ECOLOGY, BIOTECHNOLOGY, AGRICULTURE AND FORESTRY

IN THE 21ST CENTURY

PROBLEMS AND SOLUTIONS

EDITED BY
S.STANKEVYCH, O.MANDYCH

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Reviewers:
Mykola DOLYA, Ph.D., Prof., Head Department of Integrated Plant Protection and Quarantine of National University of Bioresources and Nature Management;
Oleksandr KUTS, Ph.D., leading of science collaboration, Director of the Institute of Vegetable Growing and melon growing of NAAS of Ukraine.

The monograph is a collection of the results of scientists' achievements obtained directly in real conditions. The authors are recognized specialists in their fields, as well as young scientists and graduate students of Ukraine. The studies are conceptually grouped in sections: biotechnology, ecology, agriculture, forestry, sustainable development of the economy and the principles of effective agribusiness. The monograph will be of interest to specialists in biotechnology, ecology, breeding, plant protection, agrochemistry, soil science, forestry, agribusiness, etc., researchers, teachers, graduate students and students of specialized specialties of higher educational institutions, as well as everyone who is interested in sustainable development in the agricultural sphere and Green Deal Implementation strategies.

Keywords: sustainable development, modern technologies, agricultural production, biotechnology, ecology, plant protection, forestry, agribusiness.

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ENVIRONMENTAL ASSESSMENT AND MODELING OF POLLUTION OF THE UDY RIVER WITHIN THE KHARKIV REGION

O. KOLIADA
Candidate of Agricultural Sciences, Associate Professor at the Department of Ecology and Biotechnology in Crop Production State Biotechnology University
L. GOLOVAN`
Candidate of Agricultural Sciences, Associate Professor, Head of the Department of Ecology and Biotechnology in Crop Production State Biotechnology University
Yu. CHUPRINA
PhD in ecology, Senior teacher at the Department of Ecology and Biotechnology in Crop Production State Biotechnology University

Environmental assessment and modeling of pollution of Uda River within Kharkiv region was carried out. According to the results of the assessment based on the water pollution index and the corresponding categories, the river was found to be polluted. Among the indicators of water quality, the situation with respect to the BOD_5 (biochemical oxygen demand) the content of ammonium nitrogen, nitrites, phosphates and oil products turned out to be the most critical. The value of the BOD_5 exceeded the established standards by 3.7–3.9 times, the content of ammonium nitrogen by 4.7–5.7 times, nitrites by 10.4–16.6 times, phosphates by 3.3–3.9 times, oil products – 6.6–8 times. The current situation requires the implementation of a set of operational measures to improve the quality of surface water of the river.

Key words: pollution, water, river, anthropogenic activity, ecological assessment.

Today, all over the world, and in Ukraine in particular, there are many problems in the field of protection, restoration and rational use of water resources. Constantly growing demand for water resources and uncontrolled use of water lead to the deterioration of the quality of the water environment, which in turn has a significant negative impact on people's health. Kharkiv region is one of the largest regions of Ukraine in terms of area and population. However, the water resources of the region are extremely limited, their share in the total water resources of Ukraine is only 1.8% on

average, decreasing to 0.99% in the dry season. An analysis of the ecological state of the rivers of the Kharkiv region shows that the limit of their water resources consumption has been reached and there is significant pollution. The problem of the lack of clean drinking water is becoming particularly acute in the context of global warming. Studies of climate change have confirmed the trend of increasing temperatures in the Kharkiv region, as well as decreasing the amount of precipitation, which naturally has an unequivocal effect on the functioning of aquatic ecosystems (Varavina P. & Koliada O., 2023).

The level of anthropogenic impact on the region's water resources is also increasing significantly in the context of Russian military aggression. Damage to water resources due to the war is manifested by their pollution and littering, as well as unauthorized use of water bodies. Today, the amount of total damage caused to water resources in the Kharkiv region amounts to UAH 72.000 million and is constantly growing (Ekolohichnyi pasport, 2023).

One of the most polluted rivers of the Kharkiv region is the Udy River. The total length of the river is 164 km, of which 127 km is within the Kharkiv region; the catchment area is 3.894 km^2 , of which 3.460 km^2 are in the Kharkiv region. The Udy River basin is part of the central economic region of the Kharkiv region, where processing and light industry, production of building materials, and machine-building complexes are widely developed (Rybalova O., Bryhada O. & Teslenko V., 2018).

The main source of pollution of the Uda River is the discharge of untreated sewage. A significant amount of chemicals enters the river with agricultural and municipal wastewater from the Dykanivsk treatment plants and the Bezludivsk treatment plants, as well as Rohansky and Eskhariv housing and communal services (HCS), sanatorium "Berminvody" and Kharkiv CHP-5. Up to 84.0% of the pollutants that shape the quality of the Siverskyi Donets River in transboundary sections are formed precisely in the Uda River basin. The impact of municipal and household water determines the growth of concentrations of nitrogen and phosphorus compounds (Biriukov O., 2020).

The impact of the discharge of untreated industrial and domestic wastewater largely determines the ecological state of rivers and is usually localized. At the same time, treatment plants do not provide an adequate level of oxidation of organic compounds and surface-active substances and nitrites in industrial and domestic waters. Adequate removal of phosphates is also not ensured. In order to improve the ecological situation, it is

necessary to implement wastewater treatment measures. In addition, pollutants come with surface runoff from pastures and agricultural lands, rural settlements without sewers, and from livestock farms (Zhyrnov P., 2014).

Also, the river is constantly subject to mechanical pollution due to littering by the population. Thus, in 2021, eco-activists managed to clean water from 108 tons of garbage during 15 weekly clean-ups, among which 400 kg of plastic, 2 tons of glass, and 5 tons of wood were found (Fig. 1).

Fig. 1. The littered bank of the Uda River

To reduce the level of pollution of water bodies, it is first of all necessary to monitor the ecological state of surface waters and carry out their ecological assessment.

The work determined the assessment of the level of water pollution of the Uda River according to the water pollution index (WPI), as well as in accordance with the "Methodology of ecological assessment of the quality of surface water by relevant categories" (Hrytsenko A. et al., 2012). The determination of the water pollution index was carried out according to the maximum concentration limit (MCL) established for reservoirs for fishing purposes (Table 1).

According to the value of the calculated WPI, the water in the Uda River upstream and downstream of the discharge of KP "Kharkivvodokanal" was characterized as polluted (WPI was 3.94 and 3.90 units, respectively). According to the "Methodology of ecological assessment of the quality of surface water according to the relevant categories", the water quality in the studied river in both objects was characterized as mediocre in terms of condition and moderately polluted in terms of the degree of pollution – III class, 5 (6) category.

The situation in relation to the BOD_5 indicator is very critical. This indicator is a general assessment of the organic pollution degree of a water object – the higher the BOD_5, the more polluted the water body is with organic substances. With an increase in the content of organic substances in water, aerobic bacteria, which require a large amount of oxygen for their vital activity, multiply rapidly. At the same time, the content of dissolved oxygen in the water decreases, which leads to hypoxia, which can ultimately lead to the death of certain types of aquatic organisms. The indicator of BOD_5 in both creations exceeded the normative indicator by 3.7-3.9 times. Having modeled the process of self-purification of water, taking into account the hydrological parameters of the river, it can be seen that the pollution of the river by organic substances is characteristic throughout the direction of the flow, even at a distance of more than 50 km from the wastewater discharge of KP "Kharkivvodokanal", the value of the BOD_5 indicator significantly exceeds the normative indicator of 3.0 mg/l (Fig. 2).

The high value of the chemical oxygen demand (COD) indicator is also characteristic – 2.1–2.2 times higher than the MCL, indicating water pollution by oxidized substances.

Significant exceedances of the established standards were also noted for the content of ammonium nitrogen and nitrites. Elevated concentrations of ammonium ions and nitrites indicate recent pollution of the reservoir. The actual content of ammonium nitrogen in the formation below the discharge of KP "Kharkivvodokanal" exceeded the MCL by 4.7 times (Fig. 3).

Table 1

Assessment of pollution of the Uda River (according to the data of the Kharkiv Regional Center for Hydrometeorology, 2022)

Indicator values, mg/l	Actual content, mg/l		MCL	Category	
	upstream of the discharge of KP "Kharkiv vodokanal"	downstream of the discharge KP "Kharkiv vodokanal"		upstream of the discharge of KP "Kharkivvodokanal"	downstream of the discharge KP "Kharkivvodokanal"
Suspended substances	15,3	14,5	20,0	II (3)	II (3)
BOD_5 (biochemical oxygen demand)	11,7	11,1	3,0	IV (6)	IV (6)
Mineralization	709	707	–	II (2)	II (2)
Sulfates	200	191	100	III (5)	III (5)
Chlorides	110	113	300	III (4)	III (4)
Ammonium nitrogen	2,86	2,33	0,5	V (7)	IV (6)
Nitrates	10,6	23,3	40	V (7)	V (7)
Oil products	0,4	0,33	0,05	V (7)	V (7)
COD (chemical oxygen demand)	44,0	41,0	20	–	–
Dissolved oxygen	5,81	5,73	6,0	III (5)	III (5)
Phosphates	2,74	2,33	0,7	V (7)	V (7)
Zinc	0,024	0,021	0,01	III (4)	III (4)
Iron	0,21	0,18	0,05	III (4)	III (4)
Nitrites	0,83	1,33	0,08	V (7)	V (7)
Copper	0,01	0,007	0,001	III (4)	III (4)
WPI /Ie	3,94	3,90	–	5,14	5,07
Pollution class (category)	IV	IV	–	III (5)	III (5)
Characteristics of pollution	Contami-nated water	Contam-inated water	–	"Average", "moderately polluted" waters	"Average", "moderately polluted" waters

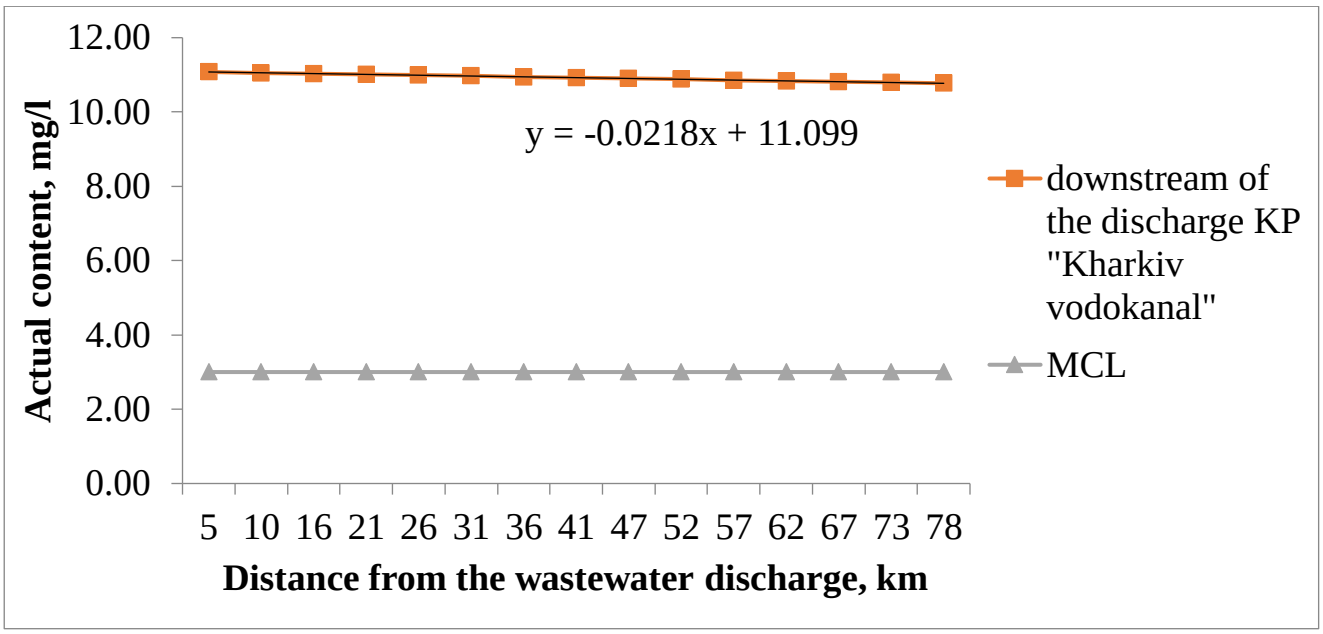

Fig. 2. Modeling of the dynamics of the BOD_5 in the Udy River depending on the distance from the wastewater discharge

The main sources of ammonium ions in reservoirs are surface runoff from livestock farms and domestic sewage, from agricultural land when ammonium fertilizers are used, as well as waste from the food, coke-chemical, woodworking, and chemical industries. A high content of ammonium nitrogen leads to poisoning of hydrobionts, because free ammonia is a strong poison for them. Poisoning occurs as a result of the fish's inability to get rid of excess ammonium accumulated during nitrogen metabolism.

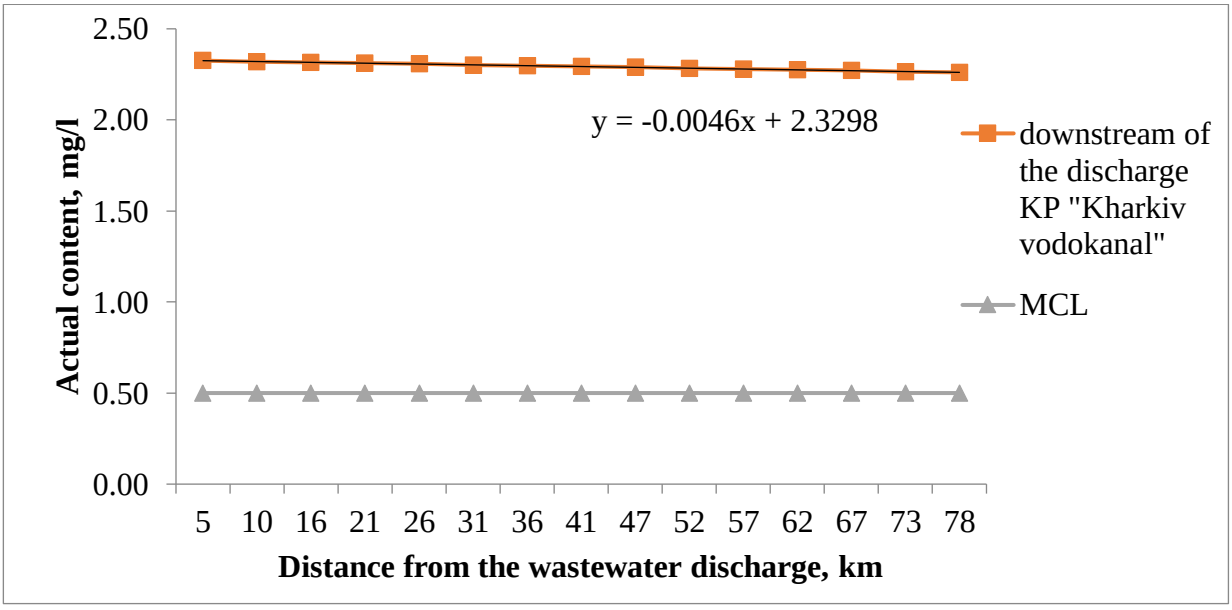

Fig. 3. Modeling of the dynamics of ammonium nitrogen content in the Udy River depending on the distance from the wastewater discharge

The analysis of the nitrite content in the Uda River shows an excess of the indicator in the the sections upstream and downstream of the discharge of KP "Kharkivvodokanal" by 10.4 and 16.6 times, respectively (Fig. 4). The increased content of nitrites indicates a very intensive decomposition of organic substances that came with the wastewater. The presence of significant organic pollution of the river water is also confirmed by the high value of BOD_5. Nitrites are non-conservative compounds and are quickly oxidized to nitrates by oxygen dissolved in water. The presence of high concentrations of nitrites in water indicates fecal contamination of water, its potential toxicity and carcinogenicity, because nitrites are easily transformed into nitrosoamines, which are carcinogenic compounds.

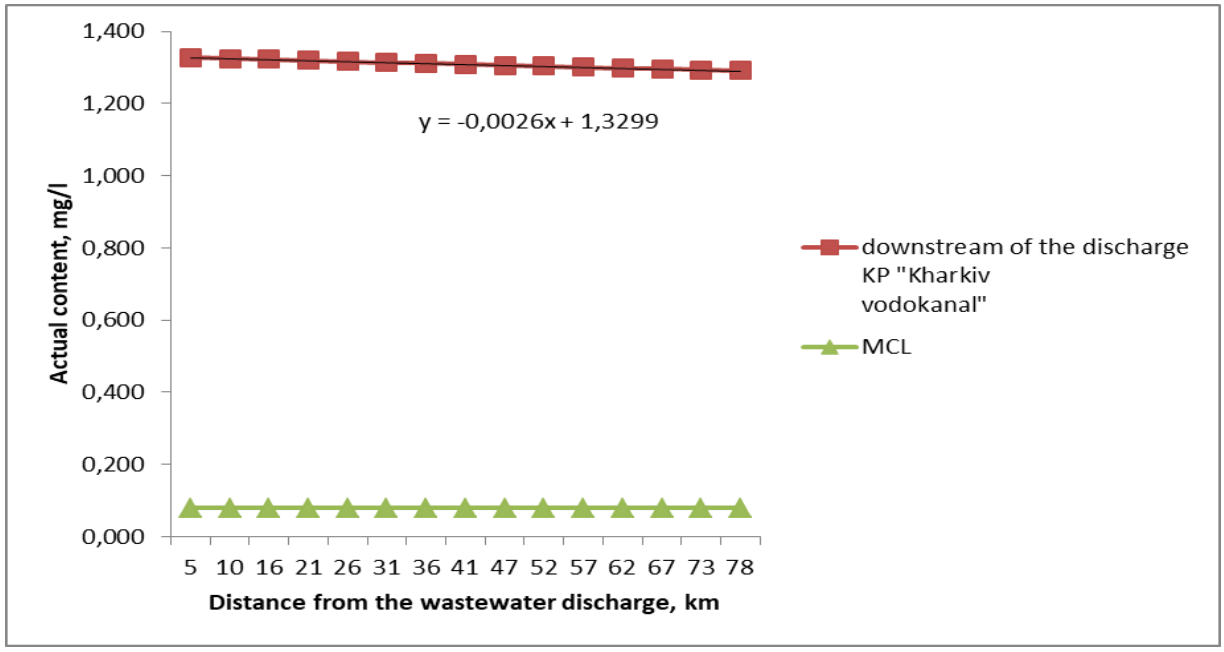

Fig. 4. Modeling of the dynamics of nitrite content in the Udy River depending on the distance from the wastewater discharge

The Uda River is also characterized by phosphate pollution. The actual concentration of the pollutant exceeds the MCL by 3.3–3.9 times, depending on the site (Fig. 5). Excessive pollution of water objects with phosphorus compounds leads to eutrophication. The consequence of the eutrophication process is a significant decrease in the oxygen content and deterioration of the living conditions of hydrobionts.

Pollution of water objects with oil products is very dangerous and toxic for all hydrobionts. Some of the petroleum products are carcinogenic. The film formed on the surface of the water interferes with heat, water and gas exchange processes between the reservoir and the atmosphere, and this is especially dangerous, as the most important biological processes take

place in the surface film of the reservoir. The actual value of the content of oil products in the Udy River exceeds the MCL for fishery reservoirs 6.8–8.0 times (Fig. 6).

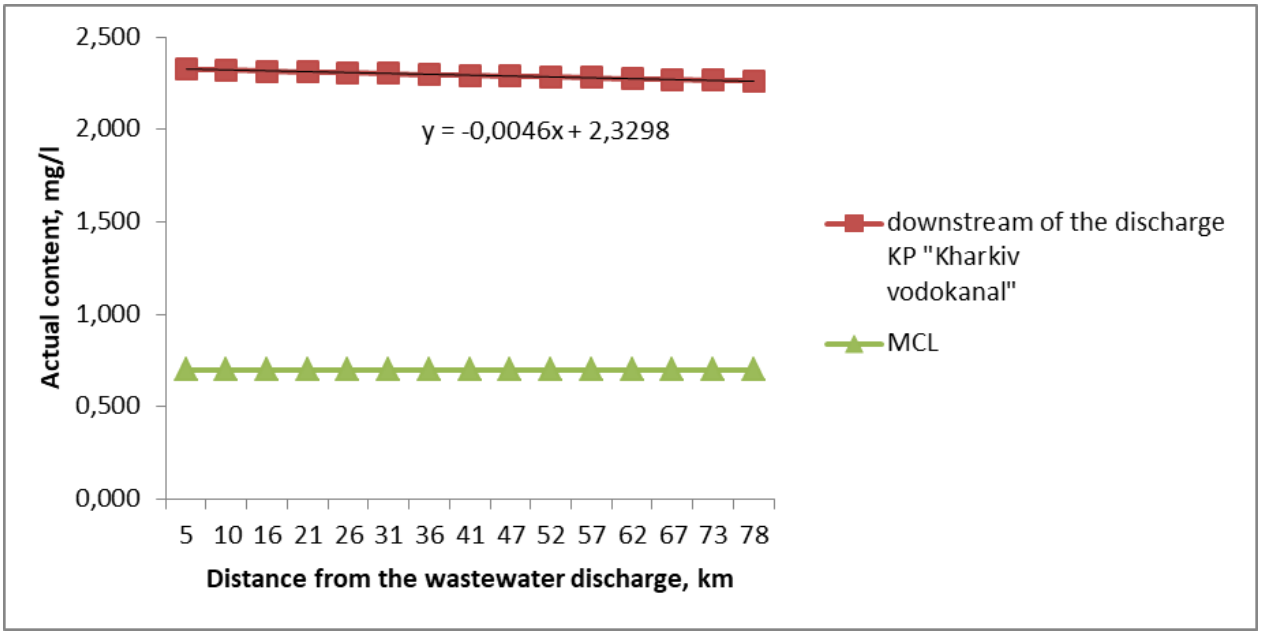

Fig. 5. Simulation of the dynamics of phosphate content in the Udy River depending on the distance from the wastewater discharge

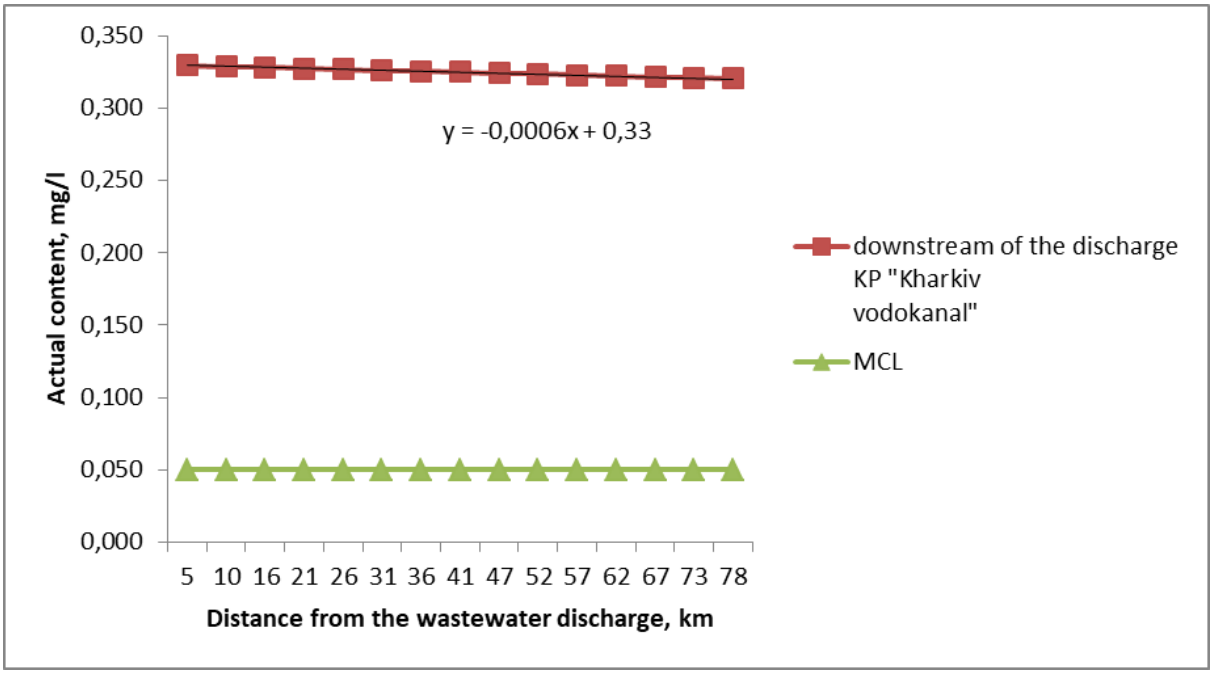

Fig. 6. Modeling of the dynamics of the content of oil products in the Udy River depending on the distance from the wastewater discharge

Thus, the Udy River, like many other rivers in Ukraine, is exposed to various anthropogenic influences, such as discharges of untreated or insufficiently treated wastewater from enterprises, agricultural activities, military aggression of the Russian Federation, and population pollution.

After conducting an analysis of the quality of surface waters of the Uda River according to the water pollution index and according to the relevant categories, it was established that the river is polluted. Among the indicators of water quality, the situation in relation to the BOD_5, the content of ammonium nitrogen, nitrites, phosphates and oil products turned out to be the most critical.

High indicators of BOD_5, ammonium nitrogen and nitrite content are evidence of recent significant pollution of the river and the passage of intensive processes of decomposition of organic matter in the reservoir. This, in turn, leads to a decrease in the oxygen content in the reservoir and intensive development of eutrophication. Water pollution can have a serious impact on the ecosystem and public health.

Significant pollution of the Uda River requires the implementation of a set of operational measures to improve surface water quality. Among such measures, it is necessary to: improve the regional river monitoring system; improvement of the hydrological regime of the river; controlling unauthorized discharges of pollutants into the river; promoting the reduction of pollution of the river by return waters; increasing the efficiency of sewage treatment discharged into the river; raising the environmental awareness of the population and developing environmental education.

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