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Hydrobiological Assessment of Water Quality in the Yesil River, Astana Region: An Environmental Evaluation

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ABSTRACT

This study provides an in-depth characterization of the water quality in the Yesil River in the Astana region for 2019, utilizing hydrochemical parameters and key indicators of bacterioplankton, zooplankton, and zoobenthos. Quantitative evaluation methods were employed to assess hydrobionts, including total bacterial counts, heterotrophic bacterial counts, bacterial multiplication rates, biomass, and abundance of zooplankton and zoobenthos, in addition to species identification for various organisms. The results indicated that, based on the bacterioplankton development level, the investigated section of the Yesil River is classified as a mesotrophic water body. As the river flows through the city, the average bacterial mass doubling time decreases due to an increase in the proportion of heterotrophic bacteria. Based on the saprobity index level for the zooplankton community, the water in the Yesil River is categorized as moderately polluted. Macrozoobenthos saprobity indices range from moderately polluted to polluted waters. The final assessment of the water quality classification and contamination degree, according to Z.G. Gold's unified classifier, revealed a shift from class 3 in the sections upstream of Astana to class 4 in sections downstream of the city.

1. INTRODUCTION

The Yesil River holds significant importance for the Republic of Kazakhstan, spanning 1,100 km across the central and northern regions of the country. It serves as a vital water source for various settlements, including the capital city of Astana, and its surrounding suburban farms. Given the scarcity of surface water in the republic and the sparse hydrographic network [1-3], maintaining the water quality of the Yesil River is of utmost importance. Furthermore, Kazakhstan has cross-border obligations with Russia regarding the river, which originates in the northern outskirts of the Kazakh hillocky area and encompasses a water catchment area of 48,100 km^2 in its upper part. Within Russian territory, the Yesil River (known as Ishim in Russia) merges into the larger Irtysh River [4].

The rapidly expanding city of Astana intensifies anthropogenic pressure on the water body, potentially leading to severe environmental issues. Factors such as river flow regulation by reservoirs, increased water consumption by industries, communal and agricultural sectors, and pollution from storm drains substantially affect the natural water levels in the river and impair its self-purification capacity [5, 6]. Deteriorating water quality in the Yesil River could harm hydrobionts and jeopardize drinking water supplies. Consequently, regular monitoring of the river's water quality is an urgent necessity.

Traditional state water quality controls for surface waters primarily rely on determining the chemical composition, which offers limited insight into the overall environmental health. Many researchers argue that aquatic organisms serve as more accurate indicators of water quality in a water body since they exhibit a sensitive response to even minor changes in various environmental factors [7-9]. Currently, numerous integrated assessment systems for water bodies exist, often employing composite indicators based on hydrochemical and hydrobiological data [10].

The primary objective of this study is to evaluate the changes in water quality within the Yesil River, specifically in response to urban influence, by examining hydrobiological indicators. The following tasks have been delineated to achieve this goal:

1. Analyze the hydrochemical characteristics of the Yesil River upstream and downstream of Astana.
2. Determine the microbiological indicators within the river, including total bacterial counts, as well as the ratio and activity of heterotrophic components.
3. Assess the saprobity of the water body based on the identified species of zooplankton and zoobenthos.
4. Provide a comprehensive evaluation of water quality in the Yesil River.

The scientific hypothesis of this study posits that the results will yield valuable insights into the habitat conditions of aquatic organisms and the extent of anthropogenic impact from the city on the Yesil River. Furthermore, the findings can elucidate the river's potential for self-recovery. The acquired data may contribute to water resource management, fisheries, and future hydroecological research [11].

2. MATERIALS AND METHODS

In the presented study, hydrochemical and hydrobiological tests have been carried out on April, July, October 2019. A total of 72 samples has been examined in 3 months, including 36 hydrochemical, 12 microbiological, 12 samples of zooplankton, 12 samples of benthic fauna. The sample locations were selected based on the study's objectives and the characteristics of the Yesil river basin in Astana. The four sections were chosen to represent different stages of anthropogenic impact on the river, starting from a control section (section No. 1) located upstream of Astana, where the river enters the city, followed by a section (No. 2) near suburban farms that may have contributed to the river's pollution, and two sections (No. 3 and No. 4) located within and downstream of Astana, where the river is expected to receive the most significant anthropogenic impact (Table 1).

Overall, the sample locations were selected to represent different levels of anthropogenic impact on the Yesil river basin in Astana, allowing for a comprehensive assessment of the water quality in the area. The use of multiple replicates at each section for hydrochemical analysis further ensures the reliability and accuracy of the data obtained.

Hydrochemical samples have been taken, both at the water surface and at the bottom, followed by mixing, fixing and processing under laboratory conditions [12]. In the water samples we have determined: biochemical oxygen consumption (BOC), nitrites, nitrates, ammonia and ammonium ions, pH, calcium, magnesium, sulphates, total phosphorus, iron, phosphates, copper, petroleum products, surfactants (synthetic surfactants), zinc, manganese.

Based on the average values of the hydrochemical indicators, the water pollution index (WPI) has been calculated according to the physicochemical parameters:

$$WPI = \frac{1}{n}\sum_{i=1}^{n}\frac{C_i}{MAC_i} \quad (1)$$

where: C_i is the component concentration; n is the number of indicators used to calculate the index; MAC_i is the established value of the standard for the relevant water body type [13].

WPI allows to establish the water pollution degree in 7 classes: I-Very clean (WPI to 0.2), II Clean (WPI 0.2-1.0), III Moderately polluted (WPI 1.0-2.0), IV Polluted (2,0-4,0), V Dirty (WPI 4,0-6,0), VI Very dirty (WPI 6.0-0.0), VII Extremely dirty (WPI>10.0).

On the above listed sections, the samples to study microbiological indicators in the river have been selected in sterile vials: the total number of bacteria, the ratio and activity of *heterotrophic bacteria* [14]. The total number of bacteria (TNB) has been determined using direct microscopic method on a membrane filter in ordinary light under the MBB-IA microscope [15]. The number of *heterotrophic bacteria* growing on MPA (dilutions 3: 1:100 and 1:1000) has been determined in water samples. Grown colonies on MPA plates has been counted after 7 days, and diluted agar plates (MPA: 10) – after 15 days [16].

The zooplankton material in the studied reservoirs has been collected by straining 100 liters of water through the Apshtein plankton network, followed by fixing formalin and identifying organisms according to known determinants [17-19]. The quantitative processing of zooplankton samples has been carried out in the laboratory by a counting method under a microscope in accordance with modern methods. To calculate the biomass, the individual mass of organisms has been calculated from the equations of linear-weight dependence based on their examples [20]. The zooplanktocenosis saprobity has been evaluated according to the Pantle and Bukk method [21].

The benthos has been collected by the Petersen bottom grab (S – 1/40 m^2). The samples taken have been processed according to conventional methods [22]. In determining the species composition of benthic organisms, determinants have been used [23, 24].

The development level of heterotrophic components of the Yesil River. has been assessed in the framework of complex studies: bacterioplankton, zooplankton, macrozoobenthos.

For the investigated area, we have used the Gold's approach for a comprehensive assessment of the Yesil River water quality as an ichthyocenosis habitat, who, along with GOST 17.1.3.07-82, takes into account a number of additional indicators [25]. The water pollution index values are differentiated in 6 classes in conjugation with biological discretors. The use of saprobity index or saprobotoxobity index in assessments is determined by the nature of the reservoir contamination: the presence of toxicants of inorganic nature [26, 27].

Characteristics of “water toxicity” in the classifier are divided into two parameters: the saprobotoxobity zone; the degree of water toxicity. These parameters, in accordance with the saprobotoxobity values, do not apply to the 1st class of water quality, since this category is of “very clean” waters, it should not have toxicity.

Table 1. Sampling points in the Yesil river basin

Section No.	Location by the current	Average depth, m	Width, m	Water use nature
1	Vyacheslavskoye reservoir 60 km above Astana	25	10000	Small navigation, fishing, recreation and drinking water supply
2	Yesil river near the Telman village, 3 km above Astana 51°5′46.69″N (51.096303) 71°28′29.17″E (71.474769)	4	40	Amateur fishery
3	Yesil river within Astana 51°9′28.94″N (51.15804) 71°24′52.48″E (71.414578)	4	40	Recreation, amateur fishing, supply of domestic and industrial wastewater
4	Yesil River near the Koktal village, 8 km below Astana 51°10′21.92″N (51.172755) 71°19′55.85″E (71.332181)	5	45	Irrigation, amateur fishing

The final expert assessment on the water quality class of the analyzed classifier is carried out according to the following principles (approaches):

– the highest class, assessing the maximum impact, should show no less than 30% of the compared indicators;

– two water quality classes allocated according to equal (or close) proportions of different indicatos are designated as borderline through a hyphen.

In the case of obtaining non-coincident assessments for water quality classes, *the rule* remains: the final conclusion is made by the parameter that reveals the maximum impact on the environment [25, 28]. The unified classifier by Gold [25] allows based on the obtained indices to determine 4 water characteristics: quality class, pollution degree, saprotoxobity zone and toxicity degree. The obtained indicators for assessing water allow to judge the habitation conditions of hydrobionts. The detection value for quality class may be expressed as a numerical score or a categorical rating system (e.g., excellent, good, fair, poor, etc.) depending on the assessment method. The detection value for pollution degree may be expressed in terms of the concentration of specific pollutants or a composite index that combines multiple pollutants. The detection value for saprotoxicity zone may be expressed in terms of the dissolved oxygen concentration or a measure of bacterial activity. The detection value for toxicity degree may be expressed in terms of the concentration of specific toxins or a composite index that combines multiple toxins. The corresponding detection value for each of the four water quality characteristics may vary depending on the specific methods and criteria used to assess them. The statistical processing of the material has been carried out by standard methods [25]. The reliability of average differences has been assessed using a two-sample Student t-test with different dispersions ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

Water pollution indices in the Yesil river in 2019 were determined on the basis of individual concentrations of nitrites, nitrates, ammonium salt, chlorides, sulfates, Ca, Mg, Fe, Cu, SSAS, petroleum products. Prior to the entry into the city, post No. 1 and section No. 2, excess concentrations of sulfates (2.59 MACs), copper (4 MACs) were observed in the water. In the city and below the city (section No. 3 and section No. 4), MACs were exceeded in waters for salt ammonium (2.5 MACs), magnesium (1.22 MACs), nitrites (1.87 MACs), petroleum products (2.68 MACs), iron (2.5 MACs), SSAS (5.3 MACs).

The Water Pollution Index (WPI) is a commonly used method for assessing the level of pollution in water bodies. The WPI is calculated based on the levels of five different parameters: dissolved oxygen, pH, biochemical oxygen demand, conductivity, and total solids. The classification standard of water pollution according to WPI:

1. WPI value between 0 and 20 (water is considered to be unpolluted or minimally polluted).
2. WPI value between 21 and 30 (water is considered to be slightly polluted).
3. WPI value between 31 and 50 (water is considered to be moderately polluted).
4. WPI value between 51 and 70 (water is considered to be heavily polluted).

We have calculated the average arithmetic parameters of the WPI for 3 months for each section. In general, if the water in the Yesil river above the city (section No. 1 and section No. 2) is estimated as “moderately polluted” (WPI 1.67 and WPI 1.93), then in the city center and below the city, water quality deteriorates (WPI 3.1 and 3.58, respectively), and is estimated as “polluted”. The water quality according to the hydrochemical indicators for our previous works has deteriorated. So, for example, in 2013 the WPI on the Yesil river was 2.3, but in 2019, no excess of manganese content was observed [29].

The results of a bacterial community study are presented in Table 2. In the Vyacheslavskoe reservoir (section 1) the total number of bacteria was 1.960±0.026 million cells/ml. The bacteria number on the FPA was 16.870±0.953 thousand cells/ml.

The ratio of these groups (N_{het}/N_b) was 0.0086. The bacteria number doubling rate was within 25-27 h. Under river conditions, the smallest average number of bacteria was observed at section 2 (3.150±0.062 million cells/ml), the total number of bacteria increased insignificantly at section 3 to 3.650±0.060 million cells/ml and 3.720±0.110 million cells/ml on section 4. However, the average time of the bacterial mass doubling decreases from 26 hours above the city to 20 hours below the city, which may indicate an increase in the bacteria activity as the river is polluted with organic residues. The latter is consistent with the fact that as the river passes through the city, the share of heterotrophs increases (from 15.00±3.120 thousand cells/ml and above the city to 81.300±5.200 thousand cells/ml in the city and 92.410±6.790 cells/ml below the city).

Increased number of heterotrophic bacteria is most likely due to the excess of readily digestible organic matter in the medium, the dying of phytoplankton and zooplankton species most sensitive to pollutants.

The proportion ratio of the *heterotrophic bacteria* (*N heterotrophs*) to the total bacterial content (*N bacteria*) as an indicator of the proportion of readily decomposable organic matter increases from section No. 2 (0.0044) and section 3 (0.022) to section No. 4 (0.025). These are high indicators for the river, which indicate a strong negative impact of the city on the river [16, 30, 31]. According to earlier studies in 2013, the maximum ratio of saprophytes to the total number of bacteria did not exceed 0.31% [29].

Table 2. Quantitative indicators (average for the season) of the Yesil river bacterioplankton (2019)

Indicators	Section No. 1	Section No. 2	Section No. 3	Section No. 4
Total number of bacteria, mln.cells/ml (Nb)	1.960±0.026	3.150±0.062	3.650±0.060	3.720±0.110
Number of *heterotrophic bacteria*, thousand cells/ml (Nhet)	16.870±0.953	15.000±3.120	81.300±5.20	92.410±6.790
Ratio of Nhet to Nb	0.0086	0.0044	0.022	0.025
Doubling time of bacteria, h	25	26	22	20

In accordance with Governmental Standard 17.1.3.07.-82, the water quality of the Yesil river investigated region was assessed according to the bacterioplankton indicators (Table 3).

Table 3. Assessing water quality in the Yesil river basin

Section	Number of bacteria, million cells/ml	Class, quality degree
1	1.96	3 – moderately polluted
2	3.15	4 – polluted
3	3.65	4 – polluted
4	3.72	4 – polluted

Source: according to Governmental Standard 17.1.3.07 – 82 [32]

The Vyacheslavskoye reservoir water corresponded to class 3, as it was moderately polluted, and the water in the area of sections No. 2, No. 3 and No. 4 was classes 4, as polluted.

Zooplankton. Within the study area, the zooplankton of the Ishim River includes widespread river species. A total of 35 species of plankton organisms have been identified, including 18 rotifers (Rotatoria), 13 cladocera and 4 copepoda. Copepoid and nauplial stages of cyclops were encountered in the river plankton throughout its entire extent. The zooplankton species composition of the Yesil River in 2019 is presented in Table 4.

The zooplankton biomass depends both on the number of dominant species and on their belonging to the main group and amounts to 0.85 to 1.70 g/m^3 in different biotopes where crustaceans dominate, biomass is higher; with the predominance of rotifers, as a rule, it is low.

The zooplankton of the upper and lower river sections is the most peculiar – not only in the number of species, but also in the qualitative composition of the community. In most biotopes, the number was formed by a group of copepods, from 45.5 to 84.0%. The value of rotifers was noticeable only in the middle reach – 42.1%. The variation in the abundance of copepods in different biotopes along the Yesil river is related to the water quality parameters of the river. Copepods are generally considered indicators of good water quality, as they are sensitive to changes in water chemistry and pollution levels. In the case of the Yesil river, the proportion of copepods in the zooplankton community is highest in the upper and lower river sections, where the water quality is relatively better, and decreases in the middle reach, where the water quality is poorer. This pattern suggests that copepods may be more abundant in areas with lower pollution levels and higher dissolved oxygen concentrations, which are conditions that favor their growth and reproduction. The decrease in the abundance of copepods in the middle reach of the river, where the water quality is poorer, may be due to a number of factors, such as increased levels of organic and inorganic pollutants, reduced dissolved oxygen concentrations, and changes in water flow and temperature.

Table 4. Zooplankton species composition of the Yesil river in 2019

Species	Environmental group	Species	Environmental group
Phylum *Nemathelminthes*		Family *Testudinellidae*	
Class *Rotatoria*		*Testudinella patina (Hermann)*	*eur*
Order *Ploemidae*		Family *Filiniidae*	
Family *Trichocercidae*		*Filinia longiseta (Ehr.)*	*eur*
Trichocerca cylindrical (Imhof)	*eur*	Phylum *Arthropoda*	
Trichocerca capucina (Wierzeisky et Zacharias)	*eur*	Superorder *Cladocera*	
Trichocerca longiesta (Schrank)	*eur*	Order *Daphniiformes*	
Family *Gastropodidae*		Family *Daphniidae*	
Ascomorpha saltans Bartsch		*Daphnia longispina s. lat.*	*eur*
Family *Synchaetidae*		*Simocephalus vetulis (O.F.M.)*	*L, p*
Polyarthra dolychoptera	*eur*	*Ceriodaphnia quadrangula (O.F.M.)*	*eur*
Polyarthra liminosa Kuticova	*pl*	*Ceriodaphnia affinis Lill.*	*eur*
Bipalpus hudsoni (Imhof)	*L*	*Scapholeberis mucronata (O.F.M.)*	*L*
Family *Asplanchnidae*		Family *Macrothricidae*	
Family *Lecanidae*		*Macrothrix hirsuticornis N.etB*	*b, p*
Lecane luna (Muller)	*eur*	Family *Chydoridae*	
Family *Epiphanidae*		*Eurycerus lamellatus (O.F.M.)*	*L, p*
Epiphanes senta (Muller)	*pl*	*Pleuroxus trigonellus (O.F.M.)*	*eur*
Family *Trichotriidae*		*Pleuroxus uncinatus Baird*	*eur*
Trichotria truncate (Whiteleg)	*eur*	*Chydorus sphaericus (O.F.M.)*	
Trichotria pocillum (Muller)	*eur*	*Alona rectanqula Sars*	*eur*
Family *Mytilinidae*		*Alona quadranqularis (O.F.M.)*	*L*
Mytilina ventralis (Ehrenberg)	*L*	*Acroperus harpae (Baird)*	*L, p*
Family *Euchlanidae*		*Graptoleberis testudinaria (Fis)*	*L, p*
Euchlanis dilatata Her.	*L*	Order *Copepoda*	
Euchlanis deflexa Gosse	*L*	Family *Cyclopidae*	
Family *Branchionidae*		*Eucyclops serrulatus (Fish.)*	*eur*
Brachionus calyciflorus Pallas	*eur*	*Cyclops vicinus Uljan.*	*eur*
Kellicottia longispina (Kell.)	*pl*	*Cyclops strenuous Fisch*	*eur*
Order *Monimotrochidae*		*Mesocyclops leuckarti Claus*	*eur*
Family *Conochilidae*			
Conochilus hippocrepis (Schr.)	*eur*		

Note: pl – planktonic, b – benthic, l – littoral (coastal), ph – phytophilic, eur – eurytropic

In spring the zooplankton of the river is poor by study results. The zooplankton number ranges from 59.5 to 101.2 thousand specimens/m^3, and the biomass ranges from 0.85 to 1.1 g/m^3. Summer stocks of animal plankton are higher; the number increases to 97.2-108.8 thousand specimens/ m^3, and the biomass reaches to 1.7 g/m^3. As in the spring, copepods predominate among zooplankton, their abundance ranges from 61.2 to 75.4 thousand specimens/m^3, and the biomass ranges from 0.567 to 0.965 g/m^3 among which the younger copepodite stages of *Thermocyclops Oithonoides* dominate. Then the *cladocera* follow, the number of which varies from 16.5 to 37.2 thousand specimens/m^3, and biomass – from 0.32 to 0.67 g/m^3. The number of rotifers in most cases is low and does not exceed 12,300 specimens/m^3, the biomass is no more than 0.2 g/m^3, due to the predominance of small species. In the autumn, the development of zooplankton decreases. The average number of plankton organisms is an average of 67.8 thousand specimens/m^3, and biomass – 0.96 g/m^3. The number is dominated by rotifers, and biomass – *cladocera (daphnia)*.

The values of the zooplankton saprobity index have been calculated for the investigated section of the Yesil River (Table 5).

The average zooplankton number on the Yesil River is 78.9 thousand specimens/ m^3, and the biomass is equal to 1.103 g/m^3 (Table 6). According to the zooplankton development, the Yesil River belongs to water bodies with the low food supply. According to the zooplankton biomass level, the Yesil River belongs to mesotrophic water bodies (biomass of 1.2-1.8 g/cm^3). According to the assessment of the saprobity index level, calculated for the zooplankton community, the water of the Yesil river entering the city corresponds to the class to moderately polluted waters, after entering the city the water in the river corresponds to class 4 – polluted.

Table 5. Distributing values of the zooplankton community saprobity index of the Yesil river (2019)

Section	Saprobity for zooplankton (Sz), score	Quality class, pollution degree
1	2.1 – ß-mst	class 3 – moderately polluted
2	2.5 – a,ß-mst	class 3 – moderately polluted
3	2.98 – a-mst	class 4 – polluted
4	3.04 – a-mst	class 4 – polluted

Table 6. Average number (N, thousand specimens/ m^3) and biomass (B, g/ m^3) of the main zooplankton groups of the Yesil river (2019)

Section	Rotifers		Cladocerans		Copepoda		Total	
	N	B	N	B	N	B	N	B
2	1.8±0.020	0.1±0.020	7.9±2.041	1.0±0.012	51.5±5.47	0.1±0.01	61.2±10.53	1.2±0.02
3	6.8±1.032	4.2±0.85	4.9±1.71	1.22±0.08	4.16±1.47	0.4±0.08	28.2±9.53	0.78±0.051
4	7.9±1.230	0.36±0.011	38.7±4.033	1.22±0.02	20.1±2.15	0.3±0.01	66.6±14.32	1.81±0.09

Table 7. Species composition, ecological groupings of zoobenthos of the Yesil river

Species	Environmental group	Species	Environmental group
Phylum *Mollusca*		Order *Diptera*	
Class *Gastropoda*		Family *Chironomidae*	
Family *Valvatidae*		*Ablabesmyia (Linne, 1758)*	*f, n*
Valvata cristata O.F.Muller, 1774	*f*	*Procladius choreus Meigen, 1804*	*eur*
Family. *Pisidiidae*		*Procladius ferrugineus Kieffer, 1919*	*eur*
Pisidium amnicum (O.F.Muller, 1774)	*f, n, ps-p*	*Tanypys villipennis Kieffer, 1918*	*f, n*
Phylum *Annelides*		Subfamily *Orthocladiinae*	
Class *Oligochaeta*		*Cricotopus algarum Kieffer, 1909*	*f*
Family *Enchytraeidae*		*Cricotopus silvestris (Fabricius, 1794)*	*f*
Enchytraeus sp.	*n, ps*	*Psectrocladius psilopterus Kieffer, 1906*	*ps, ps-p*
Family *Lumbriculidae*		Subfamily *Chironominae*	
Lumbriculus sp.	*n, ps-p*	*Chironomus plumosus (Linne, 1758)*	*n, ps-p*
Family *Tubificidae*		*Cryptochironomus defectis Kieffer, 1921*	*eur*
Tubifex tubifex (O.F.Muller, 1773)	*n, ps-p*	*Cryptochironomus sp. (genuinae N 9, Lipina 1926)*	*ps-p*
Class *Hirudinea*		*Polypedilum exectum Kieffer, 1915*	*f, n, l*
Family *Glossiphonidae*		*Tanytarsus sp.*	*f, ps-p*
Helobdella stagnalis (L., 1758)	*b*	Order *Ehemeroptera*	
Phylum *Arthropoda*		Family *Caenidae*	
Class *Arachnoidea*		*Caenis macrura Stephens, 1835*	*f, ps-p, pt*
Order *Acarina*		*Caenis sp.*	*f, ps-p, pt*
Hydracarina sp.	*nb*	Family *Ephemerellidae*	
Class *Crustacea*		*Ephemerella ignita (Poda,1761)*	*eur*
Order *Amphipoda*		Order *Trichoptera*	
Family *Gammaridae*		Suborder *Integripalpia*	
Rivulogammarus lacustris Sar.	*eur*	Family *Limnephilidae*	
Class *Insecta*		*Limnophilus flavicornis Fabr.*	*f, pt*

Note: b – benthic, p – pelophilic, ps – psammophil-psammopelophilic, ph – phytophilic, l – lithophilic, eur – eurytropic, ph – phitic (in fouling), ep – epimiotic, nb – nektobenthos

Zoobenthos. During the study 24 taxa of benthic animals have been recorded in the Yesil river, 19 of them have been identified to the species (Table 7). Among the found benthic animals, 6 classes, belonging to the *Mollusca*, *Annelides*, *Arthropoda* types, have been identified. By species diversity, the *Chironomidae* family of the *Diptera* order (12 species) dominated. The *Mollusca t*ype is represented by 2 species, *Annelides* type – 4 species, *Arthropoda* type besides chironomids is represented by ticks (1 taxon), crustaceans (1 taxon), caddis flies (1 species).

The zoobenthos number depends both on the biotope characteristics and on the season of the year [22, 33, 34]. The number of this group of aquatic invertebrates ranged from 780 to 1478 specimens/m^2, and the biomass ranged from 1.92 to 4.34 g/m^2.

In spring, the average number of benthic invertebrates was 1278 specimens/m^2, and the average biomass was 3.91 g/m^2. A significant number of larvae of chironomids have been recorded by the number and biomass in the samples – 160 specimens/m^2 and 1.12 g/m^2, among which *Chironomusplumosus predominate*. In summer, the total number of benthos decreased to 1244 specimens/m^2 and biomass reduced to 2.38 g/m^2. In autumn stocks of benthic invertebrates are also low: the average number of zoobenthos is 1140 specimens/m^2 and the biomass is 2.57 g/m^2.

Quantitatively, *oligochaetes*, as well as larvae of *chironomids*, prevailed, *oligochaetes* were the sample basis by biomass. The average number of zoobenthos along the Yesil River was 1200 specimens/m^2, and the average biomass was 2.95 g/m^2. The dominant forms in almost all samples are larvae of *chironomids* and *oligochaetes*. In general, the biomass of feed organisms in the river is low, which is understandable, given that the river has a relatively fast current, the absence of any flow, creeks [35]. Generally, faster-moving rivers tend to have lower biomass and biodiversity compared to slower-moving rivers or streams. This is because faster-moving water creates a more turbulent environment, which can make it difficult for many aquatic organisms to survive.

According to the zoobenthos development level, the reservoir can be referred to the mesotrophic type of class 3 of average food capacity (2.5-3.0 g/cm^3) in accordance with the Kitaev's scale [11]. An assessment of the species diversity of benthic organisms, taking into account the saprobity index, has made it possible to determine the water saprobity degree in the investigated area of the Yesil River (Table 8).

Indicator species of zoobenthos, in contrast to zooplankton, have showed a more pronounced degree of the reservoir saprobity at all sections. If the saprobity for zooplankton at section No. 1 corresponded to ß-mesosasaprobic, and at section No. 2a, to ß-mesosaprobic zone, then for the benthic organisms section No. 1 is a, ß-mesosaprobic, and section No. 2 is a-mesosaprobic. Thus, the water quality assessment according to hydrobiological indicators corresponded to classes 3 and 4, moderately polluted and polluted water in various sections.

Table 8. Distributing the values of macrozoobenthos saprobity index and water quality of the Yesil river (2019)

Section	Sb, score	Quality class, water pollution degree
1	2.5 – a,ß-mst	class 3 – moderately polluted
2	3.2 – a-mst	class 4 – polluted
3	3.3 – a-mst	class 4 – polluted
4	3.4 – a-mst	class 4 – polluted

In water systems with a diverse range of uses, the water quality assessment should be carried out on a set of chemical and biological indicators, taking into account the intake of organic compounds and pollutants that have toxicity [25, 36]. Table 9 gives an assessment of the Yesil River waters quality by a set of indicators in accordance with the unified Gold's Classifier [26].

Saprobity index values are taken as the arithmetic mean between the saprobity indexes for zooplankton and zoobenthos. To determine the final assessment, the average scores for each indicator have been found.

Thereby, by a set of the hydrochemical indicators, the deterioration of water quality is traced along the Yesil River near Astana from the Vyacheslavskoye reservoir (section No. 1) to the Koktal village (section No. 4) from the WPI 1.67 (class 3 of water quality) to the WPI 3.58 (class 4 of water quality). The pollution from the city was observed in salt ammonium (2.5 MACs), magnesium (1.22 MACs), nitrites (1.87 MACs), petroleum products (2.68 MACs), iron (2.5 MACs), SSAS (5.3 MACs). The pollution of the river by sulfates and copper is natural.

As the river passes through the city, the total number of bacteria increases from 1.960±0.026 (section No. 1) to 3.720±0.110 (section No. 4); the ratio of the heterotrophic component to the total number of bacteria increases, from section No. 2 (0.0044) and section No. 3 (0.022) to section No. 4 (0.025); the bacteria doubling is accelerated from 25 hours to 20 hours. This is a high indicator for the river, which indicates a large amount of easily digestible organic matter entering the river.

Table 9. Assessment of the Yesil River waters quality by a set of hydrochemical (mean monthly values) and biological indicators of 2019) in accordance with the unified Z.G. Gold's classifier

Indicator	Section			
	No. 1	No. 2	No. 3	No. 4
WPI, score	1.67 3	1.93 3	3.1 4	3.58 4
Total number of bacteria, million cells/ml, score	1.96 3	3.15 4	3.65 4	3.72 4
Saprobity index, score	2.1 3	2.5 3-4	2.98 4	3.04 4
Final class assessment and pollution degree	3 – moderately polluted	3-4 – moderately polluted, polluted.	4 – polluted	4 – polluted
Saprotoxobity area	ß-mesosaprotoxobic water, ß-mst	a-ß-mesosaprotoxobic water, a,ß-mst	a-mesosaprotoxobic water, amst	a-mesosaprotoxobic water, amst
Toxicity level	Weakly toxic	Weakly toxic	Moderately toxic	Moderately toxic

Source: [25]

The saprobity for zooplankton at section No. 1 corresponded to ß-mesosaprobic, and at section No. 2a, to ß-mesosaprobic zone. For the benthic organisms section No. 1 is a, ß-mesosaprobic, and section No. 2 is a-mesosaprobic. Sections No. 3 and No. 4 both for zooplankton and zoobenthos belong to the a-mesosaprobic zone. Thus, the water quality assessment according to hydrobiological indicators corresponded to classes 3 and 4, moderately polluted and polluted water.

A comprehensive assessment of water quality in the Yesil River in 2019 in accordance with the unified Z.G. Gold’s classifier has showed that the river water before entering Astana (section No. 1 – Vyacheslavskoye reservoir) is moderately polluted (class 3) ß-mesosaprotoxic, weakly toxic. Water in the area of Telman village to the city (section No. 2) has class 3-4 of quality – from moderately polluted to polluted waters, a-ß-mesosaprotoxobic, weakly – moderately-toxic waters. From Astana and downstream (sections No. 3, 4), water is rated by class 4 of quality – polluted, a-mesosaprotoxobic, moderately-toxic.

4. CONCLUSIONS

The final water quality assessment of the sites examined has showed that the Yesil river water before entering the city (section No. 1 – Vyacheslavskoye reservoir) is moderately polluted (class 3), ß-mesosaprotoxobic, weakly toxic. This site is characterized by the most favorable environmental conditions compared to those studied. The Yesil River in the region above the location of Astana (section No. 2 – Telman village) has a transitional from class 3 to 4 of quality – from moderately polluted to polluted waters, a-ß-mesosaprotoxobic, weakly-moderately toxic waters. From Astana and downstream (sections 3, 4), water is estimated in the class below: quality class 4 – polluted, a-mesosaprotoxobic, moderately toxic.

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