

# Hydrochemical state of the Chikoy River and its tributaries in the territory of the Chikoy National Park

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**Abstract.** The paper presents data on the physical and chemical state of the waters of the Chikoy River and some of its tributaries during the spring and summer in 2017. The results of studies of the physical and chemical characteristics of waters are analyzed: temperature, turbidity, hydrogen index, mineralization, biogenic substances (nitrogen and phosphorus), macrocomponent composition and organic matter. It was revealed that the water temperature in watercourses varied from 1.2 to 16.4 °C, the turbidity of river water varies from 35 to 55 g/m<sup>3</sup>, the oxygen content corresponds to 8.2-9.24 mg/L, the hydrogen index ranges from 6.26 to 7.34. It was noted that in the spring in the studied watercourses, Eh varied from 144 to 203 mV, and in the summer – from 287.8 to 387.2 mV, which indicates the possible presence of a number of elements in the water in the higher form of their ionic valency (Fe<sup>3+</sup>, Mo<sup>6+</sup>, Sr<sup>4+</sup>, Cu<sup>2+</sup>, Pb<sup>2+</sup>, etc.). The salinity values (TDS) of water ranged from 23.23 mg/L to 70.31 mg/L. According to the macrocomponent composition the water of the Chikoy River and its tributaries belong to the bicarbonate class of the calcium group. The Si content varies from 2.75 to 4.27 mgSi/L. The predominant form of inorganic nitrogen for the rivers under study is its nitrate form (0.07-0.27 mg/L). Phosphates varied from 0 to 0.009 mg/L, total phosphorus – from 0.006 to 0.015 mg/L. Organic substances of allochthonous origin. In general, the waters of the Chikoy River and its tributaries are ultra-fresh waters, typical of mountain taiga ecosystems.

## 1 Introduction

Assessing the state and predicting changes in the environment, including aquatic ecosystems, under the influence of external and internal factors is considered one of the most important tasks of environmental research [1]. This work was carried out on the territory of the Krasnochikoy district, in the southwest of the Trans-Baikal Territory, in the buffer zone of the Baikal natural territory. This territory has a high environmental significance, therefore, in 2014, the Chikoy National Park was created here to preserve the biological diversity of terrestrial and aquatic ecosystems. According to the Encyclopedia of Transbaikalia: Chita region (V.A. Obyazov, 2006), one of the main watercourses in the

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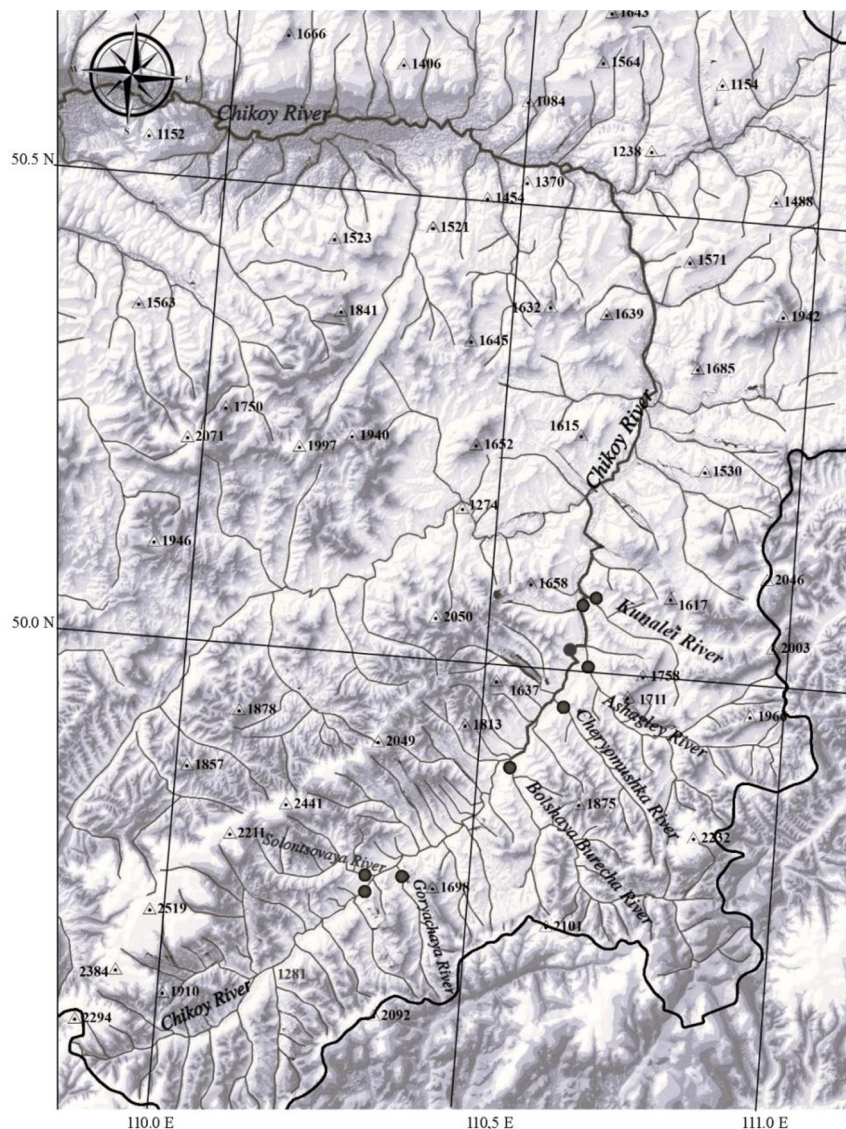
territory of the national park is the Chikoy River is the right tributary of the river. Selenga River – the main tributary of the Baikal Lake, as the UNESCO World Natural Heritage Site. The origins of the Chikoy River are formed on the eastern slope of the Chikokonsky ridge (2523 meters above sea level). The river flows through the territory of the Trans-Baikal Territory and on the territory of the Republic of Buryatia flows into the Selenga River. The catchment area is 41,500 km<sup>2</sup>. The length of the studied watercourse is 769 km.

In most of the territory of the Krasnochikoy sky district, the soils are mountainous permafrost taiga podzolized and turf subtaiga deep-freezing, permafrost meadow-forest. The main type of terrain is mountain taiga; pre-alpine open forest and char are widespread. The lower parts of the slope are occupied by larch taiga with wild rosemary cover. Forests with grass cover are common on dry slopes. At higher elevations, larch forests give way to cedar-larch forests. Pure pine forests are less common, at the upper limit of the mountain taiga and in humid places. The climate of the territory is sharply continental. The average temperature in July is +14 – +16 °C. Winter is cold, the average temperature in January is from -22 to -26 °C. The amount of precipitation is from 350 to 500 mm/year. The growing season lasts 90-130 days.

Upper reaches of the Chikoy River and its tributaries are little developed and are characterized by an undisturbed state of natural complexes [2]. In terms of fisheries, the rivers of the territory of the Chikoy National Park are an important habitat and reproduction area for valuable salmon species, such as *Hucho taimen*, *Brachymystax lenok*, and *Thymallus*. To preserve the biological diversity of aquatic ecosystems, constant monitoring of the state of the environment is necessary. Study of the hydrochemical state of the upper reaches of the Chikoy River and its tributaries remain insufficient [3] and are represented to a greater extent by the results of studies of the most developed lower reaches of the Chikoy River [4-6]. Therefore, the presented work is of great importance to fill this gap. The objectives of the research included studying such characteristics as temperature, turbidity, pH, mineralization, content of nutrients (nitrogen and phosphorus), organic matter and macrocomponent composition of the Chikoy River and its tributaries – Solontsovaya, Goryachaya, Bolshaya Burecha, Cheryomushki, Ashagley, Kunaley. The results obtained can serve as the basis for further research and updating monitoring data.

## 2 Objects and methods

Samples of water from rivers served as the material for hydrochemical analysis. Sampling was carried out in May and July 2017 on the territory of the middle course of the Chikoy River and its tributaries (Figure 1).



**Fig. 1.** Cartographic sampling scheme of the Chikoy River and its tributaries. ● – sampling location.

The Chikoy River has been explored within the absolute elevation marks from 1663 m above sea level. In the upper reaches of the Chikoy River, the right banks are eroded almost throughout under the influence of the Cryolite force. Therefore, they are distinguished by steep slopes. The left part of the valley is wide, gently sloping, partly occupied by swamp-meadow and forest vegetation. The depth of the channel at the sampling site ranged from 0.06 to 0.50 m. The bottom of the river is rocky and pebbly with sandbanks. The first sampling place in the Chikoy River is 100 m above the confluence of the Solontsovaya River, the second sampling site is before the confluence of the Ashagley River, the third is 200 m above the confluence of the Kunaley.

The Solontsovaya River is a left tributary of the Chikoy River. The length of the watercourse is 18 km. The valley of the river widens to its confluence with the Chikoy River and flows through a swampy lowland. The bottom of the river is rocky and sandy with a small layer of silt. The river flows in formed banks. The river is bordered by a mixed forest with a predominance of larch. During the period of our research, there was ice on the river. Tree blockages are noted. The right bank of the riverbed is shallow. The depth of the channel of the left bank is within 0.27 - 0.30 m. The width of the river is 6 m. Samples were taken 50 m above the confluence of the tributary into the Chikoy River. Coordinates of the sampling: 49°46'0276"N; 110°20'3791"E. The height of the sampling site is 1213 m above sea level.

The Goryachaya River is a right tributary of the Chikoy River. Sampling was carried out in the estuary part of the river. Coordinates of the sampling: 49°46'8892"N; 110°22'8822"E. The height is 1197 m above sea level. The depth of the river at the sampling site: 0.07 m under the left bank, 0.16 m on the right. The flow velocity is 1.5 m/s.

The bottom of the river is rocky and boulder. The left bank is flat, the right bank is steep (40-45°). A larch-willow forest grows along the banks of the river, and in open areas there is swamp-meadow vegetation with rare shrubs.

The Bolshaya Burecha River is a right tributary of the Chikoy River. Sampling was carried out in the estuary part of the river. Coordinates of the sampling: 49°52'4890"N; 110°33'9075"E. The height is 1228 m above sea level. Along the bank of the river at the sampling site there is a mixed forest with predominance of larch and poplar and, to a lesser extent, birch, pine and willow. The bottom of the river is rocky, the coast is low. The width of the river at the sampling site is 15 m. The depth of the river profile is from 0.12 to 0.65 m. Riffs of 50 meters are replaced by deep-water areas within 100 m. Traces of windfalls are noted along the coast and in the river.

The Cheryomushka River is a right tributary of the Chikoy River. Sampling was carried out in the middle part of the river. Coordinates of the sampling: 49°57'7859"N; 110°38'3155"E. The height is 1140 m above sea level. The bottom of the river is rocky. Stones with a white coating, overgrown with algae, moss grows in places along the shores. The water in the river is clear. The flow velocity at the sampling site is 0.8 m/s, the width of the river is 5 m, the depth is from 0.03 to 0.10 m.

The Ashagley River is a right tributary of the Chikoy River. Sampling was carried out at a distance of 200 m from the mouth of the river. Coordinates of the sampling: 50°02'1240"N; 110°39'4873"E. The height is 1077 m above sea level. The width of the river at the sampling site is 15 m, the depth is 0.5 m. The bottom of the river is pebbly-sandy, duckweed grows in shallow water. There is a roll-over 100 m above the sampling site. Along the banks there is a mixed forest with willow-birch-larch-pine composition. The speed of the river flow at the sampling site is 0.3 - 0.5 m/s.

The Kunaley River is a right tributary of the Chikoy River. Samples were taken 500 m above the confluence with the Chikoy River in a flat valley overgrown with willow. Coordinates of the sampling: 50°05'2292"N; 110°39'1024"E. The height is 1066 m above sea level. The right bank of the mouth of the river is rocky, the left bank is flat. The bottom of the river is rocky and sandy. The width of the river at the sampling site is 9 m, the depth is 0.7 m. Willows, birches and larch grow along the banks. Directly above the water, the shore is covered with moss.

Water samples were taken in plastic bottles with a volume of 1 L, after rinsing the container with water from the watercourse. To determine the content of biogenic elements, the samples were fixed and delivered to the stationary laboratory. The analysis of nitrogen forms was carried out according to GOST 33045-2014, GOST 18309-2014, phosphorus – according to Adamovich B.V. et al. (2016), methods for determining PO and COD are standard, generally accepted in hydrochemical practice [7]. The macrocomponent composition of the waters was studied using atomic absorption, photometric, gravimetric and titrimetric analysis methods. A spectrometer SPEKOL-1300 was used to measure the optical density of the solutions. The transparency of the water was measured using a Secchi disk. The physical and chemical parameters of the ecosystem (pH, mineralization, O<sub>2</sub>, temperature, turbidity, Eh) were measured at the water sampling sites using the AQVAMETER “Aquaread” device (Great Britain).

### **3 Results and discussion**

For aquatic organisms, water temperature is of great importance and is an indispensable condition for life. It affects both directly and indirectly, through other abiotic factors. The temperature of water is much more stable than that of air. During the period of our research in spring, the T °C in watercourses varied from 1.2 to 10.2 °C (Bolshaya Burecha River).

The coldest river turned out to be Solontsovaya – 1.2 °C. In summer, the water temperature in the rivers varied from 8.7 °C (Bolshaya Burecha River) to 16.4 °C (upper course of the Chikoy River) (Table 1).

**Table 1.** Some physical and chemical parameters and oxygen content in the water of the studied rivers.

Sampling site	Period	T, °C	pH	Eh, mV	TURB, EMΦ	O <sub>2</sub> , mg/L	O <sub>2</sub> , %
Chikoy River, 200 m above the confluence of the Kunaley River	spring	6.8	6.53	140	-	8.2	66.4
	summer	-	-	-	-	-	-
Chikoy River, before the confluence of the Ashagley River	spring	7.0	6.99	154	-	9.10	74.0
	summer	12.0	6.26	300.5	458	-	-
Chikoy River, 100 m above the confluence of the Solontsovaya River	spring	2.1	7.34	168	-	9.24	66.6
	summer	16.4	6.85	333.0	414	-	-
Kunaley River, 500 m above the confluence with the Chikoy River	spring	3.0	6.64	144	-	7.4	54.6
	summer	-	-	-	-	-	-
Ashagley River, 200 m above the confluence with the Chikoy River	spring	7.3	7.06	195	-	10.87	89.1
	summer	12.4	7.38	295.7	454	-	-
Cheryomushka River, the middle part of the river	spring	6.5	7.31	203	-	10.75	86.5
	summer	-	-	-	-	-	-
Bolshaya Burecha River, the mouth of the river	spring	10.2	7.23	184	-	10.42	91.2
	summer	8.7	7.40	387.2	238	-	-
Goryachaya River, 200 m above the confluence with the Chikoy River	spring	7.7	7.44	174	-	10.0	82.7
	summer	9.9	7.43	287.8	392	-	-
Solontsovaya River, 100 m above the confluence with the Chikoy River	spring	1.2	6.35	144	-	8.55	60.0
	summer	14.2	6.37	301.3	369	-	-

The hydrogen index (pH) of the Chikoy River decreased from the upper to the lower reaches from 6.53 to 7.34 in spring, and in summer – in the range of 6.26-6.85. In the lower reaches of the Chikoy River before the confluence with the Selenga River, the pH is slightly higher and is 7.7-7.8 in spring and 7.5-7.9 in summer [7]. In the tributaries, the pH changed slightly: from 6.35-7.44 in spring and 6.37-7.40 in summer. Consequently, the waters of the studied rivers are characterized by a neutral or slightly alkaline reaction of the medium. The pH values correspond to the characteristics of freshwater and indicate the presence in the waters of Ca(HCO<sub>3</sub>)<sub>2</sub> and Mg(HCO<sub>3</sub>)<sub>2</sub>.

Turbidity (TURB) of water is caused by the presence of fine impurities of organic and inorganic origin. According to the handbook "Water treatment" (2007), high turbidity of water is considered from 40 to 400 EMF and above. In the surveyed rivers, this indicator ranged from 238 to 458 EMF.

The oxygen content in spring varies from 7.4 mg/L (Kunalei river) to 10.9 mg/L (Ashagley River). Depending on the water temperature, atmospheric pressure and the level of mineralization, the concentration of oxygen dissolved in water in most watercourses is close to its full saturation. With increasing mineralization, the oxygen content increases. The highest oxygen content was found in the waters of the Ashagley, Bolshaya Burecha, Goryachaya and Cheryomushka Rivers, which is associated with the growth and development of aquatic plants. High oxygen concentration in the Cheryomushka River promotes the formation of white plaque on stones representing calcium bicarbonate. Thus, according to our data, the oxygen content in the upper reaches of the Chikoy River is 8.2-9.24 mg/L, which is typical for the lower reaches of the Chikoy River (before the confluence with the Selenga River) [8].

The redox potential (Eh) depends mainly on the degree of mineralization (concentration of dissolved mineral salts) and temperature. In spring, in the studied watercourses, it varied from 144 to 203 mV, and in summer - from 287.8 to 387.2 mV. The obtained values of Eh > + (100-150) mV indicate the possible presence in water of a number of elements in the highest form of their valence ( $\text{Fe}^{3+}$ ,  $\text{Mo}^{6+}$ ,  $\text{Sr}^{4+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$ , etc.), which is most often found in surface waters and indicates an oxidative geochemical situation in waters in the presence of free oxygen.

The macrocomponent composition of the waters of the Chikoy River and its tributaries is presented in Table 2. According to the criteria of GOST 17403-72, according to the amount of mineralization, river waters are divided into 5 groups (mg/L): < 100 – very small; 100 - 200 – small; 200 - 500 – medium; 500 - 1000 – elevated and > 1000 – high.

**Table 2.** Macrocomponent composition of the waters of the studied rivers (2017 May).

Sampling site	The content of basic ions, mg/L									Leading anions and cations
	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Si	TDS	
<b>Chikoy River</b> , 200 m above the confluence of the Kunaley River	1.63	0.38	6.39	0.72	0.88	3.7	17.1	3.02	30.98	HCO <sub>3</sub> <sup>72</sup> Ca <sub>69</sub>
<b>Kunaley River</b> , 500 m above the confluence with the Chikoy River	2.84	0.35	7.23	0.89	0.84	3.5	23.2	4.27	38.91	HCO <sub>3</sub> <sup>79</sup> Ca <sub>63</sub>
<b>Ashagley River</b> , 200 m above the confluence with the Chikoy River	2.69	0.26	8.30	0.90	0.86	4.8	23.8	3.82	41.74	HCO <sub>3</sub> <sup>74</sup> Ca <sub>67</sub>
<b>Cheryomushka River</b> , the middle part of the river	2.92	0.25	14.3	1.76	0.93	12.9	37.2	0.09	70.31	HCO <sub>3</sub> <sup>67</sup> Ca <sub>71</sub>
<b>Bolshaya Burecha River</b> , the mouth of the river	2.12	0.32	6.53	0.76	1.12	4.3	17.1	3.84	32.3	HCO <sub>3</sub> <sup>69</sup> Ca <sub>66</sub>
<b>Goryachaya River</b> , 200 m above the confluence with the Chikoy River	2.83	0.52	6.98	0.85	1.27	5.6	18.3	4.2	36.53	HCO <sub>3</sub> <sup>64</sup> Ca <sub>62</sub>
<b>Solontsovaya River</b> , 100 m above the confluence with the Chikoy River	1.62	0.54	3.86	0.55	0.7	3.1	12.8	2.85	23.23	HCO <sub>3</sub> <sup>70</sup> Ca <sub>59</sub>
<b>Chikoy River</b> , 100 m above the confluence of the Solontsovaya River	1.55	0.32	5.63	0.58	0.75	3.7	14.6	2.75	27.26	HCO <sub>3</sub> <sup>69</sup> Ca <sub>69</sub>

The mineralization values (TDS) of the waters of the Chikoy River and its tributaries in the spring ranged from 23.23 mg/L (Solontsovaya River) to 70.31 mg/L (Cheryomushka River). The amount of ions in the water of the Chikoy River and its tributaries in the summer period ranged from 26 mg/L (Ashagley River) to 31 mg/L (Bolshaya Burecha River). Consequently, the waters of the surveyed watercourses are ultra-fresh (less than 100 mg/L). Such weak mineralization is typical mainly for rivers the mountain taiga with high flow velocity and rapid water change [9]. In the lower reaches of the Chikoy River and the entire basin, the mineralization of waters does not exceed 80 mg/L. The low mineralization of the water of the rivers of the taiga zone is determined by the mountainous terrain with its characteristic high values of runoff modules and significant snow nutrition [10].

According to the macro-component composition of the waters of the Chikoy River and its tributaries, they belong to the bicarbonate-calcium type, which is typical for rivers the mountain taiga [11]. Among the trace elements Si plays an important role for aquatic

organisms. It participates in the metabolism of cells of diatoms and some other aquatic organisms to form skeletons. Si is constantly included in the composition of natural waters as a result of the widespread distribution of its compounds in rocks [12, 13]. The Si content in the water of most of the studied rivers ranges from 2.75 to 4.27 mg/L. Its lowest content was noted in the Cheryomushka River – 0.09 mg/L (Table 2). Thus, changes in the Si content in the upper reaches of the Chikoy River are within the limits found by Z.I. Khazheeva and A.M. Plyusnin in the lower reaches of the river [4].

The amount of biogenic substances (forms of nitrogen and phosphorus) serves as a complex characteristic of biogeochemical processes in natural waters and is an indicator of the development of natural transformation of organic matter and anthropogenic impact on aquatic ecosystems (Table 3).

**Table 3.** The content of biogenic elements (nitrogen and phosphorus, mg/L) and organic matter (mg/L) in the water of the studied rivers.

Sampling site	Period	NH <sub>4</sub> <sup>+</sup>	NO <sub>2</sub>	NO <sub>3</sub>	PO <sub>4</sub> <sup>3-</sup>	P <sub>total</sub>	COD	PO	OS	PO/COD
<b>Chikoy River,</b> 200 m above the confluence of the Kunaley River	spring	0.092	0.030	0.06	0.046	0.083	23.94	7.46	18.2	0.31
	summer	0.005	0.006	0.16	0.001	0.006	3.16	1.56	2.4	0.49
<b>Chikoy River,</b> before the confluence of the Ashagley River	spring	0.002	0.001	0.01	0.002	0.009	20.13	3.30	15.30	0.14
	summer	0.005	0.004	0.11	0.005	0.006	19.39	1.63	14.7	0.08
<b>Chikoy River,</b> 100 m above the confluence of the Solontsovaya River	spring	0.003	0.008	0.04	0.006	0.023	9.79	6.53	7.44	0.67
	summer	0.005	0.003	0.07	0.005	0.013	15.23	1.98	11.6	0.13
<b>Kunaley River,</b> 500 m above the confluence with the Chikoy River	spring	0.001	0.001	0.08	0.003	0.016	4.35	3.00	3.31	0.70
	summer	0.007	0.004	0.10	0.009	0.015	4.41	1.75	3.0	0.40
<b>Ashagley River,</b> 200 m above the confluence with the Chikoy River	spring	0.002	0.001	0.01	0.007	0.010	3.81	2.10	2.90	0.55
	summer	0.005	0.004	0.12	0.005	0.009	2.33	1.52	1.8	0.65
<b>Cheryomushka River,</b> the middle part of the river	spring	0.001	0.001	0.01	0.003	0.025	10.34	2.55	7.03	0.25
	summer	0.006	0.003	0.17	0.005	0.015	4.66	2.01	3.8	0.43
<b>Bolshaya Burecha River,</b> the mouth of the river	spring	0.003	0.001	0.24	0.001	0.012	6.53	4.46	7.81	0.68
	summer	0.006	0.004	0.27	0.005	0.006	9.82	4.41	7.5	0.45
<b>Goryachaya River,</b> 200 m above the confluence with the Chikoy River	spring	0.004	0.001	0.22	0.002	0.006	9.25	6.83	7.86	0.74
	summer	0.006	0.007	0.15	0.005	0.014	9.82	4.41	7.5	0.45
<b>Solontsovaya River,</b> 100 m above the confluence with the Chikoy River	spring	0.003	0.003	0.16	0.003	0.005	8.70	4.05	6.61	0.47
	summer	0.007	0.004	0.22	0.009	0.010	24.79	1.60	19.0	0.06

The amount of nitrogen and phosphorus varies depending on the intensity of the decomposition and synthesis of organic matter in the aquatic ecosystem. Nitrogen is part of the structural composition of proteins and amino acids, so it is vital for plants and animals. In water, inorganic nitrogen is found in three main forms: nitrite, nitrate and ammonium, as well as in an organic bound form. Phosphorus is one of the most important elements of the mineral nutrition of the aquatic organisms. Phosphate groups are the main structural elements of nucleic acids, phospholipids and part of adenosine triphosphate (ATP). Phosphorus in water is represented by inorganic, i.e. mineral and organic, bound forms. The amount of phosphorus in water depends on the rate of assimilation as a result of photosynthesis, chemosynthesis and decomposition of organic residues. The intake of phosphorus and the formation of its load on the aquatic ecosystem depend on the size of the catchment area, its structure (forestation), soil cover, and bogginess of the underlying rocks [14].

During the spring low water, the concentration of ammonium nitrogen in the Chikoy River and its tributaries varied from 0.001 to 0.092 mg/L, and nitrite nitrogen from 0.001 to 0.030 mg/L, i.e. their minimum contents are noted. A small concentration of  $\text{NH}_4^+$  and  $\text{NO}_2^-$  is associated with low temperatures in the ecosystem during the spring flood, rapid water change associated with high river flow rates. During the summer, the concentration of ammonium ions in the Chikoy River and its tributaries ranged from 0.005 to 0.007 mg/L, nitrite – from 0.003 to 0.007 mg/L, nitrate – from 0.07 to 0.27 mg/L. The predominant form of inorganic nitrogen for the studied rivers is its nitrate form. The amount of phosphates varied from 0 to 0.009 mg/L, total phosphorus – from 0.006 to 0.015 mg/L. The amount of phosphates in the summer period varies slightly: from 0.001 to 0.009 mg/L and the total phosphorus – from 0.006 to 0.015 mg/L (Table 3).

The insignificant content of nitrates and phosphates in spring, which is typical for most watercourses during our research, is associated with quantitative indicators of the aquatic organisms. In spring, the number of photosynthetic organisms and the production and destruction processes taking place in reservoirs increases [2, 15]. The maximum amount of biogenic elements was noted only in the lower reaches of the Chikoy River in the spring period. However, none of the indicators exceeds the MPC typical for fishery reservoirs (Bessonov N.M., Privezentsev Yu.A., 1987). Studies by Khazheeva Z.I. and Plyusnin A.M. in the lower reaches of the Chikoy River at the confluence with the Selenga River confirm an increase in the biogenic load in the spring period. The average annual content of ammonium ions during the observation period in the Chikoy River was 0.011 mg/L, the nitrate content was up to 0.090 – 0.027 mg/L, the nitrite content in May and August was at the analytical zero level. The maximum amplitude of fluctuations in the concentration of total phosphorus in the intra-annual regime varies between 0.03 - 0.048 mg/L [4].

The water quality of rivers reflects not only the ecological state of the river, but also its catchment area. At the beginning of summer, forest fires took place on the investigation territory, and then rains. The results of these processes are reflected in the content of organic substances in the river water. Organic matter in rivers is present in the form of humic substances washed off soils and swamps and in the form of decomposition products of various organic substances, mainly of plant origin. Research by B.A. Skopintseva and I.A. Goncharova. (1987) indicate that the values of permanganate (PO) and bichromate (COD) oxidizability express qualitatively different fractions of organic matter in the ecosystem. According to Lurie Yu.Yu. (1977), usually  $\text{K}_2\text{S}_2\text{O}_7$  oxidizes 95-98% of hard-to-destroy organic substances, therefore, the PO/COD indicator can be used to determine the qualitative characteristics of the origin of organic substances in watercourses. PO indicators indicate the presence of the humic and fulvic acids entering the watercourse as a result of erosion of the soil of the catchment area (especially those with high forest cover or bogginess) [16].

By the nature of the ratio of PO to COD, organic substances in the water of most of the studied rivers are of allochthonous origin, i.e., for the most part, decomposition products of plant residues coming from the soil and swamps of the river catchment area. In the upper reaches of the Chikoy River, the oxidizability of waters varies between: COD – from 9.79 to 23.94 mg/L (in spring) and from 3.16 to 19.39 mg/L (in summer); PO – from 3.30 to 7.46 mg/L (in spring) and from 1.56 to 1.98 mg/L (in summer) (Table. 3). The results obtained for the values of COD and PO correspond to the data on the lower course of the Chikoy River, before the confluence with the Selenga River [7]. In the rivers Ashagley, Bolshaya Burecha, Goryachaya and in the Chikoy River (above the confluence of the Kunaley River and above the confluence of the Solontsovy River), organic substances of a humus nature, introduced with flood waters, predominate. Evidence of this is the ratio of PO to COD, as well as the greenish color of their waters. Due to the small number of organisms, therefore, with minimal consumption of nitrogen and phosphorus, the intra-ecosystems decomposition of a small amount of organic substances, which are subsequently used by aquatic organisms, occurs. Thus, the organic substances in Chikoy River mostly come from the catchment area. The mountainous nature of the Chikoy River, the rapidity of the flow of matter, determines the practical uniformity of the values of COD and PO from the source to the mouth, up to the confluence of the water flow into the Selenga River.

## 4 Conclusions

Thus, the results obtained on the ecological state of the waters of the upper reaches of the Chikoy River and its tributaries are characterized as cold-water, with high turbidity, with a neutral hydrogen index, an oxidative geochemical environment and a low content of biogenic elements. The allochthonous organic matter in the rivers is present in the form of substances washed off soils and swamps of decomposition products of various organic substances, mainly of plant origin. In general, the waters of the Chikoy River and its tributaries are low-mineralized – ultra-fresh, bicarbonate-calcium composition. The content of nutrients is insignificant, which is typical for clean watercourses of typical mountain taiga ecosystems.

The research is a part of the project No. 121032200070-2 “Geoecology of aquatic ecosystems of Transbaikalia under modern climatic and technogenic conditions”.

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