Environmental and chemical characteristics of the Zeya-Bureya plain small river Filinovka

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Abstract. The article discusses the results of hydrochemical study of water of the small Filinovka River, the left-bank tributary of the Amur River, flowing along the south of the Zeya-Bureya Plain. Water is characterized by high oxygen content. The content of nitrogen and phosphorus compounds in water undergoes seasonal dynamics. The water of the small Filinovka River is characterized by a high content of iron and manganese, which are caused by the natural factor. The content of zinc and copper in water is higher than the fisheries standard. Macrophytes Najas marina and Ceratophyllum oryzetorum and feathers of birds Grus monacha and Grus vipio contain a high concentration of lead and cadmium. The results of studying the hydrochemical parameters of the water ecosystem of a small river flowing along the south of the Zeya-Bureya plain are the basis for studying the agricultural load on small rivers.

1. Introduction
The Amur Region has historically been the agricultural breadbasket of the Far East. The development of agriculture has led to the transformation of natural territories into agrolandscape. The use of fertilizers and chemicals has an adverse effect on the condition of soils and small rivers. The source of environmental pollution with heavy metals is agricultural activity [1, 2]. Heavy metals from soils during the flood period fall into the water of small rivers [3] and accumulate in bottom sediments. Heavy metals are dangerous environmental pollutants. Heavy metals are transmitted along trophic chains [4, 5]. In the floodplains of the Zeya-Bureya plain small rivers, lands were plowed, forests were cut down, and water storage reservoirs were built. Such major changes contributed to the deterioration of water quality in small rivers [6, 7]. It is necessary to study the ecological state of small rivers, which are very sensitive to the effects of technogenic and anthropogenic pollution. Heavy metals can accumulate in macrophytes, which enter rivers as a result of runoff from surface soil layers into water during severe flood rise and floods. Macrophytes take part in the processes of river self-purification, extracting heavy metals from bottom sediments and water. Higher aquatic plants serve as habitats and food for aquatic and near-water birds. All this determined the importance of studying the ecological state of small rivers.

The purpose of the current work is to study the ecological state of the small Filinovka river on the basis of hydrochemical indicators of water and the content of heavy metals in the components of the ecosystem.
2. Objects and research methods
The object of the study is a small river - Filinovka (Chebachikha) - the left-bank tributary of the Amur River. The Filinovka River flows into the river Amur 1835 km from the mouth; the length of the watercourse is 23 km. The uniqueness of the location of the river lies in the fact that there are wetlands nearby, which are the habitats of such bird species that are classified as endangered species in the IUCN Red List - the Far Eastern stork Ciconia boyciana (Swinhoe, 1873), as vulnerable species - black Grus monacha (Temminck, 1835) and Daurian Grus vipio (Pallas, 1811) cranes.

Water samples were taken in five sections. Sampling of water, macrophytes, and bird feathers was carried out in 2019. The mass concentration of heavy metals in water was determined by the atomic absorption method on a Quant-Z ETA spectrometer.

Macrophytes were washed with double-distilled water and dried in an oven at a temperature of 50 °C. Sample preparation was performed on the Temos-Express TE-1 complex, based on the destruction of interfering organic substances by thermal action together with oxidizing agents (HNO₃, H₂O₂). Heavy metals in macrophytes were determined by the voltammetric method using the STA-1 complex (Tomsk).

3. Research results and discussion
The water temperature corresponded to the time of year. The acid-base properties (pH) of the waters of the small Filinovka River were within the normal range (6.90–8.20), but the highest pH values were in autumn. The specific electrical conductivity (SEC) of water was 90 - 164 μS/cm, which indicates a low salinity. The smallest values of SEC of water were observed in spring in the lower course of the river, the highest - in summer in the upper course of the river (table 1).

| River | Temperature, °C | pH | SEC, μS/cm |
|-------|----------------|----|------------|
|       | spring | summer | autumn | spring | summer | autumn | spring | summer | autumn |
| I     | 12.8   | 22.2    | 4.5    | 7.6    | 7.3    | 8.0    | 97     | 138    | 120    |
| II    | 12.2   | 22.2    | 4.5    | 7.6    | 7.3    | 7.6    | 99     | 133    | 118    |
| III   | 13.8   | 22.2    | 4.5    | 7.6    | 7.3    | 7.9    | 90     | 133    | 115    |
| IV    | 12.0   | 22.4    | 4.6    | 7.7    | 7.4    | 7.8    | 100    | 130    | 118    |
| V     | 12.2   | 23.2    | 4.6    | 7.7    | 7.4    | 8.1    | 130    | 164    | 142    |

*The table shows the average values of indicators.

Water in the Filinovka River is characterized by high oxygen saturation (95-135%). In the summer, after severe floods, its content in water decreased, it was spent on self-cleaning processes. In the summer after floods, the values of BOD₅ and PO along the river decreased and amounted to 0.1–0.4 mgO₂/dm³ and 2.8–5.3 mgO/dm³, respectively (table 2).

| River | Dissolved oxygen, mgO₂/dm³ | BOD₅, mgO₂/dm³ | PO, mgO/dm³ |
|-------|----------------------------|----------------|-------------|
| I     | 7.0-14.1                   | 1.1-7.9        | 4.3-5.7     |
| II    | 7.1-13.3                   | 0.4-9.8        | 5.2-5.3     |
| III   | 8.1-14.2                   | 0.2-8.7        | 3.0-6.0     |
| IV    | 10.2-13.6                  | 0.1-8.7        | 2.8-5.2     |
| V     | 9.3-13.5                   | 0.1-9.5        | 4.6-6.8     |

*The table shows the minimum and maximum values of indicators.

The content of ammonia nitrogen in the water of the Filinovka River in spring did not exceed 0.32 mgN-NH₄/dm³. The content of nitrite nitrogen in spring in the river water was 0.009 mgN-NO₂/dm³; in summer, nitrites were found in trace quantities. In spring, nitrate nitrogen in the amount of 2.46–3.78 mgN-NO₃/dm³ was detected in the water along the river. Total phosphorus was found in the water in the spring of 0.283 mg/dm³, in the summer after the flood it decreased to 0.045 mg/dm³. In the summer,
nitrogen and phosphorus compounds are assimilated by phytoplankton and aquatic plants. In the autumn after the flood, the content of nitrogen and phosphorus compounds in the river was minimal.

In the water of the Filinovka River, the concentration of cadmium and lead did not exceed the LOC. The content of iron, manganese and zinc was a maximum in the spring and amounted to 800 μg/dm³, 530 μg/dm³, 26.8 μg/dm³, respectively. The high content of manganese and iron in natural waters is explained by regional characteristics. The contents of lead, cadmium, and copper reached their maximum values in the summer and amounted to 2.5 μg/dm³, 0.3 μg/dm³, and 3.9 μg/dm³, respectively. The copper and zinc content in the water of the Filinovka River is higher than the fishery standard. The concentrations of heavy metals in the waters of the river are arranged in a descending order: Fe>Mn>Zn>Cu>Pb>Cd (table 3).

### Table 3. The content of heavy metals in the water of the Filinovka River μg/dm³.

| River | Pb     | Cd     | Cu     | Zn     | Mn     | Fe tot |
|-------|--------|--------|--------|--------|--------|--------|
| I     | 2.51±0.2 | 0.31±0.03 | 2.66±0.3 | 14.00±1.4 | 30±3.0 | 490±82 |
| II    | 2.41±0.2 | 0.16±0.01 | 2.04±0.2 | 7.08±0.7 | 10±1.0 | 420±72 |
| III   | 2.25±0.2 | 0.14±0.01 | 3.32±0.3 | 10.68±1.0 | 10±1.0 | 540±87 |
| IV    | 1.86±0.2 | 0.18±0.02 | 3.91±0.3 | 11.03±1.1 | 40±4.0 | 560±89 |
| V     | 1.97±0.2 | 0.11±0.01 | 3.39±0.3 | 11.33±1.1 | 10±1.0 | 440±78 |

Accumulation of heavy metals by aquatic higher vegetation is actively studied by researchers [8-10], since macrophytes are used to indicate the ecological state of water bodies, to clean water from heavy metals.

*Najas marina* contains a high concentration of lead (13.5 mg/kg), *Ceratophyllum oryzetorum* has a high concentration of cadmium (2.39 mg/kg), but both plants have a deficient concentration of zinc (less than 20 mg/kg). In the hydrophytes *Myriophyllum spicatum* and *Hydrilla verticillata*, the concentration of heavy metals is within the normal range (table 4).

### Table 4. Average heavy metal content in aquatic higher plants of the Filinovka River, mg/kg.

| Hydrophyte                   | Pb     | Cd     | Cu     | Zn     |
|------------------------------|--------|--------|--------|--------|
| *Myriophyllum spicatum* L.   | 3.79±0.7 | <0.01  | 8.50±1.5  | 51.1±5.8 |
| *Hydrilla verticillata* (L.fil.) Royle | 4.53±1.35 | <0.01  | 5.03±1.2  | 34.8±6.5 |
| *Ceratophyllum oryzetorum* Kom. | 3.48±0.6 | 2.39±0.4 | 2.20±0.7  | 12.9±4.38 |
| *Najas marina* L.            | 13.49±2.7 | <0.01  | 10.72±2.1  | 14.83±2.9 |

Studies on the determination of heavy metals in the habitat of birds under threat of extinction in wetlands are relevant [11-13]. Birds live long, are widespread and are at a high level of the food chain; therefore they are successfully used for ecological monitoring of the environment. To assess the level of environmental pollution by heavy metals, organic pollutants, feathers of birds are efficiently used [7, 14].

The current work studied the content of heavy metals in feathers of *Grus monacha* (Temminck, 1835), *Grus vipio* (Pallas, 1811). Iron and zinc were found in greatest quantities in crane feathers, and cobalt and cadmium in the smallest. This ratio of elements is due to the biological role of elements and geochemical environmental conditions. The heavy metals in the feathers of birds are endogenous and characterize the ecological state of the environment. The content of heavy metals in crane feathers increased in the order Cd<Co<Ni<Cr<Pb<Cu<Mn<Zn<Fe. The feathers of birds revealed a high content of lead and cadmium.
Table 5. The content of heavy metals in feathers of birds, mg/kg.

| Name                      | Pb     | Cd     | Cu     | Zn     | Mn     | Fe     | Co     | Ni     | Cr    |
|---------------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Hooded crane Grus monachus| 38±3.8 | 0.17±0.01 | 63.6±6.3 | 94.1±9.4 | 46.8±4.6 | 772±70 | 1.9±0.1 | 4.9±0.4 | 7.2±0.7 |
| White-naped crane Grus vipio | 14±1.4 | 0.33±0.03 | 16.2±1.6 | 48.1±4.8 | 25.3±2.5 | 762±70 | 1.8±0.1 | 4.2±0.4 | 6.6±0.6 |

Heavy metal pollution of wetlands worsens water quality, contributes to bioaccumulation of heavy metals by macrophytes, fish, leads to disease and a decrease in the number of birds [15, 16]. The impact of agriculture is positive for migratory birds. For example, in autumn, migratory cranes and geese feed on grain left on agricultural fields. Mulching crop waste serves to enrich the soil while eliminating a significant source of fires that can spread in wetlands in spring or autumn, destroying nests, chicks and birds [17]. The issues of using environmentally friendly technologies in agriculture, the protection of small rivers and wetlands are essential.

4. Conclusion

The waters of the small Filinovka River are characterized by high oxygen content. In the summer after the flood, the PO and BOD₅ values decreased significantly. The concentration of nitrogen and phosphorus compounds in water depends on the season. The study revealed that in the waters of the small Filinovka River there were high concentrations of iron and manganese, which are due to the natural factor. The content of zinc and copper is higher than the fisheries standard. The hydrophytes *Najas marina* and *Ceratophyllum oryzetorum* are characterized by an excessive concentration of lead and cadmium. The feathers of birds *Grus monacha* and *Grus vipio* contain a high concentration of lead and cadmium. The results obtained are the basis for further study of the anthropogenic load on small rivers of the agrolandscape of the Zeya-Bureya plain.

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