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Integrated Environmental Monitoring of Osetr River

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***Abstract*—The article summarizes the results of a comprehensive environmental assessment of the Sturgeon river basin in 2018 based on the results of engineering and environmental surveys obtained in the framework of environmental monitoring from June 20 to July 29, 2018 on the rivers Oka and Osetr in the Zaraysky, Lukhovitsky and Kolomensky districts. The influence of anthropogenic factors on the ecological state of the Sturgeon river basin is considered. The current state of the dam on the Sturgeon river in Zaraisky district is assessed, the forecast of possible changes in the environment under the influence of anthropogenic load is presented in order to prevent, minimize or eliminate harmful and undesirable environmental and related social, economic and other consequences and preserve optimal living conditions of the population.**

Keywords—ecological state; anthropogenic loads; environmental safety; engineering and environmental surveys; water pollution

I. INTRODUCTION

Anthropogenic pressure on water resources, especially in Moscow and Moscow region, has reached a significant level in this period. The critical situation arises during the low-water period, when rivers are fed by groundwater, and their flow becomes minimal. With the formation of runoff, the hydrological and hydrochemical parameters of water change dramatically – wastewater discharges from settlements and industrial production cause great damage to the ecology of the river, and the ability for self-purification of natural waters decreases.

Any river, especially a small one, being as close as possible to consumers, reflects the ecological state of the environment. The quality of water in rivers depends directly on the state of their catchment basins.

This leads to the need for integrated environmental monitoring, which will help to track not only the change in water quality in small rivers, but also to determine their impact on larger water bodies and to create a picture of the anthropogenic impact as a whole.

II. MATERIALS AND METHODS

In accordance with the plan of measures on carrying out of ecological monitoring of small rivers from June 20 to July 29, 2018, we carried out sampling of water at 25 points on the rivers Oka and Osetr in the Zaraysky, Lukhovitsky and Kolomensky districts (Table I).

To assess the quality of surface water, hydrochemical studies have been carried out, including the determination of such values as pH, water temperature, dissolved oxygen (O_2), electrical conductivity, degree of mineralization, etc.

Sampling and laboratory analysis of 17 components was carried out in conjunction with the analytical laboratory of the SBEI "MOSEKOMONITORING" (accreditation Certificate No. ROSS RU.0001.518962; the accreditation Certificate No.ROSS RU.0001.410111) according to GOST 31861-2012. "Water. General requirements for sampling" using appropriate techniques and instruments (Table 2) [1, 2].

The results of the analysis of the created thematic maps of the spatial-temporal distribution of hydro-chemical variables (oxygen, mineralization, pH, temperature, etc.).

TABLE I. VALVES FOR WATER QUALITY MONITORING

Name of water body	No. alignments	Location		Binding alignments
Osetr river	1	54.7575589	38.8623253	sett. Zaraysk
	2	54.795014	38.87178	sett. Markino
	3	54.819833	38.821461	sett. Radushino
	4-17	54.8864833731204 54.8873970005661 54.8884680401534 54.8891749698669 54.8895130120218 54.889302039519 54.8891290370375 54.8890342 54.8888759873807 54.8884879890829 54.8877590149641 54.88757665254677 54.8887230176479 54.8923389706761	38.8032832928002 38.8032950274646 38.8030750025064 38.8018779829144 38.8001109939069 38.7983310129493 38.7966790236533 38.7958123 38.7950650043786 38.7936359737068 38.7900810409337 38.786437603149054 38.780318973586 38.7654890399426	sett. Spas-Doschaty
	18-20	54.899225961417 54.9030719976872 54.9001059774309	38.7563540227711 38.766534011811 38.780557019636	sett.Bebehovo
	21-24	54.9020919855684 54.9042799975723 54.905619006604 54.906827	38.7975649908185 38.8039590418339 38.8035189919174 38.803175	sett. Vlasyevo
Oka river	25	54.987424	38.758114	sett.Akatyevo

III RESULTS AND DISCUSSION

Mineralization of the Sturgeon river does not exceed the maximum permissible concentrations for water fishery (at a rate of up to 1000 mg/l). The water of the Osetr river belongs to the classification of Alekin O. A. This is the type of bicarbonate-calcium waters with medium mineralization 200-500 mg/l [3]. In accordance with the order of the Ministry of agriculture of 13.12.2016 No. 552 “Maximum permissible concentrations (MPC) of chemicals in water of water bodies of fishery value”, SanPiN 2.1.5.980-00 “Hygienic requirements for the protection of surface water” and GN 2.1.5.1315-03 "Maximum permissible concentrations (MPC) of chemicals in water bodies of domestic drinking and cultural water use", the content of dissolved oxygen in the summer should not fall below 6 mg/l and 4 mg/l, respectively [4-6].

Analysis of the results showed that throughout the Sturgeon river from the settlement (Next – sett. Zaraysk) to the confluence of the Oka river there were no exceedances of the established standards. The concentration of dissolved oxygen in the stocks ranged from 7.3 to 10.1 mg/l, sometimes up to 11.5 and 18 mg/l at a rate of not less than 6 mg/l for fishery-type water bodies in the summer (Fig. 1).

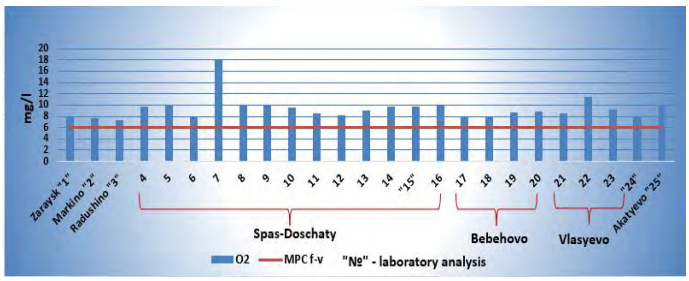

Fig.1. Oxygen content of O2 (mg / l) in the sturgeon and Oka rivers in the third quarter of 2018

TABLE II. STUDIED INDICATORS, METHODS AND DEVICES USED IN THE ANALYSIS

Value	Normative documentation on the method of quantitative chemical analysis	Means of measurement
O_2, mg/l	Instruction to the device OAIM-1-01 L	oxygen analyzer industrial multifunctional OAIM-1-01 L (inv. No.10104000729)
T, ºC	RD 52.24.496-2005 Temperature, transparency and smell of the surface waters of the land. Measurement procedure	liquid-in-glass thermometer accurate PL 27574 (inv. No.10134000457)
Transparency, cm		a sample of the font (any text printed in letters with a height of 3.5 mm and line width 0.35 mm).
pH	Federal environmental normative document (Next – END F) END F14.1:2:3:4.121-97	combined SevenEasy pH meter (inv. No.10104000727)
Suspended solids, mg/l	END F 14.1:2.110-97 Methods of measurement of suspended solids and total impurities in natural and treated wastewater samples	laboratory scales XS204 (inv. No.10104000527)
COD, mgO/l	END F 14.1:2:4.210-05 Quantitative chemical analysis of water. Method of measurement of chemical oxygen consumption (COD) in samples of drinking, natural and waste water by photometric method	COD REACTOR 45600-02 Hach spectrophotometer DR 2800 (inv. No.10104000720)
BOD_5, mgO_2/l	END F 14.1:2:3:4.123-97 Quantitative chemical analysis of water. Method of measurement of biochemical oxygen demand after n-days of incubation (BOD complete) in surface fresh, underground (ground), drinking, wastewater and treated wastewater	oxygen analyzer industrial multifunctional OAIM-1-01 L (inv. No.10104000729)
Ammonium-ion, mg/l	END F 14.1:2:4.262-10 Quantitative chemical analysis of water. Method of measurement of mass concentration of ammonium ions in drinking, surface (including marine) and wastewater by photometric method with Nessler reagent	spectrophotometer DR 2800 (inv. No.10104000720)
Nitrite-ion, mg/l	END F 14.1:2:4.3-95	

	Quantitative chemical analysis of water. Method of measurement of mass concentration of nitrite ions in drinking, surface and waste water by photometric method with Griess reagent	Shimadzu UV-1800 spectrophotometers (inv. No. No. 10124000242, 10124000243)
Nitrate ion, mg/l	END F 14.1:2:4.4-95 Quantitative chemical analysis of water. Method of measurement of mass concentration of nitrate ions in drinking, surface and waste water by photometric method with salicylic acid	
Sulfate ion, mg/l	END F 14.1:2.159-2000 Quantitative chemical analysis of water. Method of measurement of mass concentration of sulfate ions in samples of natural and waste water by turbidimetric method	
Chloride ion, mg/l	END F 14.1:2.96-97 Quantitative chemical analysis of water. Method of measurement of mass concentration of chlorides in samples of natural and treated wastewater	automatic titrator for determination chloride ions Mettler Toledo T50 (inv. No.10104000723)
Petroleum, mg/l	END F 14.1:2:4.128-98 Quantitative chemical analysis of water. Method of measurement of mass concentration of oil products in samples of natural, drinking, waste water by fluorimetric method on the fluid analyzer " Fluorat-02"	analyzers liquid Fluorat - 02-3M (inv. No. No. 10104000776, 10104000778)
Overall stiffness, ^{0}Ж	END F 14.1:2.98-97 Quantitative chemical analysis of water. Method of measurement of hardness in samples of natural and treated wastewater	T50 automatic titrator (inv. No.10104000723)
Iron, mg/l Manganese, mg/l Copper, mg/l	END F 14.1:2:4.135-98 Quantitative chemical analysis of water. Method of measurement of mass concentration of elements in samples of drinking, natural, sewage and atmospheric precipitation by atomic emission spectrometry with inductively coupled plasma	emission spectrometer with inductively coupled plasma Varian 720-ES(inv. No. 10104000529).

According to the content of dissolved oxygen, the water of the Osetr river belongs to the class “very clean” (table III). During the summer low water in June-July 2017, the concentration of dissolved oxygen dropped to 2 mg/l.

TABLE III THE CONTENT OF DISSOLVED OXYGEN

	summer, mg / l	winter, mg / l^3	degree of saturation,%
Very clean, class I	9	14-13	95
Pure, class II	8-7	12-11	80
Moderately polluted, class III	7-6	10-9	70
Contaminated, class IV	5-4	5-4	60
Dirty, V	3-2	3-1	30
Very dirty, VI	0	0	0

In accordance with the requirements for the composition and properties of water for recreational, cultural, domestic and fisheries use, there is a pH value that should not exceed 6.5-8.5.

- All along the river from the sett. Zaraysk to the confluence of the Oka (49.2 km) and from the estuary to the sett. of Akatyevo (2.09 km), the pH ranged from 7.3 to 8.5;
- Values of pH outside the prescribed standards recorded at 7 points: No.5, 6, 11, 13 (sett. Spas-Doschatyi); No. 19-20 (sett.Bebehovo); No. 21 (sett. Vlasyevo) (Fig.2).

The Osetr river belongs to the group of small rivers and is one of the largest southern tributaries of the Oka. On the river there are settlements and cities that have a negative impact on the environment, and especially on the hydro-ecological state of the water, which further affects the quality of life and health of residents.

For comparison of the qualitative composition of water of the rivers Oka and Osetr and the effect of anthropogenic factors on their status, selected additional sample in the sett. Akatyevo located upstream of the Oka river.

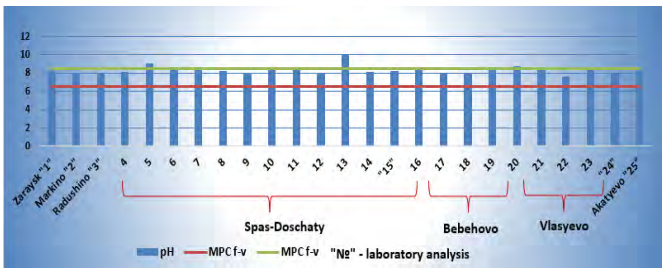

Fig. 2. pH content in the river sections of Sturgeon and Oka in the third quarter of 2018.

The results of laboratory analysis detected exceeded a number of indicators: suspended solids (2.6 MPC f-v), BOD5 (3.14 MPC f-v), nitrite ions (12.5 MPC f-v), manganese (2.4 MPC f-v), copper (5 MPC f-v).

The content of other studied parameters does not exceed the MAC value. The main sources of pollution of the river include: industrial enterprises, municipal services, agricultural lands of the Moscow, Tula and Ryazan regions, the effluents of which are insufficiently treated and contain a large range of pollutants.

In addition, in places of water protection zones, ravines and gullies, industrial enterprises dump garbage and household waste. Also, on agricultural lands there is irrational use and improper storage of manure and fertilizers, when flushing of which, pesticides, getting into the water of the Osetr river make it unfit for drinking and recreation [7-9].

In addition, highways crossing many settlements located near the coastline of the Osetr river are a source of pollution. The products of fuel combustion in places close to the rivers fall into the water with melt water and road dust.

All these anthropogenic factors, acting simultaneously with natural factors (temperature, precipitation), destroy the ecosystem of the Osetr river.

Anthropogenic pressures (for example, Zaraysk and the adjacent industrial zone) have a strong impact on the ecological state of the Osetr river basin. This is the influence of chemical, food, metallurgical industry and the influence of hydraulic structures (Next-HS).

Upstream in the city of Zaraysk is a dam, which was put into operation in 1966 on the site of the old wooden ridge dam and serves to create a backup in the upper part at the level of the LRL (lower retaining level) of 113, 50 m in order to create recreational areas in Zaraysk district. During many years of operation, surface and underwater structures of the dam were worn by 70% or more. The condition of the dam has a significant impact on the environment with subsequent positive or negative effects. The result is a change in the hydrological regime of the Osetr river and the formation of conditions for the qualitative composition of water [9, 10].

Thus, the section of the river from the sett. Zaraysk to the sett. Akatyevo exceeded by the following components: suspended solids, BOD5, nitrite ion, manganese and copper, which indicates anthropogenic contamination of surface water of the study area.

Let us note that in groundwater according to the data obtained from the administration of Zaraisky district and LLC "Ryazanproekt", the content of heavy metals, petroleum products does not exceed the MPC established by GN 2.1.5.1315-03 [9, 10].

The results of hydroecological studies of the water of the Osetr river indicate its satisfactory condition.

A. WPI, SCWPI

On the basis of the obtained data and the method of complex assessment of the degree of surface water pollution by hydrochemical parameters, calculations of the water pollution index (WPI) and the specific combinatorial water pollution index (SCWPI) were made.

The method of calculation of complex indicators allows one to estimate the chemical composition of water, to summarize the information of the analytical process, and to transform the relative indicators that comprehensively assess the degree and quality of pollution of water bodies. The integrated assessment of surface water pollution uses the results of their monitoring. In accordance with the conditions and details of the monitoring system, a combination of differentiated and integrated assessment methods is used to establish and determine the breadth of water pollution spectrum and the degree of water pollution.

The basis of the complex method - assessment of water pollution on the spectrum of pollutants:

- for any body of water at the water sampling point;
- for any time period;
- on set of hydrochemical parameters

The water quality of water bodies depends not only on individual indicators of the chemical composition of water, but also on the duration of exposure to each of these characteristics, the list and the amount of pollutants included in the overall assessment. Taking into account the state of the additive effects of toxic substances in their simultaneous presence, the final integrated water quality indicator is determined by the addition of separate indicators to assess the contribution of each pollutant in itself.

The basis of the differentiated method is the assessment of water quality of water bodies for individual pollutants using statistical methods.

B. The system of formal indicators of comprehensive evaluation

In accordance with the instructions, a set of formalized characteristics is calculated for two groups of indicators – basic and intermediate. Most of the indicators are intermediate and well-known and are used to calculate key indicators (multiplicity of exceedance of MPC; multiplicity of exceedance of concentrations corresponding to high pollution; repeatability of exceedance of MPC; the total number of ingredients taken into account in the assessment of water quality, etc.) and safety factor. Main indicators, namely: private estimated points on the number and frequency of cases exceeding MPC, generalized evaluation points; the coefficients of the complexity of water pollution; classes of water quality, etc. designed for the comprehensive assessment of water pollution. Water quality assessment can be carried out using the whole set of parameters and individual groups or single characteristics.

In addition to numerical values, appropriate verbal characteristics are also used. Using this method, the most informative complex estimates are obtained [11]:

• specific combinatorial index of pollution;

* water quality class.

SCWPI conditional estimates in the form of a dimensionless number the percentage of polluting effect, made to the General degree of contamination of the water due to the simultaneous presence of several pollutants, on average, one must taken into account in the calculation the combinatorial index of ingredients and indicators of water quality.

This complex indicator, in contrast to WPI, does not limit the number of ingredients, in addition to determining the multiplicity of MPC, determines the repeatability of exceeding the values, allows comparing the degree of water pollution in different ranges in the presence of different observation programs.

The specific combinatorial index of water pollution can vary in waters of varying degrees of pollution from 1 to 16. The higher value of the index corresponds to the worst water quality in different areas, points, points, etc.

Taking into account the fact that recently, with the expansion of the monitoring program, there is a high level of microbiological contamination of the Osetr river, the inclusion of indicators of WPI and SCWPI can be considered appropriate.

TABLE IV CLASSIFICATION OF WATER QUALITY DEPENDING ON THE POLLUTION INDEX VALUE [12]

Water Values	WPI	Water Quality Classes
Very clean	Up to 0.2	1
Pure	0.2-1.0	2
Moderately polluted	1.0-2.0	3
Contaminated	2.0-4.0	4
Dirty	4.0-6.0	5
Very dirty	6.0-10.0	6
Extremely dirty>	> 10.0	7

According to the water pollution index (WPI), the water of the Osetr river is estimated as "moderately polluted" (WPI =1.0-2.5) from the sett. Zaraysk to the confluence of the Oka (49.2 km) and is replaced by "dirty" (WPI =4.0-6.0) to the sett. Akatyevo (2.09 km) (see table. 4) [12].

SCWPI and class of water quality are defined in accordance with RD 52.24.643-2001 "guidance document. Methodical instructions. Method of complex estimation of pollution level of surface waters according to hydrochemical indicators" (Next RD - 52.24.643-2001) [11].

The calculations were carried out using a simpler method of determining water quality classes – by the value of SCWPI and the number of CIP (a critical indicator of water pollution). A free list of ingredients and water quality indicators was used as a basis for the calculation of integrated assessments No. 3 (Annex B) [11].

According to the Annex" K " RD 52.24.643-2001, in the column corresponding to the value of the bullpen-in our case 4 and 5, we find the gradation of values SCWPI.

Excess of MPC in the ranges was observed for 4-5 ingredients of the chemical composition of water from 12 determined parameters. The value of the coefficient of complexity of water pollution was in the range from 33.3 to 41.7 %, on average – 38.9 %, which indicates, according to Annex D, the "high level of pollution" of water of the Osetr river in June-July 2018.

For all pollutants typical of sustained pollution this is confirmed by the highest values of particular evaluation points according to the frequency of "Sa=4.0" (Annex G) [11].

Classification of water by frequency of pollution, water pollution by all considered indicators is defined as "sustainable" and the level of water pollution by these ingredients is different (according to Annex E).

According to the biochemical oxygen consumption (alignments No.1, 3, 24), nitrite ions (alignments No.1, 2, 3, 24), manganese (alignments No.1, 24) and suspended solids (alignments No.2, 3, 15), there is a "low level of contamination" of water. The private scores for these ingredients do not exceed 2.

According to BOD5 (alignments No.15, 25), content: nitrite ions (alignment No.15), manganese (alignments No. 2, 3, 15, 25), copper (alignments No.1-25) suspended solids (alignment No.24) – "average level of contamination". Private score does not exceed 3.

Nitrite ions are characterized by a "high level of contamination". In alignment number 6 private evaluation score-12.5.

Less contaminated alignments No. 1, 2 (sett. Zaraysk, sett. Markino) and No. 15 (sett. Spas-Doschatyi) SCWPI are 3.95; 4.26; 3.93; and the water quality belongs to class 4 and category "b", i.e. it is "dirty".

In alignments No.3 (sett. Radushino) and No. 25 (sett. Akatyevo – Oka river) water is a very "dirty" (4th class, a category "c").

The worst quality is observed for alignments, linked to the sett. Vlasyevo. (No. 24) – the water is "very dirty" (4th class, a category "d"), and SCWPI is 5.4.

IV CONCLUSION

Thus, the degree of water pollution of the Osetr river in the selected areas is characterized as "high" due to the violation of existing standards for 5 ingredients.

According to the water pollution index (WPI), water is estimated as "moderately polluted" (WPI =1.0-2.5) before falling into the Oka and is replaced by "dirty" (WPI =4.0-6.0) (Table IV).

The environmental situation is aggravated by the discharge of insufficiently treated wastewater into open water bodies, which occurs as a result of not quite effective work of sewage treatment facilities.

Floodplains of the rivers receive a big loss as a result of plowing of lands under gardens and kitchen gardens. As mentioned earlier, large accumulations of waste are generated in ravines and on the banks of the river, from which contaminated water flows during the rain. River beds are also littered-the resulting landfills can start the process of accumulation of sediments and pollutants, which will lead to overgrowing of the channel and eutrophication of the reservoir.

Subject to the implementation of measures, limiting the flow of new pollutants during the construction and operation of facilities on the river, wastewater discharge, etc., the identified concentrations will not cause damage to human health and the environment.

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