Temporal Patterns of Quality Surface Water Changes

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ABSTRACT

The dynamics of hydrochemical parameters of surface waters from the upper, middle and lower reaches of the river was analyzed. On the basis of the analysis of temporal and spatial monitoring data, a comprehensive assessment of the environmental status of the Inhulets river (Ukraine) waters by hydrochemical indicators was carried out. The study performed a comparative analysis of the river water quality assessment using different methods: an integrated assessment based on the calculation of water pollution indexes, pollution rate. A result of the evaluation of water quality in certain classes: in terms of ammonium ions and BOD5 – III quality class, the water is slightly polluted; phosphate content – V quality class, water is very low in the bottom; according to the content of suspended solids, in phosphates and BOD5 – III class of water quality, water is polluted; by a concentration of chlorides – V class of quality, degree of purity – very dirty; the value of suspended solids and chlorides – III class; in terms of the sulfate content – IV class. In general, the very excessive concentration of substances in the middle course remains stable, the environmental state is poor (quality class IV).

Keywords: surface water quality, water security, hydrochemical indicators, level of pollution, resistance degree of pollution, Inhulets river.

INTRODUCTION

Water resources are limited and vulnerable as natural objects. Among the 17 global sustainable development goals, two are directly related to water security. The growth of anthropogenic activity leads to excessive pollution of water resources (Bharti et al. 2011, Mitryasova et al. 2017, Coirolo t al., Jepson et al. 2017, Pohrebennyk et al. 2017, Staddon et al. 2017, Mitryasova et al. 2018). The proceeds of the untreated or inadequately treated industrial, municipal and domestic wastewater reduces the possibility of their use for drinking and household needs (Petrov et al. 2020, Barakat 2011, Pohrebennyk et al. 2019, Casal-Campos et al. 2015, NRDC 2013, Mitryasova and Pohrebennyk 2017, Wang et al. 2018). The urgent tasks to ensure water security are to reduce the pollution of water basins, ensure the sustainable use of water resources, the introduction of effective regulation of extraction of aquatic resources (De Haan et al. 2015, Butler et al. 2016, Ishchenko et al. 2019, Mitryasova et al. 2020, Bezsonov et al. 2017, Banjaw et al. 2017).

The majority of the population of Ukraine uses low-quality water, which poses a danger to health. The problem of the environmental state of water objects is important for all pools and rivers in Ukraine. One of the main components of environmental security towards sustainable development is monitoring the quality of water (Abbasi et al. 2012, Byrne et al. 2017, Gersonius
et al. 2013, Mitryasova et al. 2019). Ukraine is one of the few water resources countries in Europe. Under the influence of economic load, about 70% of surface and part of groundwater in Ukraine have lost their importance as sources of drinking water supply.

The assessment of the surface water quality takes into account in time and space the state of the water body, which allows identifying the trends in water quality, helps to determine the anthropogenic pressure and the consequences of water conservation measures (Farrelly and Brown 2011, Ward et al. 2019, Fernandez et al. 2012). The study of correlations between chemical components, as well as the patterns of pollutants distribution in the aquatic environment, the study of small rivers pollution problems are presented in works (Meyer et al. 2019, Mitryasova and Pohrebennyk 2017, Schickele et al. 2020, Karpinski et al. 2018).

Ukraine is the largest country in Europe, but it is one of the poorest countries in terms of the water content. Therefore, the issue of water quality, especially surface water for the country is extremely relevant. The problem of limited local water resources and uneven distribution is extremely relevant for the Mykolaiv region. The area is located in the South of Ukraine and belongs to the arid regions of the country. According to the «National Program of Water Management Development» per 1 person, the average local river runoff was 0.450 thousand m³/year, and 23.2 thousand m³/year (per 1 km² area) (https://zakon.rada.gov.ua/laws/show/4836-17). The Mykolaiv area is low-water, insufficiently supplied with water.

After analyzing the data of the Mykolaiv Regional Department of Water Resources, there is a gradual decrease in water intake by 76.2% (from 1125.5 million m³ to 267.6 million m³). The volume of surface water discharges to the surface also decreased by 43% (http://mk-vodres.davr.gov.ua/water_resources). The dynamics of water use and sewerage indicate the irrational use of resources, the deterioration of the environmental condition of water bodies and the inefficiency of treatment facilities (Figure 1). Water abstraction and resource use decreased due to the reduced water use for production and irrigation.

In 2019, 64.90 mln. m³ wastewater (32% contaminated, 66% pure without purification regulatory, legislative 2% purified) was discharged to the water bodies in the Mykolaiv region(http://www.niklib.com/eco/dop.pdf). The Mykolaiv area is considered a zone of risky agriculture; therefore, there is a need for irrigation.

The problem of pollution of water resources in the Mykolaiv area owing to the dumping of highly mineralized mine waters of the Kryvyi Rih enterprises to the Inhulets River is aggravated. The Inhulets River is extremely polluted by the discharges of polluted waters of the Kryvyi Rih mining iron ore basin.

The result of the planned annual discharge of highly mineralized mine waters of the mining enterprises of Kryvybas to Ingulets is a significant deterioration of the ecological condition of the river surface waters and damage to irrigated lands. In particular, the residents of the Snihuriv district are provided with low-quality drinking water from spring floods.

Annually, about 12 million m³ of Kryvbas mine water (mineralization reaches 4000 mg/l is discharged into the Ingulets river basin (https://adm.dp.gov.ua/pro-oblast/rozvitok-regionu/ekologiya, Lykhovyd and Kozlenko 2018, Yurasov et al. 2012). The excess of return water occurs in a clearly defined intervegetation period (February-November). After the discharge of highly mineralized waters, the measures to eliminate the consequences of the discharge are introduced through the washing of the Inhulets.

Fig. 1. Volumes of discharges of return waters to surface water bodies of the region, million m³
riverbed. At the same time, there is a dilution of water to the normalized levels of water quality in the control areas below the release. Since 2010, following the regulations of riverbed washing and ecological rehabilitation of the Inhulets River, improvement of its water quality health washing is carried out the Inhulets River bed due to constant discharges of fresh Dnieper water. Wellness and technological rinsing make it possible to improve the quality of water in the river during the irrigation period and is carried out to displace the salt prism.

The dynamics of the Dnieper water supply over the years are shown in Figure 2. As a result of the implementation of the Flushing Regulations, the water quality has slightly improved. The hardness of water was 9.4 mg-eq/l, chlorides – 109.6 mg/l, sulfates – 448.4 mg/l, dry residue – 1064.6 mg/l, but in terms of hardness and dry residue of normative indicators could not be reached. However, this type of activity is potentially dangerous for the environment, because with the periodic discharge of highly mineralized excess return water, it is impossible to comply with the current surface water quality standards. Thus, a comprehensive analysis of the ecological condition of the river by hydrochemical parameters is relevant.

The object of the work is a study based on the analysis of temporal and spatial monitoring data, a comprehensive assessment of the environmental status of the Inhulets River waters according to the hydrochemical indicators.

The Inhulets River is large with the length of 549 km. The area of the basin is 14870 thousand km. On the territory of the basin, there is one of the largest Precambrian iron ore regions in the world, the main mining center of Ukraine – Kryvyi Rih iron ore basin. Due to the intensive development of anthropogenic activity, the vegetation of the Inhulets basin was transformed. As a result of agricultural land development, almost 85% of the territory has been plowed. Natural landscapes are partially located and preserved only in a very small part of the territory (0.5%). In the northern part, there are remnants of forest, steppe, meadows, and water, rocky and sandy vegetation. Almost the entire length of the river is under man-made load, especially in the middle reaches.

MATERIALS AND METHODS

Two groups of methods were used in the work: theoretical and mathematical. The theoretical methods included: analysis, synthesis, systematization, and generalization in the process of studying the literature on the topic of research and hydrochemical indicators of the water status in the Inhulets river. In turn, the mathematical methods involved: statistical data processing, the method of averages in determining the level of pollution, graphical display of the results of work performed, correlation, and regression analysis of hydrochemical parameters and time trends quantity; the calculations were performed using the MS Excel software package, schemes were created in MapInfo.

During the assessment of the environmental condition of the river, the pollution coefficient (PC) was determined according to the method (Shakhman and Bystriantseva 2017, Mitryasova and Pohrebennyk 2020).

The pollution coefficient is a generalized indicator and characterizes the level of pollution
in general according to the list of water quality indicators. The values of multi-year measurements at several observation points of the water body were used for assessment. The value of the pollution coefficient characterizes the multiplicity of exceeding the MPC standards. When assessing the environmental state of water body, the sanitary-toxicological properties of water were taken into account. The PC values were calculated by formulas 1 and 2:

$$\gamma = 0.1 \sum_{i=1}^{9} \left( \frac{1}{N_j} \sum_{j=1}^{J_n} \sum_{n=1}^{N_{ijn}} \gamma_{ijn} \right),$$  \hspace{1cm} (1)

$$\gamma_{ijn} = \frac{C_{ijn} - f \cdot \text{MPC}_{\text{violated}}(C_{ijn} \geq \text{MPC})}{1 + f \cdot \text{MPC}_{\text{satisfies}}(C_{ijn} \leq \text{MPC})},$$  \hspace{1cm} (2)

where: $i$, 10 – serial number and the total number of controlled indicators; $j$, $J$ – ordinal number and a total number of observation points; $n$, $N_{ij}$ – ordinal number and the total number of measurements of the $i$-th indicator in the $j$-th point for the period of time being analyzed; $N_i$ – the total number of measurements of the $i$-th indicator in all observation points; $g_{ijn}$ is the multiplicity of exceeding the MPC at the $n$-th measurement of the $i$-th indicator at the $j$-th observation point.

The value of the short circuit is calculated only for ten indicators. These indicators include those indicators that exceed the value of the MPC. If the number of indicators exceeding the MPC is less than ten in the formula, the value of $g_{ijn}$ for the remaining indicators is taken equal to one (Vasenko et al. 2017).

According to the value of the pollution coefficient classify the level of water pollution according to Table 1.

The classification of waters is based on the establishment of a resistance measure to pollution (recurrence of $P$ cases of exceeding the MPC) by formula 3 (Bashynska 2018).

$$P_i = \frac{N_{\text{MPC}_i}}{N_i},$$  \hspace{1cm} (3)

where: $N_{\text{MPC}_i}$ is the number of analysis results in which the content of the $i$-th ingredient exceeds its MPC, $N_i$ is the total number of analysis results of the $i$-th ingredient.

Hydrochemical monitoring of surface waters of the Inhulets River at the observation point – Inhulets Irrigation System, Sniharivka was carried out during the irrigation period (May – September) during 2011–2018.

The characteristics of water pollution were determined accordingly and presented in Table 2.

### RESULTS

The results of monitoring for the period from 2011 to 2018 of indicators exceeding the MPC have been studied, namely: pH; Chemical oxygen demand (COD); Biological oxygen demand (BOD); Water hardness, Dry residue; Magnesium and Sodium. Characteristics of indicator measurements are specified in Table 3.

The average monthly values of substance concentrations were selected for analysis. For example, the dynamics of indicator concentrations are graphically shown in Figs. 3–9.

The hydrogen index during the study period varied in the range of 7.29–8.48. The pH indicator is integral because its value is influenced by the content of all soluble substances and the nature of intermolecular interactions. The highest pH value was recorded in 2011. During 2014–2016, the indicator was observed at a stable level. In 2018, the pH value decreased (Fig. 3). The trend line of the dynamics is presented in the form of a polynomial line. The correlation coefficient is 0.6 and indicates a significant link between pH and time values.

The dynamics of the value of COD at the observation point – Inhulets irrigation system is shown in Figure 4. The COD index varied uniformly in the range of 28–36 mgO₂/dm³ (MPC = 15 mgO₂/dm³).

Chemical oxygen demand (COD) is also an integrated indicator that shows the content of organic matter in water. Currently, COD is considered one of the most informative indicators of the anthropogenic water pollution. The value of

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**Table 1.** Indicators of water pollution by PC

| The value of the PC | 1 | 1.1…2.5 | 2.5…5.0 | 5.1…10.0 | 10.1… |
|--------------------|---|----------|----------|-----------|-------|
| The level of pollution | unpolluted (pure) | slightly polluted | moderately polluted | dirty | very dirty |
COD is the amount of oxygen (or other oxidants in terms of oxygen) required for complete oxidation of the organic compounds present in the sample, or rather all oxidizable elements from the composition of organic components. Thus, carbon is theoretically oxidized quantitatively to CO₂, and sulfur and phosphorus (if present in the compound) to SO₂ and P₂O₅. Nitrogen is converted into an ammonium salt, and oxygen is the basis for the oxidation products, while hydrogen is converted into the structure of H₂O or ammonium salt.

The trend line shows a decrease in the value of COD in time. The highest COD indicator was recorded in 2015. The high value of oxidation indicates a high content of organic matter and pollution by wastewater and poor general condition of the reservoir (algae overgrowth, lowering the water level, etc.). Such water is usually contaminated with microorganisms, causes foaming, indicates the possibility of organic fouling.

| Indicator     | Units of measurement | MPC       |
|---------------|----------------------|-----------|
| pH           | units pH             | 6.5 – 8.5 |
| COD          | mg O₂/dm³            | 15.00     |
| BOD          | mg O₂/dm³            | 3.00      |
| Water hardness | mg-eq/dm³          | 7.00      |
| Dry residue  | mg/dm³               | 1000.0    |
| Magnesium    | mg/dm³               | 40.0      |
| Sodium       | mg/dm³               | 200.0     |

Fig. 3. Changes in pH value on the sampling point – Inhulets irrigation system (Snigurivka)

Fig. 4. Changes in COD value on the sampling point – Inhulets irrigation system (Snigurivka)
The dynamics of water hardness index in time is presented in Figure 5. The hardness index gradually decreased until 2013. However, since 2014 the trend is growing. In 2018, the value of rigidity exceeded the MPC almost twice. Exceedance of the MPC was observed during the study period. According to the current trend, the change in the increase in the value of stiffness is expected in the future.

The dry residue index fluctuated within the maximum allowable concentration. This parameter determines the total amount of dissolved in water mineral inorganic salts of calcium, magnesium, potassium, sodium, heavy metals, as well as a large percentage of organic matter. This parameter is used primarily to determine the total mineralization of water. The trend line indicates a gradual increase in the value of the dry residue over time (Fig. 6). The concentration of magnesium at the observation point changed unevenly over time. The trend line indicates a tendency to increase the concentration of magnesium (Fig. 7).

The sodium concentration in the Inhulets irrigation system varied evenly. Since 2013, there has been a gradual increase in the concentration of Na (Fig. 8). The correlation coefficient is about 1, which indicates a direct dependence on time factors. The trend line shows a further increase in the sodium content at the observation point.

Excess sodium indicates a violation of the water-electrolyte balance in the river. Water with high mineralization during irrigation causes salinization of soils and harms fish spawning grounds. The observation points are selected (Fig. 9):
- point No. 1 – p. Iskrivka, Kirovohrad region, 373 km from the mouth;
- point No. 2 – p. Arkhangelske, Kherson region, 210 km from the mouth;
- point No. 3 – p. Inhulets irrigation system, 83 km from the mouth;
- point No. 4 – p. Daryivka, Kherson region, 20 km from the mouth.
For example, indicators with exceeding MPC in the points, such as BOC₅, sulfate ions and chloride ions are shown in Figs. 10–12. The BOD₅ indicator, which reflects water pollution by organic matter, was analyzed based on the results of hydrochemical monitoring at four observation points (Fig. 10). Natural clean waters have low BOD₅ values (usually their BOC₅ does not exceed 0.5–3 mg/dm³) in contrast to the man-made polluted waters.

BOD₅ exceeded MPC twice in the observation point No. 2 along the river – (p. Arkhangelske, 30 km from Kryvyi Rih). The highest concentration was recorded in 2005 and 2013. Since 2016, the value of BOC₅ has been decreasing. The dynamics of the sulfates values in the observation points are shown in Figure 11.

During the study period, the concentration of sulfates in the point No. 2 (v. Arkhangelske) exceeded MPC. The concentration of sulfates varies depending on seasonal fluctuations, as well as the content of substances is influenced by geological, biological processes and anthropogenic factors.
The dynamics of chlorides values in the control points are shown in Figure 12.

During the study period at the point of observation of the upper reaches of the river, the concentration of chlorides varied within acceptable limits. In 2002 and 2008, the number of chlorides exceeded MPC 3 times. Since 2010, in the areas below the city of Kryvyi Rih, the excess of the MPC is due to an increase in the wastewater discharges by industrial enterprises. Clear seasonality in the distribution of concentrations is observed depending on the period: summer-autumn lows, spring floods, winter lows. For example, the maximum runoff is formed in spring floods.
DISCUSSION

Using long-term observation data, the trends in water quality in the upper, middle, and lower reaches of the Inhulets River were revealed. The generalized results of the studies are presented in Tables 4–7.

The group of chemicals detected includes various inorganic compounds of nitrogen (NH₄⁺) and phosphorus (PO₄³⁻), which are termed «biogenic» or «nutritive», along with other organic matter. These groups are closely connected with natural phenomena and can affect river dwellers either positively or negatively. This problem is relevant for this section of the river. The chemicals, as a rule, are able to stimulate high productivity in some cases. That is why, the problem of eutrophication (nutrient over-enrichment) is especially urgent for this area connected to river estuaries. The agricultural runoff comprised of highly concentrated nitrogen and phosphorus cause algal blooms, which lead to fish kills when all the oxygen dissolved in water is spent on the oxidation of organic matter. For this reason, most hydrobionts, especially those that are unable to physically flee, will perish under these conditions.

If the excessively concentrated biogenic substances infiltrate into the river frequently, the entire ecosystem of a sea changes. Large perennial plants and animals – indicators of Good Environmental Status (GES), disappear. They are replaced by small, rapidly reproducing species, which form large homogeneous accumulations, but rendering the sea itself less attractive to other sea dwellers and the humans who depend on them. Underwater kelp forests represented by perennial brown algae (Cystoseira barbata) were replaced by cotton-like accumulations of finely branched green algae. Valuable fish species almost completely disappeared and were replaced by smaller and less valuable species.

Chlorides and sulfates are present in water in the form of salts of calcium, magnesium, potassium and sodium. The natural causes of the presence of chlorides in water are the leaching of soil layers by groundwater. In our case, the main source of chloride and sulfates are anthropogenic activity, namely the wastewater from the chemical industry (Tables 6–7).

The generalized water quality class on average indicators along the Ingulets River is shown in Figure 13. According to the water pollution index, the Inhulets River belongs to the III (third) class. The waters of the corresponding class are under significant anthropogenic influence, the level of which is close to the limit of ecosystem resilience.

The pollution coefficient was also calculated, which characterizes the level of pollution summarized by water quality indicators that were repeatedly measured in four observation points of the Ingulets River basin. Because, according to the available monitoring data in the studied points, the number of indicators exceeding the MPC is less than 10, so in the formula the values for the other indicators were taken equal to one. The results of the calculation of the surface water pollution coefficient (PC) are given in Table 8.

Given that the values for the remaining 7 indicators were taken equal to one:

**Table 4.** Evaluation of surface water quality by indicators (p. Iskrivka, Kirovohrad region, 373 km from the mouth)

| Indicator       | Water quality class | Water quality category | Environmental state of waters | The degree of water purity |
|-----------------|---------------------|------------------------|-------------------------------|---------------------------|
| Sulfates index  | II                  | 2                      | good                         | slightly polluted         |
| Chlorides index | II                  | 3                      | good                         | slightly polluted         |
| Ammonium ions   | III                 | 4                      | satisfactory                 | moderately polluted       |
| Phosphate ions  | V                   | 7                      | **very bad**                 | very dirty                |
| Dry residue     | I                   | 1                      | very good                    | unpolluted                |
| BOD₅            | III                 | 4                      | satisfactory                 | moderately polluted       |

**Table 5.** Evaluation of surface water quality by indicators (p. Arkhangelske, Kherson region, 210 km from the mouth)

| Indicator       | Water quality class | Water quality category | Environmental state of waters | The degree of water purity |
|-----------------|---------------------|------------------------|-------------------------------|---------------------------|
| Sulfates index  | II                  | 3                      | good                         | slightly polluted         |
| Chlorides index | V                   | 7                      | **very bad**                 | very dirty                |
| Ammonium ions   | II                  | 3                      | good                         | slightly polluted         |
| Phosphate ions  | III                 | 4                      | satisfactory                 | moderately polluted       |
| Dry residue     | III                 | 5                      | satisfactory                 | moderately polluted       |
| BOD₅            | III                 | 5                      |                                |                           |
PC = 1.11 + 1.58 + 1.36 + (1 × 7) = 1.10.

The value of the short circuit characterizes the multiplicity of exceeding the standards in the shares of the MPC. The calculated short circuit = 1.10 means that the normalized indicators of the Inhulets water quality on average 1.10 times (or 10%) higher than the MPC. In other words, in general, the water quality of the Inhulets River during the study period is 1.10 times worse than the norm.

The analysis of the results of the study suggests that the ecological condition is satisfactory; the degree of purity of water is «moderately polluted». The environmental status of the waters indicates the need for the introduction of effective technologies for cleaning the riverbed and improving the quality of the composition.

One of the known ways of utilization of mine waters is their demineralization, and the other is the injection of mine waters into unproductive deep aquifers with subsequent migration of pollutants in the underground hydrosphere.

Mine water treatment with removal of 60 to 80% of harmful impurities is provided by the use of coagulant reagents – also a possible option. At present, high-basic aluminum coagulants – aluminum hydrochlorides – are increasingly often used in the world (https://www.iwapublishing.com/news/coagulation-and-flocculation-water-and-wastewater-treatment, Prakash et al. 2014, Bratby 2006).

In many countries, phytotechnologies – bioengineering facilities – are intensively used to treat mine water before discharge into the hydrographic network. Higher aquatic plants, in combination or without a sand-gravel filter made of natural materials, are the main elements of the treatment system. Higher aquatic plants form a biocenosis, which includes various groups of microorganisms, algae, fungi and other organisms due to which water is

| Indicator    | Water quality class | Water quality category | Environmental state of waters | The degree of water purity |
|--------------|---------------------|------------------------|-------------------------------|----------------------------|
| Sulfates index | IV                  | 6                      | bad                           | dirty                      |
| Chlorides index | III                 | 4                      | satisfactory                 | moderately polluted         |
| Ammonium ions  | II                  | 3                      | good                         | slightly polluted           |
| Phosphate ions   | II                  | 3                      | good                         | slightly polluted           |
| Dry residue     | III                 | 4                      | satisfactory                 | moderately polluted         |
| BOD₅          | III                 | 5                      | satisfactory                 | moderately polluted         |

Table 6. Evaluation of surface water quality by indicators (p. Inhulets irrigation system, 83 km from the mouth)

| Indicator    | Water quality class | Water quality category | Environmental state of waters | The degree of water purity |
|--------------|---------------------|------------------------|-------------------------------|----------------------------|
| Sulfates index | III                 | 5                      | satisfactory                 | moderately polluted         |
| Chlorides index | IV                  | 6                      | bad                           | dirty                      |
| Ammonium ions  | II                  | 3                      | good                         | slightly polluted           |
| Phosphate ions   | III                 | 4                      | satisfactory                 | moderately polluted         |
| Dry residue     | II                  | 3                      | good                         | slightly polluted           |
| BOD₅          | III                 | 4                      | satisfactory                 | slightly polluted           |

Table 7. Evaluation of surface water quality by indicators (p. Daryivka, Kherson region, 20 km from the mouth)

Fig. 13. Generalized water quality class on average indicators
CONCLUSIONS

The temporal patterns of changes in surface water quality were determined. Currently, the environmental condition of the Inhulets basin is unsatisfactory. Recently, the wastewater volume discharged by enterprises of the city of Kryvyi Rih into surface water bodies is 27.5%.

During the growing season, the Inhulets River is flushed by Dnieper water, which dilutes the highly mineralized discharges of Kryvbas. However, despite the reduction of concentrations of some pollutants within the Mykolaiv and Kherson regions, the water quality does not meet the current surface water standards. According to studies in time and space, on average, exceeded MPC were in the observation points, such as the concentrations of pH, COD, BOC₅, hardness, dry residue, sulfates, chlorides, magnesium, sodium. The Inhulets water quality indicators were on average 1.10 times higher than the MPC.

According to the frequency of exceeding the MPC at the observation points: No. 1 – Iskrivka – unstable water pollution BOC₅, No. 2 – Arkhangelske – typical water pollution BOC₅, sulfate ions, and chloride ions; No. 3 – Snihurivka – unstable water pollution BOC₅ and persistent pollution by sulfate ions and chloride ions; No. 4 – Daryivka is characteristic contamination of water with chloride ions.

A result of the evaluation of water quality in certain classes: in terms of ammonium ions and BOD₅ – III quality class, the water is slightly polluted; in phosphate content – V quality class, water is very low in the bottom; according to the content of suspended solids, phosphates and BOD₅ – III class of water quality, water is polluted; by concentration of chlorides – V class of quality, degree of purity – very dirty; the value of suspended solids and chlorides – III class; in terms of sulfate content – IV class. In general, the highly excessive concentration of substances in the middle course remains stable, the environmental state is poor (quality class IV).

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