Article

Geoecological Assessment of Anthropogenic Impacts on the Osetr River Basin

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Abstract: This paper presents the results of a geoecological assessment of the human-induced impact on the geosystem components of the Osetr river basin in the Moscow region. To assess the surface water quality of this river basin, hydrochemical surveys were conducted which included the determination of parameters such as the pH index, water temperature, the amount of dissolved oxygen (O2), electrical conductivity, salt content, COD (chemical oxygen demand), BOD5 (biochemical oxygen demand for 5 days), etc. Within the framework of ecological monitoring, a reconnaissance survey of the dam in Zaraysk was conducted, during which the basic ecological indicators were determined. The assessment was performed to assess the radiation, chemical, sanitary, epidemiological, and physical-ecological risk factors. The work resulted in geoecological zoning of the middle part of the Osetr river basin based on water pollution levels (WPI—water pollution index, SCWPI—specific combinatorial water pollution index), the amount of human-induced impact, and the human-induced load (point-rating method), using definitions of five categories of river channel sections with human-induced load and ecosystem conditions.

Keywords: rivers and their basins; geochemical migration; watershed ecology; anthropogenic loads; environmental safety

1. Introduction

Ecological assessment of various water sources today is extremely relevant due to increased pressure on all environmental systems. Water sources are one of the most susceptible objects to this pressure. Water ecosystems are currently under increased threat from rising human populations, accompanied by increased agricultural and industrial growth.

Today, few of the world’s water bodies are valuable as healthy ecosystems and many fail to meet sanitary requirements. Therefore, the systematical monitoring of the ecological quality of water sources is very important and needs to utilize a variety of assessment and evaluation methods [1,2].

Considering the fact that most cities are located on the banks of rivers, people’s perceptions of surface waters is not very conducive to their long-term preservation, as they forget that there are very few rivers left, particularly with water that is suitable for safe human consumption. Among water control practices, there is a special focus on the problem of protecting small rivers, which are not capable of overcoming the powerful burden of human-induced loads due to their smaller capacities.

Small rivers, due to their maximum proximity to consumers, reflect the ecological conditions of their local environments. Water quality in rivers is directly dependent on their basin’s conditions. At the contemporary stage of industrial production development, methods for assessing the status of the human environment components have begun to solve complex fundamental problems, in the context
of which the problem of improving quality of life is of utmost importance. This prompts the need for comprehensive ecological monitoring and geoecological assessments that will make it possible to track not only any change in water quality in small rivers but also to determine their effect on larger water bodies and to develop a pattern of human-induced impact in general (Meybeck M. et al., 1992; Selezneva A. V., 2003; Erba S. et al., 2009; Lord M. L. et al., 2009; Logunov O. Yu., 2012; Yazikov E. G., 2013; Konstantinova T. et al., 2013; Reshetnyak O. S. et al., 2017; Wang X. et al., 2018; and others) [3–9].

Pursuant to the action plan for ecological monitoring of small rivers, during the period of 20 June–29 July 2018, a water sampling was performed at 25 locations of the Osetr and Oka rivers in the Zaraysk, Lukhovitsy and Kolomna districts [10].

In cooperation with the Mosecomonitoring research laboratory and in line with GOST 31861-2012 “Water. General sampling requirements”, the sampling and laboratory analysis was performed with 17 components using appropriate techniques and instruments [11].

The spread of long-term patterns of non-adaptive use of water resources and exceeding of the limits of environmentally acceptable human-induced impacts have resulted in the deterioration of the Osetr river’s ecological conditions in recent years, as well as a reduction of its natural and economic functions. These reduced functions include a reduction of water supply and capacity; reduction of water discharges during floods and, as a result, an increase of flooded areas; intensified erosion processes; growth of continuous runoff; a decrease in water quality and related forms of quality; an increase in material damages; degradation of agricultural land and natural ecosystems; a reduction in biodiversity; etc. These lead to the conclusion that the current conditions of the Osetr river and its water collection, at present, do not fully comply with regulatory requirements [1,11,12].

During the reported period, a comprehensive study was conducted of the geoecological conditions of the environmental components of the Osetr river basin in the Moscow region. As part of this study, a geoecological assessment was presented of the human-induced impacts on the Osetr river basin in the Zaraysk, Lukhovitsy, and Kolomna districts, while maps and charts were compiled reflecting changes in the qualitative water content and to components of the Osetr river basin geosystems.

In light of the urgency of the environmental problems affecting the river, the intended goals of this study were to provide a comprehensive geoecological assessment of the human-induced load while studying the contemporary ecological conditions of the studied area, to identify major environmental impact factors, to assess the area’s pollution levels, and to perform zoning of the studied area in terms of the human-induced load levels, including areas with critical, high, moderate, medium, and low levels of anthropogenic load.

2. Materials and Methods

The Osetr river—one of the largest southern tributaries of the Oka river—flows in the Moscow, Ryazan, and Tula regions of Russia. Its length is 237 km. Its source is to the west of the Melekhovka inhabited area of the Tula region, and in the beginning, it flows from west to east. Near the Serkovo inhabited area, the river turns north at a right angle, without changing direction up to the mouth. Throughout its entire length, the river is significantly meandrous. The width of the its channel near the town of Serebryanye Prudy is 23 m, and 48 m near Zaraysk. The total fall of the stream with an average channel slope is 0.48 m/km [10].

The river’s basin area is approximately 3350 km². Absolute heights of 150–190 m are common for much of the length of this river; the highest sections of the river, with elevations of up to 250 m, are located at the river source and on the border of the Serebryanye Prudy and Zaraysk districts. These are the so-called Altukhovskie heights. The watersheds separating the Osetr basin from the basins of neighboring rivers—Vozha, Pronya, Bolshaya Smedva, etc.—are at elevations of 50–80 m above the river but occasionally reach 100–130 m.

The entire area between the Osetr valley and the borders of its basin is divided by a dense and complex hydrographic network, where 16 primary tributaries are distinguished (with lengths ranging from 20 to 45 km or more). Among them, there are such rivers as Mordves, Polosnya, Sukhoy Osetrik,
Neznanka, etc. The largest tributaries of the Osetr river are located in the southern and significantly expanded part of its basin [10].

2.1. Ecological Characteristics of the Osetr River Basin

The Osetr river is classified as belonging to the group of small rivers and is one of the largest southern tributaries of the Oka river. Along the river, there are settlements and cities that negatively affect the environment, and especially the hydroecological condition of water, which subsequently affects the quality of life and health of the people residing there. Additional water samples were taken at the Akatyev settlement in order to compare the qualitative content of the Osetr and Oka river water and to study the impact of human-induced factors on the river conditions [13–16].

The environmental situation is aggravated by the poorly-treated sewage waters containing a wide range of pollutants of industrial enterprises, public utility services, and agricultural lands of the Moscow, Tula, and Ryazan regions. The floodplains of the rivers are heavily damaged because of plowing the land for gardening purposes. Large amounts of waste accumulate in ravines and on the banks of the river, which can trigger the accumulation of sediment and pollutants, which will result in the river channel death. Inefficient use and improper storage of manure and fertilizers is registered in the fields, and when they are washed off, pesticides get into the Osetr river water and make it unsuitable for drinking and recreation.

Human-induced loads (e.g., Zaraysk and the adjacent industrial zone) have a strong impact on the ecological situation of the Osetr river basin. This is the impact of the chemical, food, and metallurgical industries, as well as the influence of hydraulic structures.

Upstream the Osetr river, in Zaraysk, there is a dam, which was commissioned in 1966 on the site of an old wooden crib dam and serves to create a backwater in the upper pool at the flood-control storage level of 113.50 m for the purpose of establishing recreational areas in the Zaraysk district. As a result of its many years of operation, the surface and underwater structures of the dam have been worn by 70% or more. The dam condition has a significant impact on the environment with subsequent positive or negative effects. This results in the change of the river hydrological regime and the development of conditions for the qualitative content of water. The Osetr river is of great importance for the residents of the Moscow region, as it serves as a source for recreational, domestic, and fishery use [17–19].

2.2. Methods for the Estimation of Anthropogenic Impacts on the Osetr River Basin

The basis for the development of geoecological assessment and zoning were the results of comprehensive studies of the Osetr river conditions, namely, data obtained in the course of the scientific research from 2015 to 2018 at the stations from Zaraysk to the Akatyev settlement, scientific concepts, regulatory documents and other applicable legal acts, technical reports on the results of engineering and environmental surveys, methods of comprehensive assessment of the surface water pollution levels using hydrochemical indicators, quality standards for water bodies of household—drinking and cultural—domestic water use, statistical data, cartographic materials, data of hydrological and hydrochemical examinations and climate monitoring, including information obtained from the results of field work in 2015–2018, as well as data provided by the officials of the Zaraysk district, Ryazanproekt LLC, RusGidro, MOSECOMONITORING, research laboratories Meshchersky Scientific and Technical Center, and Ecocenter research lab, as well as the data provided by the Federal Agency for Water Resources [11,17–19].

The following methods were applied for the purpose of developing a geoecological assessment of the human-induced impact on the Osetr river basin [20–26]:

- Method of a comprehensive assessment of the surface water pollution index in terms of the hydrochemical indicators;
- Method of the human-induced impact environmental risk analysis;
Method of assessing the human-induced load on river ecosystems, considering their regional specific features;

Point-rating method.

The method of calculating comprehensive indicators (WPI—water pollution index, SCWPI—specific combinatorial water pollution index) makes it possible to assess the chemical content of water, generalize the information of the analytical process, and convert relative indicators that provide comprehensive assessment of the level and quality of water pollution. Monitoring results are used for the comprehensive assessment of surface water body pollution. In accordance with the conditions and details of the monitoring system, a combination of differentiated and integrated assessment methods is applied to establish and determine the range of water pollution and water pollution levels.

The comprehensive method is based on the assessment of water pollution in terms of the pollutants’ range: for any water body at the water sampling point; for any period; and through the combination of hydrochemical indicators [20].

The water quality of water bodies depends not only on certain indices of the water chemical content, but also on the duration of exposure to each of these characteristics and the list and the amount of pollutants included into the overall assessment. Given the condition of the additive effects of toxic substances in case of their simultaneous presence, the overall comprehensive water quality index is determined by the addition of certain indices to assess the effect of each pollutant itself.

The assessment of the water body water quality in terms of individual pollutants using statistical methods serves the basis for the differentiated method.

For the comprehensive assessment system of formalized indices, in accordance with the instructions, a set of formalized characteristics is calculated for two groups of indices—main and intermediate. Most of the indices are intermediate and publicly known and are used to calculate the main indices (MPC—maximum permissible concentration ratio multiplicity; excess of multiplicity concentration corresponding to a high pollution; repeatability of MPC excess cases; total number of ingredients considered in assessing the water quality; etc.) and safety factor. The main indices, namely, individual assessment points for the multiplicity and frequency of the MPC excess cases; generalized assessment points; water pollution complexity factors; water quality classes; etc., are intended for a comprehensive assessment of the water bodies pollution. Water quality assessment can be performed using the entire set of parameters and individual groups or individual features [20].

In addition to numerical values, the relevant verbal characteristics are also used. This method provided for the most informative comprehensive assessments—specific combinatorial water pollution index and water quality degree.

The SCWPI provides conditional assessment, estimates in the form of a pure number the polluting impact contributing to the aggregate water pollution level, caused by the simultaneous presence of a number of pollutants, on average, and is one of the factors considered when calculating the combinatorial index of water ingredients and quality indices [21,22].

This comprehensive index, in contrast to the WPI, does not limit the number of ingredients; in addition to determining the MPC multiplicity, it determines the value excess repeatability and allows comparing the levels of water pollution in different sections in case of different monitoring programs [23].

The specific combinatorial water pollution index can vary from one to sixteen in waters of different pollution levels. A higher index value corresponds to the worst water quality at various sections, points, stations, etc.

Human-induced impact risk analysis involves the process of identifying and assessing the possible negative consequences arising from violations in any systems, and expressing such effects in quantitative terms.

Risk assessment means a scientific analysis of risk occurrence in order to identify hazards, as well as their severity under certain (special) conditions [24,25].
Assessment of the human-induced environmental impact risk should be considered as an opportunity based on an analysis of a set of abiotic and biotic factors and criteria for their variability, which characterize the level of the aquatic environment pollution, nature and level of violations, structural and functional content of planktonic and benthos groups of aquatic organisms, and the effect of human-induced and other factors [24].

To determine the level of susceptibility to human-induced impact and the natural ecosystem capability of self-recovery, a direct or indirect assessment is performed for their sustainability, which affects the further outcome (result) of the adverse effects of the human-induced impact.

The procedure of the human-induced impact risk assessing includes assessing the probability of a negative human-induced impact using abiotic and biotic factors, which depend on the contemporary condition of the ecosystem in question and the human-induced load.

When assessing the human-induced load on river ecosystems, the boundaries are defined of the areas of normal functioning and altered areas (subjected to the influence of any impact factor). This will make it possible to assess various ecosystem conditions caused by natural and human-induced transformation, where significant changes have occurred of the ecosystem conditions, given the potential adverse effects of various factors and natural features of the locations (regional specific features) [21–28].

Scales are established based on the results of assessing the river ecosystem conditions depending on the degree of their inconsistencies, as well as identifying cause–effect relationships between the effect on the biota and its response.

To assess the human-induced load of the studied section of the river, data were used from the analysis of long-term hydrological and hydrochemical information at the monitoring stations, in terms of the level of human-induced impact, degree of human-induced impact, aquatic environment pollution level, and the values of the influx of chemicals (ammonium nitrogen, EOS by BOD$_5$ (easily oxidized substances by biochemical oxygen consumption) and petroleum products).

The comparative method based on a comparison of the analysis results and collection of data on monitoring observations obtained at the water bodies of Russia or in areas with different levels of human-induced impact served the basis for selecting hydrochemical and hydrobiological indices and criteria for their variability. The quantitative assessment was developed considering the major provisions set forth in the documents on a comprehensive assessment of surface water pollution level, and biological methods for assessing the human-induced eutrophication and environmental regression [27,28].

The amount of human-induced impact is of environmental importance and includes an assessment of the involvement (participation) of the human-induced component into the aquatic environment content and is calculated as the water complexity factor when calculating the specific combinatorial water pollution index (SCWPI). Human-induced load, determined by the human-induced impact factor, is caused primarily by the pollutants.

Studies conducted over the past few years have confirmed the feasibility of using the human-induced impact index to assess the human-induced load, the value of which is determined by the results of the SCWPI calculation using the mandatory list of the 15 most regularly identifiable established indices in accordance with GD 52.24.643-2002 [21].

This has offered a chance to reveal trends in the variability of human-induced load along the length of the Osetr river and correlate aquatic ecosystems according to the degree of the existing human-induced load.

The degree of the aquatic environment pollution is determined according to GD 52.24.643-2002 via the comprehensive assessment method, which allows assessing water pollution simultaneously in terms of the list of the most regularly identifiable established indices and classifying the water according to its pollution degree [21].

In the absence of data of routine hydrobiological observations, the assessment of the condition of ecosystems of the selected river sections was conducted in terms of the variability of modal intervals of
concentrations of such indices as dissolved oxygen, BOD5, and ammonium nitrogen using the classifier presented in Table 1 pursuant to the R 52.24.661-2004, R 52.24.776-2012, R 52.24.819-2014 [24–26].

Table 1. The scale of conversion of the absolute human-induced load factors values to the relative ones.

| Group Number | Human-Induced Load Factor                                                                 | Scale                        |
|--------------|------------------------------------------------------------------------------------------|------------------------------|
| 1            | - Results of hydrochemical and hydrobiological monitoring (the amount of dissolved oxygen (O2), BOD5, indices of WPI and SCWPI); - Results of ecogeochemical examination of soils (soil pollution index); - Results of hydrochemical and hydrobiological monitoring (salt content); - Number of “hot spots" (enterprises\ major water pollution sources); | Eight-tier scale (0 to 7 points) |
| 2            | - Density of highways and main roads; - Results of hydrochemical and hydrobiological monitoring (pH, water temperature, COD, petroleum products, heavy metals, suspended solids, sulfates, chlorides, nitrogen group, organoleptic indicators (smell, taste, color), impurities); | Three-tier scale (0 to 2 points) |
| 3            | - Results of ambient air analysis (amount of electromagnetic radiation, noise exposure, heavy metals); - Results of ecological geochemical examination of soils (area contaminated with radioactive cesium-137, radiation, heavy metals, pH, petroleum products, bens(a)pyrene, epidemiological indicators). | Two-tier scale (0 to 1 points) |

The development of the point-rating method, zoning, and partition process was based on the above methods in combination with a set of human-induced load elements.

The point-rating method makes it possible to assess and compare the human-induced load from various pollution sources, located in different climatic zones and having an unlimited range of water flow values.

Statistical reporting data of water resource departments in the constituent entities of the Russian Federation (reservoirs, results of hydrochemical and hydrobiological monitoring), earlier studies’ data (results of ambient air analysis, results of the ecological and geochemical soil analysis, etc.), and digital topographic maps (forest cover, swampiness, density of roads, oil and gas pipelines, etc.) were used as information sources.

To assess the human-induced load in accordance with the proposed method, data are required on the river water flow, volume of waste water, and concentration of pollutants released into the watercourse from the water collection area.

To assess the human-induced load on water bodies, there is a huge number of techniques. Some of them assess the load only by the amount of pollutants released into the water body as a result of the discharge of waste water, while others use not only the amount of pollutants, but also the surface area of the water body.

The assessment was performed in three stages [11]:

1. Obtaining the absolute values of the human-induced load factors within each section (Table 1);
2. At the second stage, the numerical values of each human-induced load factor were converted to integral-value points on a scale from 0 to 7. For a number of factors insignificantly represented throughout the area under consideration, a three-tier scale (from 0 to 2) or a two-tier scale (from 0 to 1) was used;
3. At the third stage, the relative influence of the human-induced load factor was considered in comparison with other factors: The points obtained in the first and second stages of the assessment were summed up and then, according to these sums of points, the areas were compared with one other.

The overall point scale was developed, according to which the sections were classified into 5 groups: areas with critical, high, moderate, medium, and low human-induced load.

Map charts were developed using ESRI ArcGIS and Golden Software Surfer 13 using the interpolation method according to the data from the tables of distribution of hydrochemical values in...
the selected sections, changes in water quality depending on the values of WPI and SCWPI, as well as the results of calculating the amount and degree of human-induced impact.

3. Results and Discussion

In the course of the research, it was found that due to hydrological features (relatively small volumes of runoff and low self-cleaning ability, the dependence of the water regime on climatic and weather conditions, etc.) and features of natural and climatic conditions, like many other small rivers in the region, the Osetr river has an increased sensitivity to anthropogenic impact.

Based on the data obtained and the comprehensive assessment of the surface water pollution level in terms of hydrochemical indices, the WPI and SCWPI calculations were performed.

Given the fact that recently, with the expansion of the monitoring program, a high level of microbiological pollution of the Osetr river has been registered, the inclusion of the WPI and SCWPI indices into the calculation can be considered appropriate.

Calculations were carried out using a simpler method of determining water quality classes—by the value of the SCWPI and the number of CIWP (critical indicator of water pollution). To calculate complex estimates, a free list of ingredients and water quality indicators No. 3 was used [20] (Annex B).

Exceeding the MPC in the target areas was observed for 4–5 ingredients of the chemical composition of water from 12 determined indicators. 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 contamination” of the water of the Osetr river in June–July 2018.

All pollutants are characterized by stable contamination, which is confirmed by the highest values of the private assessment points for repeatability “Sa = 4.0” [20] (Annex G).

Regarding the classification of water by the frequency of pollution cases, water pollution by all considered indicators is defined as “stable” and the level of its water contamination by these ingredients is different [20] (Annex E).

A “low level of contamination” of water is observed for the biochemical consumption of oxygen (sections 1, 3, 24), nitrite ions (sections 1, 2, 3, 24), manganese (sections 1, 24), and suspended substances (sections 2, 3, 15). The values of the individual evaluation points for these ingredients do not exceed 2.

According to BOD5 (sections 15, 25), the content of nitrite ions (section 15), manganese sections (2, 3, 15, 25), copper (sections 1–25), and suspended substances (section 24) represents an “average level of contamination”. The private evaluation score does not exceed 3 [15,22].

Nitrite ions are characterized by a “high level of contamination”. In section 6, the private evaluation score is 12.5.

Sections 1, 2 (Zaraysk, Markino), and 15 (Spas-Doschaty) were less polluted. The SCWPI for them is, respectively, 3.95, 4.26, and 3.93, and the quality of water belongs to class 4 and category “b”, i.e., is “dirty” (Figure 1b).

In sections 3 (Radushino) and 25 (Aktyuyevo-Oka river), the water is “very dirty” (class 4, category “b”).

The worst quality is noted for the target, tied to the Vlasyevo (24), where the water is “very dirty” (class 4, category “g”), and the SCWPI is 5.4.

According to the water pollution index (WPI), the Osetr river water is defined as “moderately polluted” (WPI = 1.0–2.5) from Zaraysk to the Oka influx point (49.2 km) and changes to “polluted” (WPI = 4.0–6.0) up to Aktyuyevo (2.09 km) (Figure 1a) [23].

On the basis of the data held, ecological zoning of the investigated part of the Osetr river is based on the level of contamination of the pond (WPI, SCWPI) and on the proportion of anthropogenic impact and degree of anthropogenic load (the point-rating method), highlighting 5 areas of the riverbed with anthropogenic pressures (low, medium, moderate, high, and critical) and the status of ecosystems (natural, equilibrium, crisis, critical, and catastrophic).
The allocation of zones and sites was based on the method of application of integral indicators and indices for the assessment of the ecological state of water bodies and the system of assessment of the risk of anthropogenic impact on freshwater ecosystems.

Studies conducted over the past few years have confirmed the feasibility of using the human-induced impact index to assess the human-induced load, the value of which is determined by the results of the SCWPI calculation using the mandatory list of the 15 most regularly identifiable established indices in accordance with RD 52.24.643-2002 [21].

The SCWPI offers a chance to reveal trends in the variability of human-induced load along the length of the Osetr river and correlate aquatic ecosystems according to the degree of the existing human-induced load [21,29].

In the absence of data of routine hydrobiological observations, the assessment of the condition of ecosystems of the selected river sections was conducted in terms of the variability of modal intervals of concentrations of such indices as dissolved oxygen, BOD5 and ammonium nitrogen using the classifier presented in Table 2 pursuant to the P 52.24.661-2004, P 52.24.776-2012, P 52.24.819-2014 [24–26].

Based on the calculation results, a modal interval is defined for each river section providing the values of the human-induced impact amount, and the human-induced load was measured according to the criteria provided in Table 3.

The analysis of the obtained results reveals that two sections were identified at the studied part of the river with a low human-induced load (Zaraysk–Markino) and four with moderate load (Radushino–Akatiyevo) (Figure 2).

![Map charts of the water quality change depending on the values: (a) water pollution index (WPI); (b) specific combinatorial water pollution index (SCWPI).](image_url)
Table 2. The scale of assessing the condition of the Osetr and Oka rivers ecosystems according to the degree of the human-induced load.

| No. of Section | Modal Intervals of Mass Concentrations | Ecosystem Condition | Amount of Human-Induced Load | Human-Induced Load Degree |
|----------------|----------------------------------------|---------------------|-----------------------------|---------------------------|
|                | Min. Value O$_2$ | EOS by BODS | Ammonium Nitrogen | | |
| 1 (Zaraysk)    | 7.9 | 2.6 | 0.109 | natural | 25 | 0 |
| 2 (Markino)    | 7.6 | 1.6 | 0.109 | balanced | 25 | 0 |
| 3 (Radushino)  | 7.3 | 2.3 | 0.140 | crisis | 31.25 | 0 |
| 4 (Spas-Doschaty) | 9.8 | 4.5 | 0.039 | natural | 31.25 | 0 |
| 5 (Vlasyevo)   | 8 | 3.6 | 0.242 | crisis | 31.25 | 0 |
| 6 (Akatyeyvo)  | 10.1 | 6.6 | 0.0039 | natural | 31.25 | 0 |

Table 3. Scale to assess the Osetr and Oka rivers ecosystem human-induced load by the amount of human-induced impact.

| No. of Section | Modal Interval of Human-Induced Impact Amount, % | Human-Induced Load |
|----------------|-----------------------------------------------|-------------------|
| 1 (Zaraysk)    | less than 30 | low |
| 2 (Markino)    | less than 30 | low |
| 3 (Radushino)  | 30 to 45 inclusive | moderate |
| 4 (Spas-Doschaty) | 30 to 45 inclusive | moderate |
| 5 (Vlasyevo)   | 30 to 45 inclusive | moderate |
| 6 (Akatyeyvo)  | 30 to 45 inclusive | moderate |

Figure 2. Map charts of the human-induced load areas in the Osetr and Oka river sections for 2018: (a) In terms of the human-induced load degree; (b) In terms of the amount of the human-induced load.
The developed point-rating method for assessing the degree of human-induced load made it possible to define five categories of the river channel areas with human-induced load (small, medium, moderate, high, and critical).

The absolute values of the human-induced load factors within each section were obtained; statistical reporting data of water resources departments in the constituent entities of the Russian Federation (reservoirs, results of hydrochemical and hydrobiological monitoring), earlier studies data, and digital topographic maps (forest cover, swampiness, density of roads, oil and gas pipelines, etc.) were used as information sources [11,17,20–23].

The numerical values of each human-induced load factor were converted to integral-value points on a scale from 0 to 7. For a number of factors insignificantly represented throughout the area under consideration, there was used a three-tier scale (from 0 to 2) or a two-tier scale (from 0 to 1); the scale of conversion of certain absolute values into points for each factor was compiled through expertise (Table 1).

The relative influence was considered of the human-induced load factor in comparison with other factors: The points obtained in the first and second stages of the assessment were summed up, and then, according to these sums of points, the areas were compared with one other.

The developed overall point-rating scale made it possible to classify the human-induced load into five groups: areas with critical, high, moderate, medium, and low human-induced load (Table 4).

| Total Points | Human-Induced Load |
|--------------|--------------------|
| up to 20     | low                |
| 20–40        | medium             |
| 40–60        | moderate           |
| 60–80        | high               |
| 80–100       | critical           |

The obtained results analysis reveals that the studied sections of the Osetr and Oka rivers are classified as having medium human-induced load, which is mainly due to the use of water resources for agricultural, household purposes, as well as due to the lack of centralized waste water discharge (Table 5).

| No. of Section | Total Points | Human-Induced Load |
|----------------|--------------|--------------------|
| 1 (Zaraysk)    | 22           | medium             |
| 2 (Markino)    | 21           | medium             |
| 3 (Radushino)  | 21           | medium             |
| 4 (Spas-Doschaty) | 21       | medium             |
| 5 (Vlasyevo)   | 23           | medium             |
| 6 (Akatyevvo)  | 20           | medium             |

4. Conclusions

During the research process conducted in the framework of ecological monitoring in 2017–2018 at the Zaraysk–Akatyevvo section, it was defined that due to hydrological and natural and climatic conditions (relatively small run-off volume and low self-clarification capacity, the hydrological regime dependence on climatic and weather conditions, etc.), the Osetr river, like many other small rivers of the region, is hyper-susceptible to the human-induced impact.

In general, based on the results of the performed studies, it can be noted that no gross violations were detected of the regulatory documents dealing with environmental protection of the Osetr river...
basin. The amount of research work conducted complies with the requirements of the regulatory and methodological literature and is sufficient to assess the current situation.

Human-induced loads (e.g., Zaraysk and the adjacent industrial zone) have a significant impact on the ecological situation of the Osetr river basin. This is the impact of the chemical, food, and metallurgical industries, as well as the influence of hydraulic structures.

The obtained results analysis reveals that the studied sections of the Osetr and Oka rivers are classified as having medium human-induced load, with total points of 20 to 22, which is mainly due to the use of water resources for agricultural, household purposes, as well as due to the lack of centralized waste water discharge.

Based on the results obtained, forecast of possible changes in the environment under the influence of the human-induced load, and programs for the rehabilitation and protection of small and medium rivers, a set of measures has been developed to solve environmental problems in the Osetr river basin in order to prevent, mitigate or eliminate harmful and undesirable environmental and related social, economic, and other consequences and maintain optimal living conditions of the population [30].

Conclusions about the geocological state of the studied river are of great practical importance and can be applied to identify and protect areas with critical environmental conditions when monitoring the catchment area and developing environmental measures, to predict the development of possible crisis situations and operational management of the current situation and further research of the territory, as well as in the educational process of students.

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