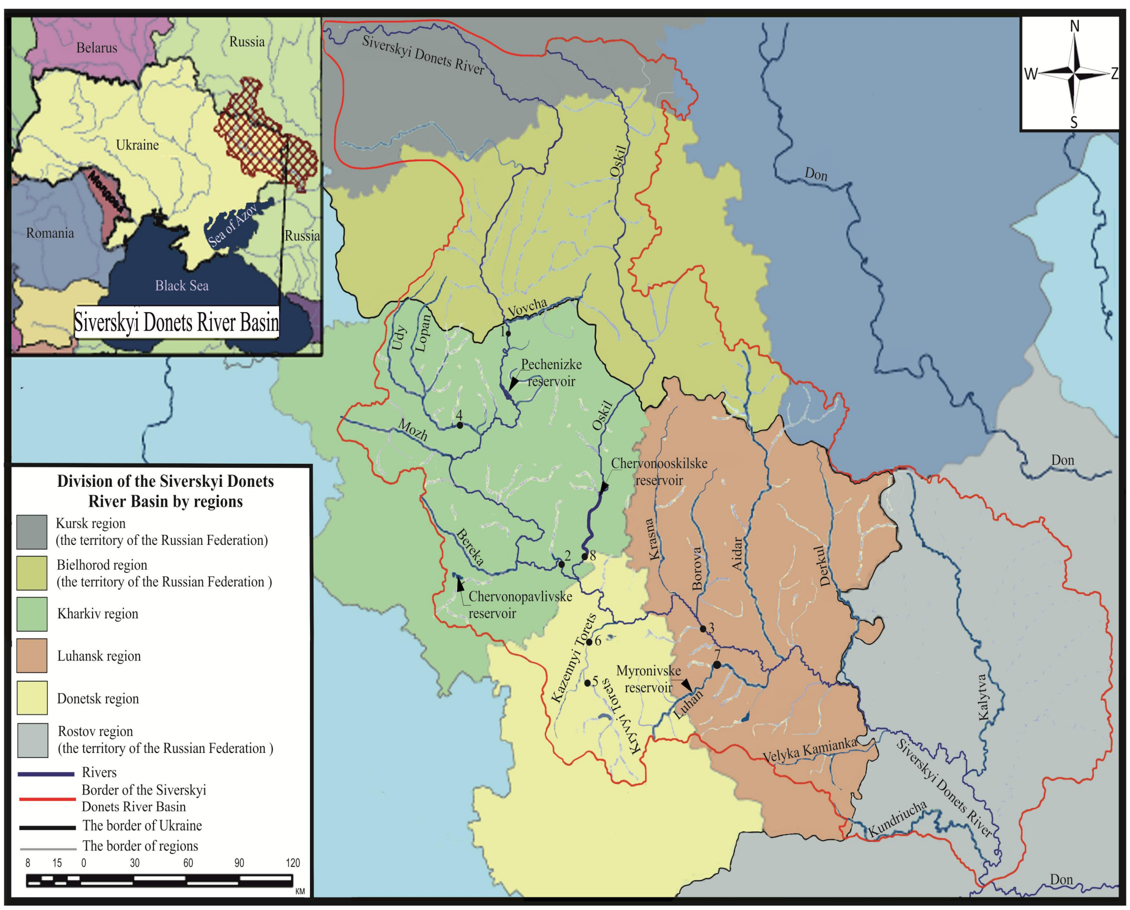

Fig. 1. Division of the Siverskyi Donets River Basin by regions with designation to located the observation points

The study relied on the data hydrological observations generated from the early 50th of the last century up to 2015. Hydrochemical observations on the studied rivers began were conducted from 1990. Three hydrological station for hydrological and hydrochemical observations are located on the main river (Ohirtseve, Izium, Lysychansk). The Kazennyi Torets, Kryvyi Torets, Luhan tributaries are located within the Donbas. The Udy tributary is a wastewater collector from the Kharkiv City. Water flow in the Oskil tributary is the highest, and is regulated by the Chervonooskilske reservoir.

2.2 Methodology

Estimation was based on the method of difference integral curves.

The regularity analysis of runoff fluctuations was based the method of difference integral curves. The graphs of these curves are used for the highlighting of the phases of water content and cycles (long-term cyclical) in runoff fluctuations [14]. The ordinates of this curve $f(t)$ are the accumulated over time by sums of deviations of the relative values of annual runoff from unity [14]:

$$f(t) = \sum_{t=1}^{T}(k(t) - 1) \quad (1)$$

Where,

T- number of observation years;
$k(t) = Q(t)/Q_{aver}$ - modular coefficient *k(t)*;
$Q(t)$ – annual runoff;
$Q_{aver.}$- The average value of annual runoff for the entire observation period, the average value of the modular coefficient *k(t)* for a long period equals 1: $k_{aver.} = 1$.

The period of time for which the section of the integral curve has an inclination upward in relation to the horizontal axis corresponds to a positive phase of the runoff fluctuations. The period of time for which a section of the integral curve has a downward slope in relation to the horizontal axis corresponds to a negative phase. Entire water content cycle contains one positive and one negative phases, or conversely. The beginning and end of the cycle can be distinguished by characteristic points (maxima or minima of the curve), as well as by the intersection of the curve of the abscissa axis. The beginning and end of the cycle can be distinguished by characteristic points (maxima or minima of the curve), as well as the intersection of the curve to the abscissa axis.

Relationships between the characteristics of water quality and content were established from regression analysis. The assessment of ecological condition of water was assessed as the complex index of it [15].

This index is calculated in respect of the dates of hydrochemical and physicochemical observations carried out at the stations of observation of main river and tributaries of the Siverskyi Donets River. The main component of the calculations is the relation between the observed concentration of chemical substances and their normative value (the maximum permissible concentration (*MPC*)). The maximum permissible concentrations are individually prescribed for different water users. This study based on the *MPC* for fisheries.

For the determination of the total effect of substances on the river's ecological status, the block's indices are calculated. Each block includes a specific group of chemical or physico-chemical indicators. Block's indices are calculated as the blocks of mineralization; ecological and sanitary (suspended matter, pH, dissolved oxygen, bichromate oxidation, BCO5); sanitary-toxicological (nitrates, chromium, sodium, potassium, calcium, magnesium, chlorides, sulfates); toxicological (ammonium, nitrites, lead, zinc, SSAS, iron-manganese) and fishery (phenols, petroleum products) respectively.

For the ecological-sanitary block the value I_5 is calculated as the average of the blocks of individual substances in water [15]:

$$I_5 = \frac{1}{n}\sum_{i=1}^{n}\frac{C_i}{MPC_i}, \quad (2)$$

where, C_i - the concentration of the individual substance in water;
n – the amount of indices included to the block;
MPC_i - maximum permissible concentration of the individual substance.

In order to avoid unnecessary smoothing of the output data, the averaging is not performed for the other block indices calculated as [15]:

$$I_j = \sum_{i=1}^{n}\frac{C_i}{MPC_i}, \quad (3)$$

Where,

C_i - the concentration of the individual substance in water;
n – the amount of indices included to the block;

MPC_i - maximum permissible concentration of the individual substance.

The overall assessment is established as the average of the block indices considered as follows [15]:

$$I_E = \frac{1}{m}\sum_{i=1}^{m} I_j, \qquad (4)$$

Where,

I_E - the generalized block index;
C_i - the concentration of the individual substance in water;
I_j - block index;
m – the total of block indices considered.

The condition of water quality is established based on the values of the overall index of water condition as: category 1, the quality condition is "very clean", the indicator of ecological condition $I_E$is 0.25; category 2, quality condition –"clean", indicator of ecological condition equals I_E0.51-1.0; category 3, quality condition –"enough clean", indicator of ecological condition I_E - 1.01-2.0; category 4, quality condition –"slightly polluted", indicator of ecological condition I_E - 1.01-2.0; category 5, quality condition – "moderately polluted", indicator of ecological condition I_E - 2.01-4.0; category 6, quality condition –"polluted", indicator of ecological conditionI_E 4.01-8.0; category 7, quality condition is "very polluted", indicator of ecological condition I_E> 8.00.

3. RESULTS AND DISCUSSION

Fluctuations of the water content in the Siverskyi Donets River along its (Ohirtseve - Izium - Lysychansk) stretch contain high and low water phases observed from 1950 up to 2015 as illustrated on Fig. 2. The river runoff in the observation point of Izium and Lysychansk is significantly disturbed by anthropogenic activity. Fluctuations of the river runoff in the upper Ohirtseve flow can be considered as close to natural ones. The high-water phase of fluctuations began in 1977 for all points of observation. The terms of transition to the low-water phase in different observation points of the same river do not coincide due to the regulation of runoff by reservoirs, formation of artificial floods from reservoirs, diversion of water through channels and discharges of industrial waters. In the upper observation point of Ohirtseve the low-water phase began in 1990, which conforms to the observed data on other plain rivers of Ukraine. In the two lower observation points (Izium and Lysychansk) a steady transition to the low-water phase occurred from 2006 to 2008.

Maximum water runoff of spring flood characterized decrease in the period 1990-2015. The highest amount (peaks) of maximum water runoff in the main river and tributaries were observed in 1994, 1996, 2003 and 2006 as illustrated on Fig. 3, but each time it were lower mainly due by the impact of climate change. As the air temperature increase and transit to positive values during the winter's hydrological season (from December to February), the soil freezing depth decreases and infiltration capacity increases. That is, creating the conditions favorable for the increase of infiltration loss to the underlying surface and a decrease of surface runoff. Increasing the amount and duration of winter thaws reduces the water supply in the snow cover before the start of spring flood and characteristics of maximum runoff. As the air temperature increase, increase the loss for evaporation from the land surface duringthe warm season responsible for the reduction of surface runoff during the low-water period. The overall result is a decrease of runoff throughout the year.

The total river runoff during spring flood is 70-80% of the annual runoff, and contributes in the formation of river water quality. On the one hand, melted surface water flushes off the harmful substances from the surface of the catchment (diffuses source of pollution) to the river; on the other hand, for pollution whichis point contamination, the increase of river water is conducive for the water dilution processes and self-purification.

The block indices of water quality and the overall index of water condition were used in the studying of relationships between the characteristics of the water quality and content of rivers. The annual values of the annual runoff modules (q, dm^3 / s / km^2) at the observation points served as characteristics of the river water content.

The highest values of the indices of mineralization block I_1 and sanitary-toxicological block I_2 at a given q characterize for the rivers of Donbas (Kazennyi Torets, Kryvyi Torets, Luhan). The highest toxicological contamination established was of the Udy River (a result of Kharkiv City's impact), the Siverskyi Donets River – the town Lysychansk and the Kazennyi Torets River (Donbas). The most adverse for fishery is the main river whose water has high concentrations of phenols and petroleum products. In accordance to the averaged long-term indices of the ecological condition of water in all considered observation points, the water of this river belongs to category 6 (“polluted”) and category 7 (“very polluted”).

The study also revealed that as the water contents of the rivers increase, the indices of the mineralization block I_1 and the sanitary-toxicological block I_2 decrease. The indices of toxicological I_3 and fishery I_4 blocks are increasing (Table 1). Relationships between indices of the ecological-sanitary block I_5 and water content were not found to bestatistically significant. Responsible for the absence of steady trends in the changes of the water quality of the Oskil River at the observation point of Chervonooskilske hydroelectric power plant (lower canal pound) is the impact of the reservoir located in the upstream of the Chervonooskilske hydroelectric power plant. The discharge of mine and industrial water into the rivers of the Donbas (Kazennyi Torets and Kryvyi Torets) also impact on the credibility of the obtained regression equations found to be statistically in significant in some cases. The overall index of the water condition I_E has a steady upward trend due to increasing river water content. The numbering ofobservation points (Table 1) is designated on the map of Siverskyi Donets River Basin shown on Fig. 1.

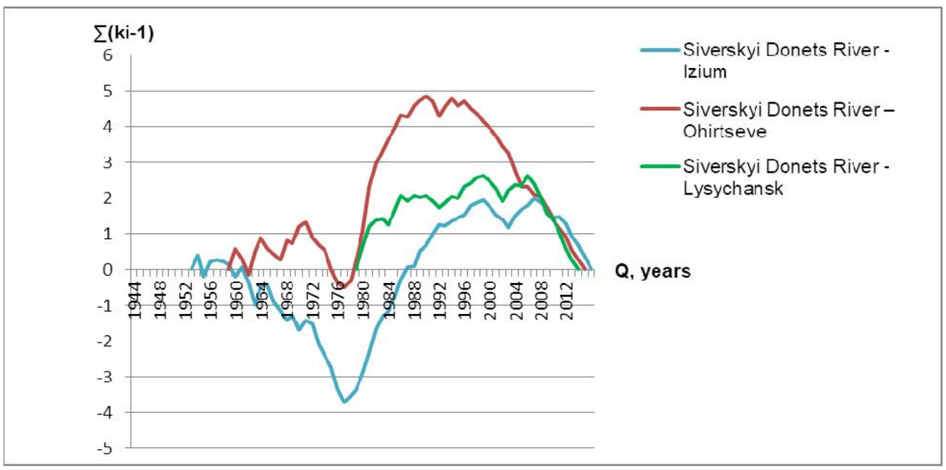

Fig. 2. Combined graphs of the difference integral curves of annual water content at the different observation points of the Siverskyi Donets River stretch studied

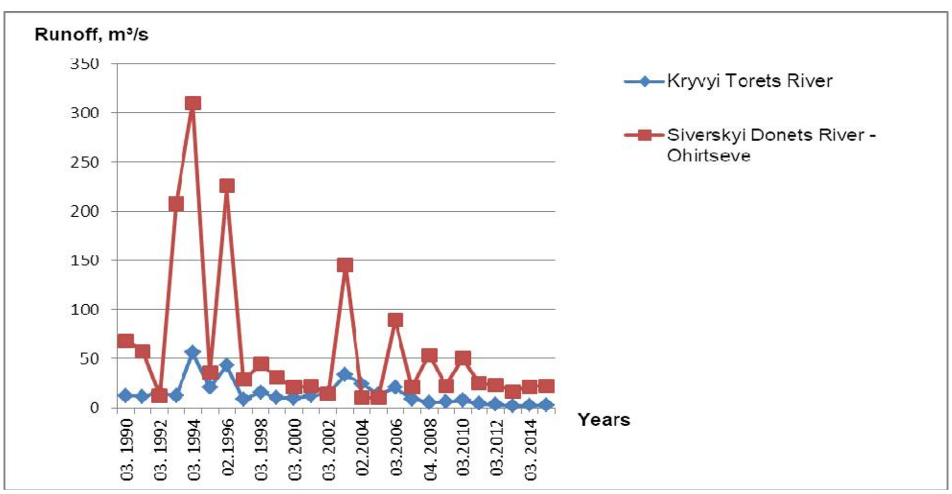

Fig. 3. Timeline of maximum monthly runoff values (m³ / s) during spring flood in the Siverskyi Donets River - Ohirtseve and in the Kryvyi Torets River - Druzhkivka (within the city)

Table 1. Equations of linear pairwise regression that describe linear relationships the between block indices and annual runoff over the period from 1990 to 2015

The numbering of observation points	River	Equation type	Correlation coefficient	Conclusion
		Mineralization block		
1	Siverskyi Donets – Ohirtseve (upstream 0.3 km from the village)	$I_1 = -0.0428q + 0.708$	-0.681	The relationship is statistically significant
2	Siverskyi Donets - Izium (downstream 1.5 km from the town)	$I_1 = -0.141q + 1.19$	-0.565	The relationship is statistically significant
3	Siverskyi Donets - Lysychansk (downstream 4 km from the town)	$I_1 = -0.143q + 1.54$	-0.426	The relationship is statistically significant
4	Udy (downstream 9 km from the Kharkiv City)	$I_1 = -0.052q + 1.047$	-0.706	The relationship is statistically significant
5	Kryvyi Torets – Druzhkivka (within the town)	$I_1 = -0.124q + 2.48$	-0.684	The relationship is statistically significant
6	Kazennyi Torets –Sloviansk (downstream 3 km from the town)	$I_1 = -0.013q + 2.39$	-0.343	The relationship is statistically significant
7	Luhan – Kirovsk (downstream 1 km from the town)	$I_1 = -0.039q + 1.57$	-0.232	The relationship is statistically significant
8	Oskil – Chervonooskilska reservoir, lower canal pound)	$I_1 = -0.003q + 0.697$	- 0.062	The relationship is statistically insignificant
		Sanitary-toxicological block		
1	Siverskyi Donets – Ohirtseve (upstream 0.3 km from the village)	$I_2 = -0.272q + 2.68$	-0,663	The relationship is statistically significant
2	Siverskyi Donets - Izium (downstream 1.5 km from the town)	$I_2 = -0.043q + 6.12$	-0,592	The relationship is statistically significant
3	Siverskyi Donets - Lysychansk (downstream 4 km from the town)	$I_2 = -0.969q + 7.72$	-0,563	The relationship is statistically significant
4	Udy (downstream 9 km from the Kharkiv City)	$I_2 = -0.336q + 4.95$	-0,706	The relationship is statistically significant
5	Kryvyi Torets - Druzhkivka (within the town)	$I_2 = -0.697q + 14.0$	-0,662	The relationship is statistically significant
6	Kazennyi Torets –Sloviansk (downstream 3 km from the town)	$I_2 = 1.10q + 13.5$	0,175	The relationship is statistically insignificant
7	Luhan – Kirovsk (downstream 1 km from the town)	$I_2 = 0.127q + 16.5$	0,033	The relationship is statistically insignificant
8	Oskil – Chervonooskilska reservoir, lower canal pound)	$I_2 = 0.159q + 2.71$	0.255	The relationship is statistically insignificant
		Toxicological block		
1	Siverskyi Donets – Ohirtseve (upstream 0.3 km from the village)	$I_3 = 3.05q + 1.90$	0,526	The relationship is statistically significant
2	Siverskyi Donets - Izium (downstream 1.5 km from the town)	$I_3 = 0.239q + 0.415$	0,406	The relationship is statistically significant
3	Siverskyi Donets - Lysychansk (downstream 4 km from the town)	$I_3 = 12.2q + 0.591$	0,468	The relationship is statistically significant
4	Udy (downstream 9 km from the Kharkiv City)	$I_3 = 1.59q + 22.7$	0.325	The relationship is statistically significant
5	Kryvyi Torets - Druzhkivka (within the town)	$I_3 = 0.67q + 30.96$	0.080	The relationship is statistically insignificant
6	Kazennyi Torets –Sloviansk (downstream 3 km from the town)	$I_3 = 0.087q + 26.8$	0.007	The relationship is statistically insignificant
7	Luhan – Kirovsk (downstream 1 km from the town)	$I_3 = 2.30q + 5.44$	0,548	The relationship is statistically significant
8	Oskil – Chervonooskilska reservoir, lower canal pound)	$I_3 = 0.097q + 0.46$	0.153	The relationship is statistically insignificant

		Fishery block		
1	Siverskyi Donets – Ohirtseve (upstream 0.3 km from the village)	$I_4 = 11.1q - 15.4$	0.582	The relationship is statistically significant
2	Siverskyi Donets - Izium (downstream 1.5 km from the town)	$I_4 = 3.36q - 2.46$	0.597	The relationship is statistically significant
3	Siverskyi Donets - Lysychansk (downstream 4 km from the town)	$I_4 = 4.94q - 2.54$	0.472	The relationship is statistically significant
4	Udy (downstream 9 km from the Kharkiv City)	$I_4 = 1.93q - 2.31$	0.611	The relationship is statistically significant
5	Kryvyi Torets - Druzhkivka (within the town)	$I_4 = 1.24q + 0.291$	0.465	The relationship is statistically significant
6	Kazennyi Torets –Sloviansk (downstream 3 km from the town)	$I_4 = -0.158q + 4.32$	- 0.053	The relationship is statistically insignificant
7	Luhan – Kirovsk (downstream 1 km from the town)	$I_4 = 1.74q - 1.322$	0.686	The relationship is statistically significant
8	Oskil – Chervonooskilska reservoir, lower canal pound)	$I_4 = 0.52q - 3.185$	0.355	The relationship is statistically insignificant
		Ecological-sanitary block		
1	Siverskyi Donets – Ohirtseve (upstream 0.3 km from the village)	$I_5 = -0.028q + 0.776$	-0.368	The relationship is statistically significant
2	Siverskyi Donets - Izium (downstream 1.5 km from the town)	$I_5 = 0.0298q + 0.752$	0.234	The relationship is statistically significant
3	Siverskyi Donets - Lysychansk (downstream 4 km from the town)	$I_5 = 0.038q + 0.712$	0.101	The relationship is statistically insignificant
4	Udy (downstream 9 km from the Kharkiv City)	$I_5 = -0.001q + 0.903$	-0.014	The relationship is statistically insignificant
5	Kryvyi Torets - Druzhkivka (within the town)	$I_5 = 0.002q + 0.72$	0.070	The relationship is statistically insignificant
6	Kazennyi Torets –Sloviansk (downstream 3 km from the town)	$□_5 = 0.027□ + 0.681$	0.461	The relationship is statistically significant
7	Luhan – Kirovsk (downstream 1 km from the town)	$□_5 = 0.02□ + 0.723$	0.143	The relationship is statistically insignificant
8	Oskil – Chervonooskilska reservoir, lower canal pound)	$□_5 = 0.002□ + 0.661$	0.148	The relationship is statistically insignificant
		Generalized index of the water condition		
1	Siverskyi Donets – Ohirtseve (upstream 0.3 km from the village)	$□_□ = 2.76□ + 1.87$	0,591	The relationship is statistically significant
2	Siverskyi Donets - Izium (downstream 1.5 km from the town)	$□_□ = 1.53□ + 1.20$	0,488	The relationship is statistically significant
3	Siverskyi Donets - Lysychansk (downstream 4 km from the town)	$□_□ = 3.21□ + 1.61$	0,462	The relationship is statistically significant
4	Udy (downstream 9 km from the Kharkiv City)	$□_□ = 0.626□ + 5.46$	0.487	The relationship is statistically significant
5	Kryvyi Torets - Druzhkivka (within the town)	$□_□ = 0.218□ + 9.69$	0.115	The relationship is statistically insignificant
6	Kazennyi Torets –Sloviansk (downstream 3 km from the town)	$□_□ = -0.124□ + 9.29$	-0.135	The relationship is statistically insignificant
7	Luhan – Kirovsk (downstream 1 km from the town)	$□_□ = 0.776□ + 4.88$	0.609	The relationship is statistically significant
8	Oskil – Chervonooskilska reservoir, lower canal pound)	$□_□ = 0.155□ + 0.245$	0.419	The relationship is statistically insignificant

4. CONCLUSION

The findings of this study categorize the water quality of the rivers of the Siverskyi Donets Basin as "polluted" and "very polluted". The analysis of block indices of water quality (mineralization, sanitary-toxicological, toxicological, fishery, ecological-sanitary) showed that the substances of toxicological (ammonium, nitrites, SSAS, heavy metals) block and fishery block (petroleum products, phenols) are the most impacting on the water quality of the rivers of the Siverskyi Donets Catchment. They also show that the water content of the rivers of the Siverskyi Donets Basin is the most impacting on the mineralization of the water. The mineralization decreases as the water runoff increasing in the rivers. This fact is explained by the dilution effect of water. In part, this conclusion is also valid for sanitary-toxicological contamination. Consideration of other types of pollution also enabled to observe an increase of the quantitative indicators of pollution as the water content of rivers increase due to the significant role of spring flood in the formation of the chemical composition the rivers studied. At high maximum of the flood there is an intensive flushing of harmful substances from the surface of the catchments that leads to a degradation of the water quality happen. The overall index of the ecological condition of water $□_{□}$ increases as the water content also increases. The rivers with significant anthropogenic loading, and with the runoffs transformed by economic activity didn't exhibit statistically significant dependence of the overall index of quality on the water content of the rivers of Donbas (which include Kazennyi Torets, Kryvyi Torets), where mine and industrial water discharges occur, and of the Oskil River in the lower canal pound of the Chervonooskilske HPP.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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