The ecological characteristics of small rivers in the Shilka river basin by zoobenthos organisms

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Abstract. Zoobenthos organisms are directly related to the biogeochemical processes occurring at the bottom and in the water column of the channel. The paper presents the results of studies of the quantitative characteristics of the zoobenthos and the water quality of small rivers in the river basin of Shilka in the area of gold mining enterprises.

1. Introduction
The Shilka River flows through the territory of the Trans-Baikal Territory and is the left part of the river Amur. The length of the river is 560 km. The basin area is 206 thousand \text{km}^2 – and is the second largest Amur basin.

In the Shilka river basin, there are about 100 rivers less than 200 km long, which is up to 99\% of the total number of watercourses in this river network. Due to the fact that small rivers are an integral part of larger systems and affect the formation of hydrobiological characteristics, their study is relevant. During the passage of large floods, there occur morphological changes in river channels, thereby affecting the biotic components of the ecosystem. In addition to floods, significant changes are made by mining in the channels of such rivers. A number of researchers note that in order to better preserve and restore the ecosystem of the stream, it is necessary to bring the aquatic ecosystem to the corresponding unregulated conditions. At the same time, a field arose in environmental research, involving the study of the modified and heterogeneous previously regulated systems. To understand the basic processes occurring in river ecosystems, it is necessary to pay attention to the duration of monitoring observations, compliance with the landscape characteristics, distribution and structure of biotic communities.

It is known that the quantitative characteristics of biotic components are used to assess the impact factors, which indicate changes in the state of aquatic ecosystems. The literature provides various methods of the ecological state of rivers, based on the use of physical, chemical, hydrological and biological indicators. One of the widely used indicators for the biological assessment of water quality is the communities of macroinvertebrates in different parts of rivers [1–5].

The task of the conducted environmental studies was the accumulation and analysis of information, the result of which is presented in the form of an assessment of the quality of the studied ecosystems, the identification of possible structural and functional changes in biotic components, with the aim of using this information in the development of parameters of permissible load, assessment of damage to
biological resources, impact on the ecosystem as a whole and the formation of an idea of the ways to solve these issues.

2. Materials and Methods
Field collections of the material from benthic invertebrates were carried out in June and September 2020 in small watercourses of the river basin of Shilka in the area of gold mining enterprises: Cherny Uryum, Itaca, Alekseevsky, Zheltuga, Boguzeya, Davenda, Kudechi, Luzhanki, Kara, Bogocha. The order and characteristics of the watercourse are given in table 1. At each station, the coastal zone of the observation section was surveyed.

Table 1. The order of the investigated tributaries of the Shilka main river.

| Name of the river | Distance from the mouth, km | Watercourse characteristics | Area, km² |
|-------------------|-----------------------------|----------------------------|-----------|
| Cherny            | 247                         | 76                         | 12100     |
| Zheltuga          | 173                         | 48                         | 1350      |
| Luzhanki          | 275                         | 45                         | -         |
| Kara              | 280                         | 37                         | -         |
| Bogocha           | 290                         | 25                         | -         |
| Cherny Uryum      | 76                          | 136                        | 5190      |
| Boguzeya          | 18                          | 36                         | -         |
| Davenda           | 30                          | 36                         | -         |
| Kudechi           | 32                          | 25                         | -         |
| Itaka             | 50                          | 91                         | -         |
| Alekseyevsky Stream | 52                          | 17                         | -         |

* no data.

The quantitative samples of benthic invertebrates were taken with a standard Petersen bottom grab with an area of 0.025 m² in triplicate, and the Schroeder-Zhadin method was also used by collecting organisms from stones and taking into account their area. For the qualitative samples, the collection of benthic organisms was carried out manually from coastal stones and vegetation using the Schroeder-Zhadin method without taking into account the area [6–8]. When studying the species composition, keys were used [9–22]. To assess the species diversity, the Shannon-Weaver index was used. The ecological state of watercourses was described using [8].

3. Results and Discussion
As a result of processing the benthofauna samples, taxa of different systematic levels were identified, belonging to the same Nematoda type and to four classes: Clitellata, Arachnidae, Insecta, and Gastropoda. The most diverse class of insects is represented, among which five orders have been identified: Plecoptera, Ephemeroptera, Trichoptera, Colembola and Diptera. The order of Diptera of the Chironomidae family, represented by three subfamilies: Orthocladiinae, Chironominae, and Tanypodinae, was noted to be dominant in the species richness. Mayfly orders are subdominant in the species diversity. The structure was based on the species classified as widespread eurybiontic and eurythermic species. By the nature of the studied biotopes, psammophilic and pelophilic species, developing on sandy and silty soils, prevailed.
In general, the species composition of the studied areas is characterized by the dominance of Chironomidae, followed by Ephemeroptera and Plecoptera. The representatives of Colembola, Nematod and Gastropoda were the isolated species.

The abundance of zoobenthos in the studied areas varied from 0.027 to 3.280 × 10^3 ind. m^-2 (table 2). In June, chironomids (up to 100%), oligochaets – 35%, and Diptera (family Culicidae and family Tipulidae) – 22% dominated among the groups. The maximum number was noted in the background section of the Itaka River – 3.280 × 10^3 ind. m^-2, with a predominance of chironomids up to 58% of the genera Corynoneura, Cricotopus, Tanytarsus and oligochaets up to 35%, and in the Alekseevsky Brook – 1.240 × 10^3 ind. m^-2, with a predominance of chironomids up to 87% of the genera Orthocladius, Cricotopus, Tanytarsus, Tanypus. In September, oligochaets and chironomids (up to 100%) and trichoptera (up to 80%) dominated among the groups. The maximum number was noted on the Kara River and Kudechi River – 0.599 × 10^3 ind. m^-2, with a predominance of chironomids up to 87% of the genera Orthocladius, Glyptotendipes, Stictochironomus, Tanytarsus, Tanypus.

The biomass of benthic fauna varied from 0.022 to 9.057 g m^-2 (table 2), excluding caddis trichoptera and molluscs (in accordance with the methodology). In June, the predominant biomass groups were chironomids and plecopters up to 100%, ephemeropters up to 70%. At the same time, the maximum biomass was noted in the background section of the Itaka River – 3.220 g m^-2, where the basis was made up of chironomids up to 47%, oligochaets up to 27% and trichopters up to 19%. In September, the predominant groups in terms of biomass were chironomids and oligochaets up to 100%, plecopters and trichopters up to 90%. At the same time, the maximum biomass was noted on the Cherny Uryum River below the gold mining area – 9.057 g m^-2, where the basis was made up of fewer, but large-sized trichopters – 90% of this. Limnophilidae and above the gold mining area – 1.670 g m^-2, with a predominance of diperans by weight of family Tipulidae up to 99%.

The species diversity index was assessed using the Shannon-Weaver method. The index varied from 0 to 3.14 bits specimen^-1 (table 2). The maximum indices were recorded in June on the Cherny Uryum River above the gold mining area – 3.14 bits specimen^-1, represented by six species of chironomids of the genera Orthocladius, Thienemanniella, Cricotopus, Tanytarsus, Tanypus, two species of ephemeropters of the genera Baetis and Heptagenia, as well as larvae of diperans and gastropods of the genus Cincinna. In September, the Shannon-Weaver index reached 2.12 bits specimen^-1 Kudechi River of the channel drainage channel, represented by three species of chironomids of the genera Thienemanniella, Tanytarsus, Tanypus, ephemeropters of the genus Baetis, and trichopters flies of the genus Apatania.

**Table 2. Quantitative indicators of zoobenthos in June/September.**

| Station name          | Number, ×10^3 ind. m^-2 | Biomass, g m^-2 | Shannon-Weaver, bit specimen^-1 | Water quality |
|-----------------------|--------------------------|-----------------|---------------------------------|---------------|
|                       |                           |                 | average                         | maximum       | by Woodiwiss class | by TBI saprobity zone |
| Cherny Uryum River    |                           |                 | 3.14/1.00                       | 3.59/1.00     | 5/1               | II/IV                 |
| Upstream              | 0.79/0.07                | 1.05/1.67       |                                 |               |                   | α-mesosaprobic/ polysaprobic |
| Downstream            | -/0.07                   | -/9.06          | -/1.00                          | -/1.00        | -/4               | -/III                 |
| Itaka River           |                           |                 |                                 |               |                   | -/α-mesosaprobic      |
| Upstream              | 3.28/-                   | 3.22/-          | 1.00/-                          | 1.00/-        | 2/-               | IV/-                  |
| Downstream            | 0.32/-                   | 0.10/-          | 3.06/-                          | 3.70/-        | 2/-               | IV/-                  |
| Alekseevsky Brook     | 1.24/0.03                | 1.05/0.02       | 2.52/0                          | 3.17/0        | 2                 | IV                    |
| Zhel'tuga River       | 0.07/-                   | 0.05/-          | 2.22/-                          | 2.59/-        | 2/-               | IV/-                  |
| Downstream            |                           |                 |                                 |               |                   | polysaprobic         |


| River/Location                          | Biotic Index | Saprobity            |
|----------------------------------------|--------------|----------------------|
| Davenda River mouth Boguzeya River     | 0.41/-       | mesosaprobic         |
|                                        | 0.14/-       |                      |
|                                        | 2.06/-       |                      |
|                                        | 2.32/-       |                      |
|                                        | 5/-          |                      |
|                                        | II/-         | mesosaprobic         |
|                                        | α/-          |                      |
| Davenda River                          | 0.20/-       |                      |
|                                        | 0.10/-       |                      |
|                                        | 2.06/-       |                      |
|                                        | 2.81/-       |                      |
|                                        | 2/-          |                      |
|                                        | IV/-         | polysaprobic         |
|                                        | α/-          |                      |
| Downstream from the drainage reservoir | 2.00/-       |                      |
|                                        | 2.10/-       |                      |
|                                        | 1.00/-       |                      |
|                                        | 1.00/-       |                      |
|                                        | 2/-          |                      |
|                                        | IV/-         | polysaprobic         |
|                                        | α/-          |                      |
| Former drainage reservoir              | 0.16/0.60    | mesosaprobic         |
|                                        | 0.05/0.23    |                      |
|                                        | 1.91/2.12    |                      |
|                                        | 2.00/2.81    |                      |
|                                        | 5/2          |                      |
|                                        | II/IV        |                      |
|                                        | α/-          | mesosaprobic         |
|                                        | polysaprobic |                      |
| Luzhanki River                         | -/-0.02      |                      |
|                                        | -/-0.00      |                      |
|                                        | -/-1.90      |                      |
|                                        | -/-2.00      |                      |
|                                        | -/-2         |                      |
|                                        | -/-IV        |                      |
|                                        | α/-          | mesosaprobic         |
|                                        | polysaprobic |                      |
| Kara River                             | 0.40/-0.6    | polysaprobic/α       |
|                                        | 0.65/0.54    | mesosaprobic         |
|                                        | 1.76/3.04    |                      |
|                                        | 2.00/3.46    |                      |
|                                        | 2/5          |                      |
|                                        | IV/II        |                      |
|                                        | α/-          | mesosaprobic         |
|                                        | polysaprobic |                      |
| Bogocha River                          | 0.69/-       | α                    |
|                                        | 0.34/-       | mesosaprobic         |
|                                        | 2.97/-       |                      |
|                                        | 3.32/-       |                      |
|                                        | 5/-          |                      |
|                                        | II/-         | mesosaprobic         |
|                                        | α/-          |                      |

Water quality was assessed by the Woodiwiss Biotic Index, and saprobity by the extended Trent Biotic Index (TBI) recommended by Roshydromet. The Woodiwiss biotic index took values of 1, 2, 4, 5, which corresponded to V, IV, III, II quality classes, extremely dirty, dirty, polluted and slightly polluted waters. 55% of the cases of the studied samples could be attributed to dirty waters, 33% to slightly polluted ones. It can be noted that the low water quality in the assessment is due to the formation of biotopes with the dominance of the chironomids complex.

4. Conclusion
The fauna of macrozoobenthos is represented by the dominant group of chironomid larvae with high ecological plasticity. Larvae of mayflies, stoneflies and caddisflies were also observed inside the streams. The distribution of larvae is determined by hydrological conditions, soil types, and specific features of life cycles. The studies carried out revealed a low species diversity in the worked-out areas of gold mining and low water quality.

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