

Lake Water Quality Of Kazan City (Russia) Kaban Lake In The Anthropogenic Pollution Conditions And Improving Actions Implementation

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Abstract- Researches of lake water quality for the Kaban system in Kazan are conducted. Lakes Lower and Mid Kaban in the past were suitable for city water supply, but because of the trade and household sewage intake, by 1970th it became strongly polluted. For the purpose of water quality improvement the project of improvement, according to which the majority of the sewage production earlier dumped to lakes was taken away on treatment facilities, was developed and realized, cleaning was carried out for bottom of lakes L. Kaban and M. Kaban from the polluted ground deposits, the collecting pipe for collecting the emergency sewer waters is constructed, coasts are well arranged. Improvement of water quality turned out to be consequence of the held events. However, the anthropogenic impact remains rather high. The researches of water we conducted in Kaban Lake showed its low quality. In this regard, for each of the studied lakes the main sources of pollution were revealed. On the basis of impact level assessment on lakes and their current state, the set of measures for improvement of water quality is offered.

Keywords: lakes, pollution, restitution, monitoring, management, water use, environment.

Introduction

Lakes of the urbanized territories, as a rule, are subject to the strong anthropogenic influence which results in their state precipitant deterioration. Decline in lakes water quality limits possibility of lakes use by some water users and causes economic damage. In this regard, the problem of the polluted reservoirs restitution became timely, including Kazan. However, projects of water objects restitution demand larger financial investments therefore examples of their exercise in Russia and abroad are not numerous [1-3]. In this regard huge scientific and practical interest is represented by long-term observation for condition of the Kaban lakes system in Kazan at different stages of their pollution and restitution actions promoting restitution of lakes.

The system of the Kaban reservoirs in Kazan consists of three lakes (Lower, Mid and Top Kaban) and two channels (Bulak and Botanical). Lakes fall into to small lakes type of a bayou-karst origin (tab. 1). They have the mixed delivery (ground waters, atmospheric precipitation, surface drain). Lakes Lower and the Mid Kaban connect among themselves by channel.

Table 1. Morpho-metric indexes of Kaban system lakes

Lake	Area, hectare	Volume, thousand m ³	Average depth, m	Maximal depth, m
L. Kaban	47.5	3950.8	8.3	16.3
M. Kaban	127.0	11156.2	7.1	22.8
T. Kaban	24.7	1930.3	7.9	15.4

Lakes Lower and Mid Kaban in the past were suitable for city water supply, but because of the trade and household sewage intake, by 1970th it became strongly polluted. For the purpose of water quality improvement the project of improvement realized in 1981-1993 was developed. According to the project, the majority of production sewage earlier dumped to lakes L. Kaban and M. Kaban, was taken away on treatment facilities, cleaning of the lakes bottom was carried out for L. Kaban and M. Kaban from the polluted ground deposits, the collecting pipe for collecting the emergency sewer waters is constructed, coasts are well arranged [4].

Now to lakes dump storm sewage from adjacent territories, the conditional and clear warmed-up waters. Reservoirs become soiled compounds of heavy metals, oil products, biogenic elements. Lakes are used by locals for the recreational and sports purposes. On lake M. Kaban the competitions of the international level gathering large number of participants and audience are held. The poor water quality caused by anthropogenic impact on lakes can have an adverse effect on citizens and city visitors health, cause diseases, including infectious.

Scientific and practical interest is represented by research of lakes condition and assessment of long-term results of the held improving measures.

Research data and techniques

Studying of Kaban Lake condition on physical and chemical indexes was carried out in 2002-2014,

thus protocols of the water analysis results made by organizations in charge of the state and departmental monitoring, nature protection monitoring share data of laboratory water ecosystems of KFU for use.

For evaluation test of water eco-sanitary classification according to which (on the basis of 4 hydro-physical and 8 hydro-chemical indexes) waters of the studied object belongs to a particular class and category of water quality with the corresponding rank index (RI) was used [5]. The water pollution indexes (WPI) were calculated, it is recommended for formalized complex evaluation test of water in 6 hydro-chemical parameters on formula:

$$WPI = \frac{1}{n} \sum_{i=1}^n C_i / PDK_i$$

where C_i – substance concentration of i ; n – number of the indicators used in index calculation, $n = 6$; PDK_i – marginal substance concentration of i [6].

For identification of hydro-chemical indexes changes during researches comparison with share materials of KFU water ecosystems Laboratory was carried out [7, 8].

Main Part

On lake L. Kaban in the 1980th restitution means were held, water quality improved. But the modern researches show that it is impossible to call an ecological condition of the lake safe.

During the summer period the surface layers of water are oxygen saturated, owing to mass development of phytoplankton, and in benthonic

water layers with oxygen deficiency. Electrical conductivity of the water surface layer changed from 990 to 1415 microsec/cm, benthonic – from 1132 to 1557 microsec /cm. Water is very hard. Water transparency of the lake L. Kaban in August, 2014 was very low and made only 0,25 m. The content of ammonium and phosphates was high in benthonic layers of water whereas in the surface layers of water the content of ammonium and phosphates did not exceed admissible values. The content of nitrates and nitrites characterized water as "very" and "rather clear". In the lake water high BPK_5 values characterizing water as "extremely dirty" were noted. Sizes of chemical oxygen consumption also showed strong pollution of the lake organic matters, characterize water as "very dirty" at surface and as "extremely dirty" at the bottom.

The content of oil products in the lake water was at the marginal level in the surface layer, and in benthonic layer exceeded admissible standards by 2,4 times. From compounds of heavy metals copper was characterized by the concentration exceeding norm by 1,2 times in the surface layer, by 2,9 times – in benthonic. Excess of admissible concentration was noted for Zincum (by 2,4 times at surface and by 2,9 times at the bottom) and chromes in benthonic layer (by 9,4 times).

The index of the water surface layer impurity in 2014 corresponded to transition from "moderately polluted" to "polluted", IZV of benthonic layer characterizes water as "extremely dirty" (the seventh quality class): the increase in index was affected as much as possible by very low content of oxygen and high values of HPK and BPK_5 .

The greatest influence on water quality in the lake L. Kaban renders intake of storm sewage that leads to pollution of ground deposits by compounds of heavy metals, oil products, etc. For decrease in loading pollutants of the storm sewerage water it must be taken away on treatment facilities for cleaning. For these purposes the application of power tool cleaning, installations of micro-straining drum

type is possible. Improvement of water quality in the lake requires carrying out improving actions. It is necessary to carry out partial withdrawal of the surface layer of ground deposits in places of storm sewage production for prevention of secondary lake water pollution. For dredging of ground deposits the hydro-mechanized way is the best. In parallel, for water saturation by oxygen it is necessary to carry out water aeration. For the lake biological cleaning, withdrawal of biogenic substances, heavy metals and oil products it is possible to use the higher water plants.

Main sources of pollution of the lake. M. Kaban are the mass receipt of storm drains leading to pollution and lake oozing; thermal and chemical pollution of the lake sewage of combined heat and power plant; pollution owing to the emergency dumpings of the enterprises and releases of the economic and fecal sewerage; secondary pollution from ground deposits. Water temperature in the lake M. Kaban is 2-3°C higher, than in other lakes, owing to intake of power plant thermal sewage. Water type in the lake is mainly sulfate-hydrocarbon-calcium. For the last 7 years mean values of the main ions sum increased from 758 mg/dm³ to 1031 mg/dm³ (in surface layers – 758-958 mg/l, in benthonic – 757-1402 mg/l). Water is highly mineralized. Among cations calcium, among anions - sulfates prevail. Water is very hard. Composition of gases in solution in the lake M. Kaban corresponds to eutrophic reservoirs. In the surface layers the content of dissolved oxygen is high-11,8-14,9 mg/dm³ (118-146%), and in the thickness of water (it is lower than 6 m of depth) its contents falls to zero. Presence of hydrogen sulfide was noted at depth of 6 m and below. The unsuccessful gas mode was formed due to accumulation of organic matter arriving with waste and storm waters. Water transparency of the lake M. Kaban in August of 2014 was equal to 0,50 m.

The content of ammonium nitrogen in the surface layers of water changed from 0,07 to 1,6 mg/dm³, in the benthonic – from 4,8 to 16,8 mg/dm³,

which by 3 times exceeds admissible values. The maximal concentrations were noted around production of the production sewage and storm sewerage. In some years (2006, 2010) was noted excess of admissible concentration of the nitrites content in water (by 1,2-1,6 times) that is caused by high maintenance of NO_2 in sewage. The content of phosphates changed from 0,025 to 3,82 mg/dm³, the maximal values were noted in benthonic water layers.

Water of the lake contains many organic matters, especially in benthonic water layers. The size of permanganate oxidizability in benthonic layers exceeds admissible concentration by 13,9 times. In the surface layer this index characterizes water as "quite clear".

Water of the lake contains oil products in concentration exceeding marginal concentration by 2,9-4,7 times, compounds of manganese, Zincum, copper, iron in the concentration exceeding marginal by 21 times. The index of water impurity on the surface layer corresponded to the III quality class - "the water is moderately polluted", IZV of benthonic layer characterizes water as "extremely dirty" (the VII quality class). Change of index values towards their increase was influenced by very low content of oxygen and high value of permanganate oxidizability and nitrates concentration.

Improvement of water quality in the lake requires carrying out improving actions. Its withdrawal from the ground deposits surface layer is necessary. It is possible to apply the hydro-mechanized ground deposits dredging. We recommend to remove ground deposits on the area of 70 hectares, 2 m thick, with a total amount of 140 000 m³. On those sites where withdrawal of the polluted soil is impossible screening of the bottom - powdering of ground deposits by clean sand layer, clay or sorbing material 15-30 cm thick is recommended. It is necessary to carry out aeration of water for water saturation by oxygen, for the purpose of oxidizing processes and self-cleaning processes acceleration. For lake M. Kaban it is necessary to

aerate water in 4 places at the same time, in places of sewage production. On releases of the storm sewerage it is necessary to place treatment facilities for storm drains, with use of power tool cleaning.

Along a coastal zone of the lake M. Kaban it is necessary to provide the continuous system of gardening with inclusion of existing green plantings sites. For biological cleaning of the lake, withdrawal of biogenic substances, heavy metals and oil products is offered as well as use the highest water vegetation. Microphytes can also be used for pre-refining of water in the KTPP-1 channel flowing into the lake.

In lake T. Kaban sewage do not arrive, therefore the composition of water in the lake is close to natural. Electrical conductivity of water of the lake. T. Kaban is low (400-500 microsec/cm), water of the lake was characterized by "average" mineralization. From cations magnesium, among anions chlorides and hydro-carbonates, in the benthonic – hydro-carbonates prevailed in the surface layer of water. Water is hard. The content of the dissolved oxygen in the surface layer made 12,2 mg/dm³ that correspond to 140% of saturation. Water transparency of the lake T. Kaban in the summer of 2014 it was equal to 1,05 m. Concentration of ammonium, phosphates in benthonic water layers exceeded admissible norms. In the water surface layers the ammonium, phosphates and nitrates concentration were much less. In the lake water high content of easily oxidizable organic matters was noted (on BPK₅) that characterized water as "very dirty" in the surface layer and as "strongly polluted" - in benthonic. Sizes of chemical oxygen consumption also show the considerable pollution of the lake organic matters, characterize water as "strongly polluted" at surface and at the bottom.

The content of oil products in the surface layer did not exceed norm, and in benthonic layer exceeded it by 1,3 times. Water of the lake contains the increased concentration of copper, Zincum, manganese and iron compounds. Their concentration

exceeded admissible values by 2-9 times. The highest content of heavy metals compounds was observed in benthonic water layers.

The index of water impurity on the surface layer corresponded to the III quality class - "the water is moderately polluted", IZV of benthonic layer characterizes water as "extremely dirty" (the VII quality class). Change of index values towards increase most strongly was influenced by the low content of oxygen in benthonic water layers, high values of BPK, high concentration of phosphates and manganese.

Lake T. Kaban is a recreational facility, the city beach is located here. Pollution takes place owing to intake of the surface drain waters from an adjacent urban area, highways, and to atmospheric transfer. The lake is used for economic purposes and rest of locals, a water intake, nearby gardening associations, and also for watering of green plantings and roads of Kazan. During the summer 2880 t of water is being withdrawn from the lake on average, that causes decrease in the water line. A large number of vacationers in summertime and lack of equipped paths with hard coating led to trampling of the coastal territory, damage of wood and shrubby vegetation. Improvement of the lake condition requires carrying out preventive actions including improvement of coastal zone, arrangement of specific points and platforms for vacationers, assignment and purification of storm sewage from highways. For biological cleaning of the lake, withdrawal of biogenic substances, heavy metals and oil products is offered as well as use the highest water vegetation. In winter time it is necessary to provide aeration of benthonic water layers in the periods of greatest water "blossoming".

Summary

1. The improving events held on Kaban Lake in Kazan in 1980-1990 led to significant improvement of their ecological state and water quality.

2. The modern researches showed that for lakes deficiency of oxygen in benthonic water layers, presence of oil products and heavy metals at the concentration exceeding marginal is characteristic.
3. Indexes of the Kaban Lake water surface layer impurity corresponded to the category "moderately polluted" - "polluted", and benthonic - "extremely dirty".
4. Storm sewage from the Kazan territory, and conditional and clear thermal sewage of combined heat and power plant have the greatest impact on water quality of Kaban Lake (on the lake M. Kaban).

Conclusion

Thus, the conducted researches showed that at high anthropogenic loading, it is not enough to single-pass carrying out improving actions. In self-contained reservoirs which are located in the urbanized territories, a large amount of suspended matters, oil products, heavy metals, as a part of storm, surface, emergency sewage arrives. It leads to pollution of water and ground deposits, negatively influences communities of hydro-bionts. For maintaining of ecosystem condition and water quality which satisfies water users it is necessary to hold repeated reduction measures every 15-20 years.

Acknowledgments

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University

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