WATER RESOURCES OF TAIGA-ALAS LANDSCAPES IN CENTRAL YAKUTIA AND PROBLEMS OF WATER SUPPLY FOR THE POPULATION

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Alas lakes are the only source for water supply for more than 20% of Yakutia's total population. The waters of alas lakes are saturated by many mineral and organic compounds. During summer warm season in shallow alas lakes the rapid development of animal plankton, animal benthos and algoflora takes place. Based on the results of biological and chemical analysis the water in lakes is evaluated as enough pollutioned. As affected by natural climat rhythms the lakes of alas suffer cyclical flustuations. During short period of time these lakes may have not only abrupt water level fluctuations, but can completely dry up and appear again. Recently as an addition to natural factors the anthropogenic factors play role. For water supply of population living on alas region by qualitative potable water the system of large water lines was constructed from Lena river with the total lenght about 250 km and with planned production capacity of 20 million cubic meters per year.

Keywords: alas, lakes, composition, cycle, problems of water supply

Introduction

The river network on the Central Yakutia plains is developed weakly, as proposed by G.E.Chistyakov (1964) its density equals 0,2 km/km^2 and is the lowest not only in Yakutia but through the entire zone of boreal forests. Owing to weak degree of drainage of the area lakes are broadly distributed there. The most numerous genetic group of lakes is constituted by lakes of thermokarst depressions – alases. There are over 16 000 alases and two-three times more lakes scattered on this area, because an alas may have several lakes. The water mirror area of alas lakes varies within a broad range from some square meters to 20-25 square kilometers. The water volume difference in lakes is also great from some dozens to millions of cubic meters. Alas lakes are the only sources of water supply for the 1/5 of the whole population of Yakutia.

Alas lakes features

Alas lakes developed on the thermokarst basin bottoms are local bases of erosion and centers of biogeochemical accumulation for enclosed local areas. Owing to this cause their waters are saturated by many mineral and organic compounds. By the concentration level of matters soluble in water these lakes are referred to fresh or salty natural waters. Mineralization of lake waters fluctuates within 0,5 to 3,2 g/l of salts and higher. By their chemical composition lake waters belong to the hydrocarbonate class, sodium group with predominance of HCO_3 ions. The ratio of ion bicarbonate to the amount of Ca^{2+} and Mg^{2+} varies depending on the year season and lake age and approximates to 4-8. Sulfate-chloride ratio in salty lakes is < 1, that is characteristic of soda-sulfate waters, and in fresh water lakes it is > 1 indicating a soda-chloride type. Among cations ions of alkali elements are the most. The correlation of the sodium and potassium ion amount to the one of calcium and magnesium in waters of the examined alas lakes changes from 1,7 to 4 and greater. By pH value lake waters are referred to an alkaline series. The organic matter content in alas lakes is always high varying from 305,9 to 517,7 mg/l. Peculiarities of lake water hydrochemistry are caused by chemistry of mother rock mainly represented by carbonate loess-like loams.

The biogenic elements content is very important for biological productivity of a water pond. Their concentration decline in water results in total decrease of biological productiveness. Phytoplankton development together with higher water vegetation entails biogenic element consumption and mineralization of dead organisms and organic matter causes their accumulation in water thickness. The processes of organic matter decomposition are faster in less mineralized waters and low content of ammonia nitrogen in water of salty lakes evidences it indicating oxygen deficiency in these ponds. The contents of nitrite nitrogen in all pond waters is high enough and, most likely, shows general phytoplankton enhanced activity. The nitrite amount becomes greater since mid summer when there is the highest water warming-up in lakes and abundant "flowering" of ponds owing to phytoplankton activity. The amount of nitrate nitrogen is also sufficiently high and gives several times increase in salty lake waters. Nitrogen accumulation by autumn goes at the expense of organic matter mineralization and plankton dying.

The greatest phosphate concentration is marked in waters of young thermokarst basins. This feature of water composition of in alas lakes may be bound with the fact that they appear in taiga flooding the wood around, mineralization of which in anaerobic conditions enriches water by phosphates. There is soluble iron and silicon in all pond waters, their content decreases in summer season and this is bound with mass algae production in alas lakes. In waters of all lakes there is much organic matter (300 to 500 mg/l and more) and by this index these shallow ponds well-warmed-up in summer may be regarded as eutrophic lakes. During a warm period of the year there is a high level of chemical oxygen intake (COI = 400-700 mg/l). Oxygen intake and organic matter content increases even greater after mid-summer and show a rapid development of organisms in lakes during this time of the year.

In water of the studied lakes 21 zooplankton species are recorded. Their amount by mid-summer reaches 34000-64000 ind./m^3 on the open littorals but is not less than 19000-20000 ind./m^3 in different parts of lakes when decreasing. Zooplankton can produce from 595 to 4500 mg of biomass per every cubic meter of lake water space. In some alas lakes of the Lena-Amga interfluve zooplankton amount comprises 1,5 mln ind/m^3, and their biomass makes 9-10 g/m^3 (Larionova, 1983). Biomass of zoo benthos is even greater. The bulk of zoo benthos of alas lakes is composed of organisms referring to 17 systematic groups. The dominant group is chironomids larva. There are from 75 to 340 individuals belonging to different forms of zoo benthos per every square meter of water surface. Biomass produced by zoo benthos varies from 0,8 to 13,2 g/m^2. As found by A.M.Larionova (1983) the number of zoo benthos in the interfluve lakes may be 12,3-65,0 g/m^2. Quantitative figures of zooplankton and zoo benthos in lakes of Central Yakutia during summer is a lot higher because of favorable living conditions unlike the lakes of the entire taiga and tundra zone.

Algoflora of alas lakes comprises 204 algae species of 8 divisions. Genera *Oscillatoria, Cosmarium and Navicula* are rich in species diversity among lake algoflora. The number of algae species, their amount and biomass in lakes depends on intraseasonal dynamics. There is one peak in numbers and biomass which occurs since late July until mid-summer. This is the time for abundant development of blue-green algae causing water “flowering”. This event goes simultaneously with the highest water warming-up in lakes, and its volume and depth decline on the account of strong evaporation. Basing on figures showing the numbers (538 mln cells/l), biomass (over 28 mg/l), Tuhnmark coefficient equal 2,9 Pshennikova E.V. (1994) attributes alas lakes to euthropic and highly euthropic ponds. 44 algae species or 22,3% of the total species number found in lakes are saprobe indicators in lake algoflora that most often belong to α-β-mesosaprobes and polysaprobes. By biological and chemical analysis water of these lakes is considered sufficiently polluted.

Hydrological conditions of lakes

Under influence of natural rhythms of the climate the alas lakes fluctuate cyclically. During the short period of time these lakes can have sharp fluctuations of water level and completely dry and appear again. Many researchers note cyclical character of alas lakes concerning water abundance supply (Nemchinov, 1958; Bosikov, 1991; Makarov, 1983, Desyatkin, 1998, Desyatkin, 2001). Generalizing the archival documents, D.S. Makarov found the droughty period that lasted till 1861, which was replaced by a damp period within 1862-1905, then a new droughty period came (1905 –1950), and since 1951 there was a damp season again. The existence of the found century rhythm proves to be true thanks to archival data and modern equipment observation of the Russian hydrometeorological service system.

The activity of the main power source of the Earth – the Sun is of cyclic recurrence. It is shown by the change of spot number on a visible surface of the sun, which annually varies from 45 (for the years of 1804 and 1818) up to 190 spots (for 1957). The sun most brightly shines at a maximum solar spots, in such periods the Earth temperature becomes higher. There are 11-year cycles, from which 90-year and longer rhythms are composed, they render determining influence on ecosystems functioning on the Earth, causing fluctuations of the climate. The analysis of meteorological data for the whole observation period on city station “Yakutsk”, carried out by Gavrilova M.K. (1987), has allowed to reveal the rhythm of oscillatory movements on years, basing on the 11-year cycle. The greatest rhythm in temperature and precipitation makes approximately 55 years, i.e. includes five 11-year cycles. There are "max" air temperatures occurred in January in the years of 1846-1855, 1903-1912, 1955-1964. and "min” in 1836-1845, 1891-1990, 1946-1955. As for “max” precipitation of January they were recorded in 1903-1912, 1954-1963, and "min" in 1890-1899, 1944-1953. Fluctuations of meteorological parameters cause dynamics of alas humidity and water abundance supply of lakes.

Observations for the water supply on a small model alas during 1987-2003 show that the area and volume of lake’s water had significant fluctuations. The meteorological conditions for the given interval of time had also essential fluctuations: amount of summer precipitation was from 68 up to 234 mm (fig. 1), height of a snow cover was from 31 to 51 cm and water stock in snow - from 30 to 99 mm.

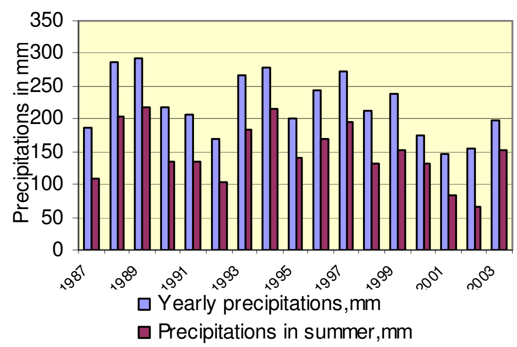

Fig.1. Precipitations quantity of year and summer, mm

For the period of observation the area of the alas lake changed from 0,03 to 5,78 hectares, and volume of water declined from 90 to 36414 cubic meters (fig. 2). So we can observe essential dynamics because the lake area showed a 192 time change, and water volume decreased more than 400 times.

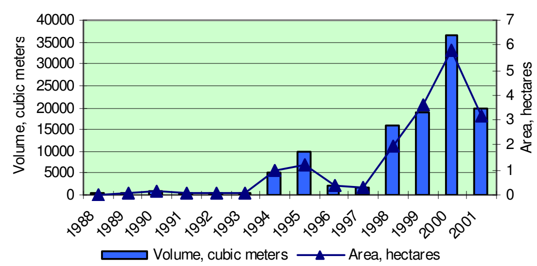

Fig.2. Water volume and alas lake area dynamics during period 1987-2003

Water fluctuation of another alas that is larger is demonstrated on the example of the Tungulu alas, with over 10 km long and 6-7 km wide. As archival materials witness in the 30-s of the 17th century (1630) this alas looked like an extensive meadow having about 40 small drying up lakes within scattered through the alas. Until the mid-18th century (1730-1750 years) the Tungulu alas looked like one large lake. The first half of the 19th century was very droughty, during this time the lake completely dried up again. Since 1862 the damp period began, and by summer of 1885 there was too much water, that the alas was completely filled with water again. The end of this damp period falls to 1905. The damp period of the 19-th century was replaced by a droughty cycle of the 20-th century lasting till 1951 and was characterized by the data of the Yakut Hydro-Meteorological Service by 23 dry poor harvest years. For this time there happened a significant reduction of the lake size, it broke up into two parts: western - Large Tungulu and eastern - Small Tungulu. In 1932 the lakes of Tungulu alas were surveyed by the State Hydrological Institute expedition (Leningrad), and in 1943 and 1953 by the Yakut Management expedition of Hydro Meteorological Service (System …, 1957). The results of these researches are presented in Table 1.

Table 1

Size changes of Large and Small Tungulu Lakes

Date of survey	S, km^2	W, mln. m^3	Max. depth., m	Mid. depth., m
Large Tungulu Lake				
08. 1932	32,4	140,54	8,00	4,34
08. 1943	27,1	76,5	6,05	3,82
07. 1953	20,0	60,0	4,55	3,00
Small Tungulu Lake				
08. 1932	12,24	42,60	9,00	3,43
08. 1943	3,43	5,92	6,30	1,72
07. 1953	3,95	7,80	6,80	1,97

Nowadays Tungulu Lake despite the damp period that came after the mid-20^{th} century completely has dried up owing to anthropogenic influence.

Anthropogenic influence

The natural fluctuations of water stock in the alas lakes are one of the negative factors unfavorably influencing on steady development of the region. Recently anthropogenic factors were added to the natural ones. It is established, that for the last 40-50 years dry low productive larch and pine woods were destroyed by rural people on the area up to 1,0-1,3 mln. hectares within the Lena and Amga interfluves (Desyatkin, 2003). Strong anthropogenic transformation of woods combined with grassland overgrazing and overtrampling, degradation of the alas meadows caused the occurrence of destroyed centers of natural landscapes, and this resulted in water balance disturbance of large territories towards aridity.

Decrease of lands covered by forests promotes larger water loss at evoparation. So, the total evaporation during a warm season of the year by our observation (1987-2004) in larch forest averages 163 mm/season while on stubbed taiga sites – 215 mm or in 1,3 times more than in the forest. Grasslands lost water even greater: xerophylic –225, mesophylic 250 and hygrophylic –320/season that is higher of the total evaporation in the forest by 138, 153 and 196%, respectively. Recently negative man-caused effect entailed decrease of river sink and disastrous dehydration of alas basins with complete lake drying up. Rural residents faced the problem of acute deficiency of drinking water and natural grassland productivity on large alas areas.

Problem of water supply and its accomplishment

To supply the people living in alas regions by drinking water, in 1992 a decision was adopted relating to the construction of the system of large water pipe lines stretching from the Lena river to Lake Myuryu and the upper rivers of the Suola and Tatta. The total length of water lines should be 250 kilometers with pipe diameter 500 and 1220 mm. By the project calculation to supply 30 settlement points along the water pipe line 31 water storage ponds should be erected with the total water volume about 27 million cubic meters. To gain this goal 20 million m^3 of water must be transferred from the Lena every year. Now the water pipe system has been completely built, but cannot perform on a large scale because of lack of reliable source of energy supply and can supply only 7 mln m^3 of water every season. Owing to water pipe operation alas lakes are replenished by river water with general mineralization from 80-100 to 400-500 mg/l during floodings. Under the natural conditions these lakes got additional water through atmospheric precipitation (10-30 mg/l of concentrated substances). Further coming of more mineralized river waters containing greater iron content may cause with time the change of hydrochemical composition of artificial pond waters. We need to study the influence of river water enriched by iron on hydrochemical and hydrobiological state of lake ecosystems in taiga-alas landscapes.

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