The Khanty-Mansi Autonomous Okrug-Yugra (Russia) typical intra-bog algocenoses analytical assessment

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Abstract. The work was carried out on the Khanty-Mansiysk Autonomous Okrug nine typical intra-bog lakes freshwater algae material in the period 2008-2018. The studies were carried out according to the classical methods adopted in algology. Species identification was carried out using light microscopes Nikon ECLIPSE E200 and OLYMPUS SX4, taking into account the nomenclature changes published in the international electronic database Algae Base. Algae, mainly phytoplankton, were studied in nine lakes with a 50 to 1162 hectares area. Each of the analysed limnological systems is characterized by both general and specific features, which, on the one hand, reflects belonging to high latitudes water bodies, and on the other hand, indicates the differences between each of the systems, due to their type and anthropogenic load. A high significance was revealed in the families Desmidiaceae and Eunatiae all lakes, a generic ranks structure significant diversity, in which the genera Dinobryon, Eunotia, Staurastrum are of the greatest importance. The work analyses the identified algae taxonomic composition calculates the algocenoses saturation, specificity, and similarity coefficients, and the dominants' composition.

1. Introduction
The Khanty-Mansiysk Autonomous Okrug - Yugra (hereinafter referred to as KhMAO-Yugra) is rich in lakes, mostly small, intra-boggy [1]. The lakes sizes vary widely. Microscopic algae are any aquatic ecosystem most important component [2]. This article presents materials from the algological communities study in 9 intra-boggy lakes.

Three lakes: Aran-Tur, Range-Tur and Pon-Tur form a lake complex in the Kondinsky Lakes natural park named after Stashkevich, which is located in the Soviet region in the Khanty-Mansi Autonomous Okrug-Yugra west [3, 4]. The natural park territory about 50% is swampy. The Lake Aran-Tur area is 1162 hectares, with about 1.5 meters average depth. The second-largest lake, Range-Tur, has the Khanty-Mansi Autonomous Okrug-Yugra a natural monument status, the lake shape is round, the depth is within 1-3 meters. The third lake, Pont Tur, belongs to the large soric origin, the depth reaches 4 meters. Lakes Karasevo and Bezymyannoe are located in the Nizhnevartovsk region western part in the Pokachevskoye oil field area, on a slightly rugged, highly swampy area, the depth of the lakes reaches 5 meters.

Lake Possen-Lor is included in the Museum-Ethnographic and Ecological Park Ugra, it is located 70 km from the city Nizhnevartovsk. The lake area is 50 hectares, the depth does not exceed 5 meters. Lake Vill'ent is the Samotlor group part, located in the Nizhnevartovsk region, the shape is close to rounded, the mirror area is 100 hectares, the shores are rugged, flooded, very unsteady, the lake depth is up to 5 meters.
The Lakes Komsomol'skoye (500 hectares) and Vartovskoye (320 hectares) are of soric origin and are located within the city Nizhnevartovsk, which was built on the Ob' River right bank and its territory was previously a swampy taiga.

The research purpose is to identify the limnological algae composition and structure features in the Khanty-Mansiysk Autonomous Okrug-Yugra conditions.

2. Materials and methods
The work is based on materials from 520 algological samples taken during the open water period 2008-2018. Simultaneously with sampling, the water temperature and active reaction were measured using a portable pH meter (pHcan 2 Wateroof). The studies were carried out according to the methods accepted in algology [5-10]. The algae study was carried out mainly on a material fixed in a 4% formalin solution, processed by a sedimentary gravimetric method. For the diatoms' identification by the cold burning method, 70 const preparations were made, followed by centrifugation and the valves closing in Canadian balsam. The algae were studied using light microscopes Nikon ECLIPSE E200 and OLYMPUS SX4 with multiple magnifications from 640 to 2000. For identification, we used the keys and guidelines of domestic and foreign authors generally accepted in algology and taking into account the nomenclature changes published in the international electronic database [11-14]. The found species, varieties and forms, genera, families, classes, divisions, the dominant algae composition systematic spectrum is given. The phytoplankton composition species similarity coefficient for river sections was calculated using the Sorensen formula [15].

3. Results and discussion
The water temperature range at 15-20 centimetres depth in lakes was within 6-23°C (table 1).

| Parameter                  | Karasevo | Bezymyannoe | Possen-Lor | Aran-Tur | Pont-Tur | Vill'en | Komsomol'skoe | Vartovskoe | Range-Tur |
|----------------------------|----------|-------------|------------|----------|----------|---------|-------------|------------|-----------|
| Temperature, °C             | 12-18    | 12-18       | 14-18      | 14-22    | 11-19    | 12-22   | 11-23       | 4-23       | 6-25      |
| Secchi disc transparency, cm | 88-95    | 80-91       | 76-89      | 27-60    | 15-30    | 50-66   | 44-67       | 39-78      | 50-97     |
| pH                         | 3.5-6.0  | 3.4-5.5     | 4.5-5.5    | 5.4-6.6  | 4.7-7.1  | 4.1-5.0 | 3.4-6.2     | 4.5-5.5    | 3.3-5.3   |
| Samples number             | 33       | 22          | 75         | 101      | 102      | 102     | 101         | 39         | 103       |

Water low transparency is registered in the lakes: the minimum is Pont-Tur, the maximum is in the lakes Karasevo, Bezymyannoe, Possen-Lor and Range-Tur. The transparency range for the Secchi disc in lakes varies from 15 to 97 centimetres. The pH activity in most lakes indicates an acidic environment, especially in the coastal zone.

In total, 613 algae from 7 divisions were found in the studied lakes: Cyanobacteria are represented by 53 species and intraspecific taxa (hereinafter referred to as species), Euglenophyta - 41, Dinophyta – 2, Chrysophyta – 38, Xanthophyta – 25, Bacillariophyta – 178 и Chlorophyta – 276.

In the species number terms, the highest diversity was found in the Lake Range-Tur plankton, the second place is occupied by Lake Aran-Tur, and the third - by Karasevo (table 1).

The identified algae systematic composition and structure testifies to the leading role of the division Chlorophyta (45.1% of the list composition) and Bacillariophyta (29.1%). Similar observations were
noted earlier by us in the river Vakh [16]. The *Cyanobacteria* division occupies the third position with a diversity of 53 species or 8.6% of the total composition.

**Table 2.** The identified algae composition in the Khanty-Mansi Autonomous Okrug-Yugra (Russia) intro-bog lakes.

| Department       | Karasevo | Bezymyannoe | Possen-Lor | Aran-Tur | Pont-Tur | Vill'ent | Komsomol'skoe | Vartovskoe | Range-Tur |
|------------------|----------|-------------|------------|----------|----------|----------|---------------|------------|-----------|
| Cyanobacteria    | 10       | 1           | 6          | 20       | 9        | 2        | 11            | 1          | 20        |
| Chrysophyta      | 3        | 1           | 4          | 28       | 6        | 9        | 1             | 5          | 2         |
| Bacillariophyta  | 35       | 13          | 26         | 64       | 46       | 11       | 11            | 33         | 106       |
| Xanthophyta      | 3        | 3           | 2          | 10       | 8        | 0        | 0             | 2          | 11        |
| Euglenophyta     | 1        | 0           | 4          | 6        | 4        | 6        | 3             | 21         | 11        |
| Dinophyta        | 1        | 0           | 0          | 1        | 1        | 0        | 0             | 0          | 1         |
| Chlorophyta      | 97       | 8           | 27         | 53       | 48       | 12       | 57            | 18         | 105       |
| Total            | 150      | 26          | 69         | 182      | 122      | 40       | 83            | 80         | 256       |

Of the 9 classes, the top five in species richness terms include *Bacillariophyceae - 168, Conjugatophyceae - 141, Chlorophyceae - 104, Cyanophyceae - 53, Euglenophyceae - 41*, accounting for 82.7% of the algae detected. For the Khanty-Mansi Autonomous Okrug-Yugra some watercourses, which are insignificant waterlogging conditions, we have repeatedly noted the above list in the leading classes [17-22].

The family spectrum in the lakes is represented by 82 taxa, of which 38 play the most important floristic function. The top ten in species richness terms includes *Desmidiaceae - 127 (20.7% of found algae), Scenedesmaceae and Eunotiaceae 40 each (6.5 each), Dinobryaceae - 35 (5.7), Naviculaceae - 23 (3.7), Closteriaceae - 22 (3.6), Pinnulariaceae and Euglenaceae - 20 (3.3) each*, *Selenastraceae - 17 (2.8) and Hydrodictyaceae - 14 (2.3%).* Algae, not only tolerant to low pH values but also widespread green algae *Scenedesmaceae, Hydrodictyaceae [23-27].* The *Euglenaceae* family representatives in the region are most widely represented in bog systems, especially in oil pollution conditions [28-31]. More than the families half (50) include 1-3 species, the total number is 70 species, 11.4% of the total composition.

The algae the greatest saturation in families was noted in the Lake Range-Tur - 4.19, followed by the lakes Karasevo - 3.94, Aran-Tur - 3.43, Pon-Tur - 2.77, Komsomol'skoe - 2.44, Vartovskoe - 2.28 indicators. The lowest family saturation coefficient is observed in the lakes Possen-Lor - 2.15, Vill'en - 2.10 and Bezymyannoe - 2.00.

The first ten genera include *Eunotia, Staurastrum, Closterium, Cosmarium, Pinnularia, Staurodesmus, Scenedesmus, Dinobryon, Navicula and Trachelomonas*, including 40 to 15 species, respectively, their share was 36.2% of the total composition, a high proportion was noted (33.7%) genera with 1-3 species. The first 6 genera listed above have high ecological plasticity and tolerance to the environment, which is formed in lakes under the sphagnum bogs influence, namely, low water salinity and acidification [32, 33]. The generic saturation is low, its range is from 1.44 (Bezymyannoe Lake) to 2.58 (Karasevo Lake).

To determine the studied lakes algocenoses species similarity level, the Scherensen-Chekanovsky coefficient was used, which measurement unit ranges from zero (no similarity) to one (complete similarity). The greatest similarity in the algae species composition was found between lakes Aran-Tur and Range-Tur (0.29), Pon-Tur and Aran-Tur (0.26), which is explained by the fact that they belong to the natural park Kondinsky Lakes a single natural complex, therefore, have similar environmental conditions. Of no small importance is the algae studies period fact in these lakes, which dates back to 2011-2013.
35 species are common to the listed lakes: 5 from the *Cyanobacteria*, 15 from *Bacillariophyta*, and 15 from *Chlorophyta*.

The algae species composition similarity coefficient in other lakes ranges from 0.14 to 0.08, the smallest similarity was found between lakes Karasevo and Pon-Tur, Komsomol'skoe (0.08 and 0.09, respectively).

In general, the Scherensen-Chekanovsky similarity measure values indicate a similarity very low degree in the algae species composition in the studied lakes.

Specific, i.e. found only in the aquatic ecosystems one, the genera for the Khanty-Mansi Autonomous Okrug-Yugra studied lakes are 77 genera: for Lake Range-Tur 33 genera, for Karasevo 13 genera, Pon-Tur - 8, Aran-Tur, Possen-Lor, Komsomol'skoe, Vartovskoe - 5 each, Bezymyannoe - 3, no specific genera were found in Lake Vill'ent. Thus, the identified algae the genus composition specificity coefficient is assessed as low, the highest was noted for lake Range-Tur, amounting to 28.9.

There are 352 specific species, with a green algae predominance (table 3).

**Table 3.** The algae specific and the specificity coefficient (Cs) number in the Khanty-Mansi Autonomous Okrug-Yugra (Russia) intra-bog lakes.

| Lake          | Karasevo | Bezymyannoe | Possen-Lor | Aran-Tur | Pont-Tur | Vill'ent | Komsomol'skoe | Vartovskoe | Range-Tur |
|---------------|----------|-------------|------------|----------|----------|----------|---------------|------------|-----------|
| Species number| 44       | 5           | 23         | 53       | 25       | 10       | 30            | 28         | 134       |
| (Ks)          | 29.33    | 19.2        | 33.33      | 29.44    | 20.49    | 25.00    | 36.14         | 35.00      | 52.34     |

Thus, the species composition specificity coefficient can be estimated as moderate, the highest is observed for the lake Range-Tur, the lowest for the lake Bezymyannoe.

The dominant complex definition provides information on the algological community structure and productivity. The dominants and codominants complexes for all lakes differ in a species set (table 4).

**Table 4.** The Khanty-Mansi Autonomous Okrug-Yugra (Russia) intra-boggy lakes algae Dominant complexes.

| Lake          | Dominant complex                          | Lake          | Dominant complex                          |
|---------------|-------------------------------------------|---------------|-------------------------------------------|
| Karasevo      | *Tabellaria fenestrata* (Lyngbye) Kützing  | Aran-Tur      | *Asterionella formosa* Hassall            |
|               | *Tabellaria flocculosa* (Roth) Kützing     |               | *Tabellaria fenestrata* (Lyngbye) Kützing |
|               | *Tribonema viride* Pascher                 |               | *Aulacoseira italica* (Ehrenberg) Simonsen|
| Bezymyannoe   | *Tabellaria fenestrata* (Lyngbye) Kützing  | Vartovskoe    | *Kephyron boreale* Skuja                  |
|               | *T. flocculosa* (Roth) Kützing             |               | *Dinobryon borgei* Lemmermann             |
|               | *Tribonema viride* Pascher                 |               | *Navicula radiosa* Kützing                |
|               |                                            |               | *Trachelomonas planctonica* Swirenko      |
|               |                                            |               | *Selenastrum gracile* Reinsch             |
In total, 29 dominants were identified: 12 representatives belong to the green division, 5 algae from the diatoms and golden divisions, 4 - cyanoprokaryotes, and 1 - yellow-green algae.

The algae most diverse dominant group is found in lakes Possen-Lor and Pont-Tur. No dominant species were found in lake Komsomol'skoye. The dominant complex for each lake is individual: small-celled algae, mainly from the green division, are characteristic for Possenny-Lor; in mid-August 2016, Mallomonas denticulate dominated in the lake. In Lake Pont-Tur in the June 2012 second decade, the Anabaena contorta most active development was observed, the dominants half here belong to cyanobacteria. Lake Aran-Tur is distinguished by a golden algae high variety presence, in which some are the dominant algae part. For Lake Range-Tur, the class Conjugatophyceae, the families Closteriaceae and Desmidiaceae representatives are diverse, but their number is very low, so we do not observe them as the dominant ones part.

The species Tabellaria flocculosa dominates in 5 lakes, 3 water bodies are characterized by Tabellaria fenestrata in high abundance, the species rest dominate in no more than 2 water bodies.

Thus, the following conclusions can be drawn: the algae species composition in the the Khanty-Mansi Autonomous Okrug-Yugra lakes varies from 26 to 256 representatives, it depends on the lake area, the samples number, their sampling and anthropogenic impact time.

As the classes, families and genera spectra analysis a result, it was revealed that algae a large proportion are included in the leading taxa composition, however, there is single-species, two-species, and three-species taxa a very high proportion.

Estimation by the Sørensen-Chekanovsky coefficient revealed algological communities a low similarity in lakes, the highest was noted for lakes located in their formation and climate similar conditions.

The families and genera saturation coefficient are not high, the algae specificity in the studied lakes is low, and the species specificity is moderate, which indicates the algal communities' instability.

The dominant complex includes green algae almost half, which at high latitudes is an unexpected sign, but this phenomenon can be explained by the fact that the Khanty-Mansi Autonomous Okrug-Yugra limnological reservoirs have all the factors for the water rapid heating. However, this phenomenon requires constant monitoring, since anthropogenic factors in the oil production area can provoke some algae blooming.
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Conflict of interest
The authors declare no conflict of interest.

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