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Ways to Reduce Concentration of Sulphates in Reservoir-Cooler Based on Kenon Lake in Chita

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Abstract **– The paper presents calculation results of hydrochemical balance. There are developed and described methods to reduce the concentration of sulfates in reservoir-cooler - Lake Kenon CHPP-1 in Chita. The operation of a coal station and disposal of its waste without anti-filtration measures directly affect soil feeding of the lake. Thus, the anthropogenic impact of the city-forming plant threatens the lake's ecosystem and quality of groundwater. The measure proposed in the paper should help reduce negative factors affecting the natural ecosystem and, then continue to use coal fuel to maintain the quality of the reservoir. One of the main consequences of the implementation of these methods is time calculation when water is restored to its natural state. It will help to use this part of the reservoir for recreational purposes.**

Keywords – reservoir-cooler; Kenon Lake; ash dump; filtration; CHPP-1; concentration; sulfates.

I. Introduction

The significant impact on the state of natural water bodies is also exerted by huge accumulations of TPP wastes - ash dumps that dust the atmosphere and filter heavily polluted water into the soil and underground horizons.

The problem of burial and disposal of ash waste from power engineering in its scale stands out among many problems of technogenesis [8]. These processes also significantly depend on local climatic conditions: winds, depth of soil freezing, soil composition, and amount of precipitation.

When designing, operating and upgrading thermal power plants, we should talk about optimizing the environmental protection technologies of the plant's energy system in general, and take into account local climatic conditions while minimizing major process losses.

Depending on its location, any TPP has an effect by local climatic conditions. In Zanbaykalsky Krai this is a sharply continental climate, which has a negative impact on environmental protection processes and technologies. Under conditions when the outdoor air temperature reaches minus 30 ... 45 ° C and below during the winter long period (up to 4–5 months), great operational difficulties may be caused by freezing of standard coolers (for example, evaporation pools, cooling towers, etc.) [11].

For TPP and boiler rooms design, it is very important to zone the territory by dust storms and heavy precipitation. TPP design and operation require the consideration of average monthly values of evaporation from the water surface, data on precipitation, runoff and snow melting intensity. Increased precipitation leads to wet coal in open fuel depots. The operation efficiency of gas turbine installations is significantly affected by fluctuations in the air temperature [11].

Lake Kenon is located in the northwestern part of Chita in the area between the Ingoda river and its left tributary of the Chita river. It is geographically and structurally associated with the central part of Chitines-Ingodinsky intermountain depression. The length of the reservoir is 5.7 km, the average width is 2.8 km, the maximum depth is 6.8 m, the average depth is 4.4 m, the mirror area is 16 km2 [7], the estimated water volume in the lake at a normal level (abs. mark 654.8 m) is about 91.5 million m3 [2]. The Kadalinka river from the west and the Ivanovsky creek from the north flow into the lake. In addition to the depression, the drainage basin of the lake includes the southeastern slope of the Yablonoi Mountains, where there is most of the surface flowing into the lake is formed by gravity [9].

The basin of Lake Kenon is located in the Chitines-Ingodinsky depression within the anticlinal kink that separates Chita and Ingodinsky synclines. At the same time, the formation of water-bearing rocks is opened, containing fracture-formation waters, where the lake waters actively interact. As a result, the western part of the lake bottom is an intermediate discharge zone, and the southern part is an intermediate feeding zone for the Lower Cretaceous aquifer complex [4].

TPP located on the bank of Lake Kenon as a reservoir-cooler has become the main industrial facility that has radically changed hydrochemical characteristics and ecological state of this reservoir since 1965 [3].

The ash dump is located 3 km north-west of the CHPP-1 and Lake Kenon, which also serves to draw water to the hydraulic ash disposal system. To maintain the level of water in the lake is swapping from the river Ingoda. It covers the area of about 115 hectares and located in natural lowering of the hilly-ridge surface of the bottom of Chitines-Ingodinsky intermountain depression [3].

As a result of filtration, there is a halo with the length of more than 3 km up to the lake from the hydraulic ash dump of Chita CHPP-1 to Lake Kenon with bicarbonate-sulphate water and a salinity of more than 1.0 g / l, substandard in terms of drinking on total mineralization, the value of hardness and the content of magnesium and silicon. Due to the mixing of seepage leaks with groundwater of the aquifer, the sulfate ion content decreases in comparison with the ash dump, and hydrocarbonate increases due to its higher content in groundwater, but sulfate remains the dominant anion in the contaminated zone [5].

At present, lake water is characterized by a three-component composition of cations and a predominance of sulfates in the anionic composition [9].

The particular danger of high sulfate concentrations in lake water is that in the enriched with organic matter (detritus) bottom sediments, conditions are created for hydrogen sulfide contamination of silts and bottom water layers, especially during a freeze-up period. This may be related to the incidence of fish death [9].

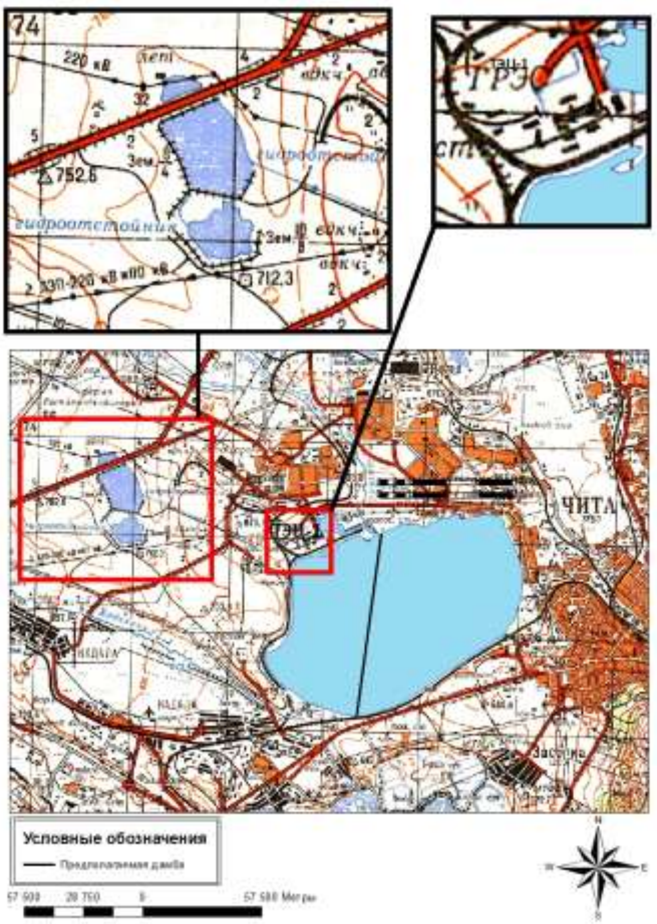

Fig. 1. Geographical location of the study area, lake Kenon, CHPP-1, ash dam.

The idea to restore Lake Kenon to its natural state by dividing its geosystem into two parts belongs to Olga Yuryevna Tokareva, PhD in Technology, associate professor of Technosphere Safety Department at Transbaikal State University. The method proposed by her considers the division of the reservoir's geosystem into technogenic and communal parts, followed by a set of technical and biological measures in both parts and at catchments. It is proposed to divide Lake Kenon with a dam. With this arrangement, the dam tributaries the Kadalinka, the Ivanovka also flow into the technogenic part of the reservoir. Therefore, there is intercepting filtration water from the ash dump.

Figure 1 shows the location of Lake Kenon, CHP-1 and a hydraulic ash dump. It also schematically shows the supposed dam, which will divide lake's geosystem.

II. Purpose of the Study

The aim of this paper is to calculate how the content of sulphates in the technogenic part of the lake will change. There are two options to reduce the level of sulfates in the technogenic part.

III. Hydrochemical Balance

Based on calculations by O.Yu. Tokareva, S.G.Tarasova, the hydrochemical balance was calculated. The flow from the utility unit is 7.27 million m3 / year. The transfer from the Ingoda river to the municipal - household one is equal to 20.77 million m3 / year [10]. The obtained values of concentration and mass of sulfates at the end of the year are taken as initial values for the next year.

Hydrochemical balance is calculated according to the equation:

$$M_2^{к} = M_2^b + M_1^k + M_{ad} + M_{m\,tpp} - M_2^f$$

where $M_2^{к}$ – mass of substance in the technogenic part at the end of the year, t;

M_2^b – mass of substance in the technogenic part at the beginning of the year, t;

M_1^k – mass of the substance in the volume of transfer from municipal to the technogenic part per year, tons / year;

M_{ad} – mass of the substance infiltrated from the ash dump, t / year;

$M_{m\,tpp}$– mass of the substance entering the technogenic part as a result of TPP water cycle, t / year;

M_2^f– mass of substance filtration from the technogenic part into the soil, t / year;

The magnitude of substance mass entering the technogenic part as a result of TPP water cycle is negative. This situation is due to the fact that a significant portion of sulphates goes to the ash dump together with water of hydraulic ash disposal [1].

In the second option, the transfer from the Ingoda river is divided into two directions - into the communal-household part and into the technogenic part. Consequently, ratios in volumes change. The transfer from the Ingoda river to the technogenic part for the first year amounts to 6.50 million m3 / year, the flow from the public utility unit is 0.77 million m3 / year, the pumping from the Ingoda river to the public utility is equal to 14.27 million. m3 / year. For the remaining 11 years, the transfer from the Ingoda river to the technogenic part for the first year is 7.27 million m3 / year, there is no overflow from the utility part, and the transfer from the Ingoda river to the utility one is equal to 13.50 million m3 / year.

The transfer from the Ingoda river to the technogenic part is added. The calculation will take into account the filtering from the communal - household part.

The hydrochemical balance of the technogenic part is calculated using the equation:

$$M_2^k = M_2^n + M_1^k + M_{ad} + M_{m\,tpp} - M_f + M_2^p$$

M_2^n – mass of substance in the technogenic part at the beginning of the year, t;

M_1^k – mass of the substance in the volume of transfer from municipal to the technogenic part per year, tons / year;

M_{ad} – mass of the substance infiltrated from the ash dump, t / year;

$M_{m\,tpp}$– mass of the substance entering the technogenic part as a result of TPP water cycle, t / year;

M_2^f – mass of substance filtration from the technogenic part into the soil, t / year;

M_2^p – mass of the substance transferred from the Ingoda river to the technogenic part of tons / year;

The hydrochemical balance of the utility part is calculated using this equation:

$$M_3^k = M_3^b + M_1^p - M_1^k - M_3^f$$

where M_3^k – mass of substance in the municipal unit at the end of the year, t / year;

M_3^b– mass of substance in the municipal unit at the beginning of the year, t / year;

M_1^p – mass of the substance transferred from the Ingoda river to the municipal part of tons / year;

M_1^k – mass of the substance in the volume of transfer from the utility to the technogenic part per year, tons / year;

M_3^f – mass of filtration substance from the utility to the ground, t / year.

IV. Results

Based on the data presented in the graphs, it is clear that the concentration in the first variant has a more gradual decrease in the level.

In the second variant, the concentration in the technogenic part has a sharp decline only in the first year, the following years the graph goes to the same value of the constant concentration. This is due to the reduction of the negative mass of the substance entering the anthropogenic part as a result of TPP water cycle. It is reduced due to changes in the volume of flow in the technogenic part. In the communal area there is a slower decrease in sulphates. At the same time, the flushing time is extended to the natural level by more than 10 years.

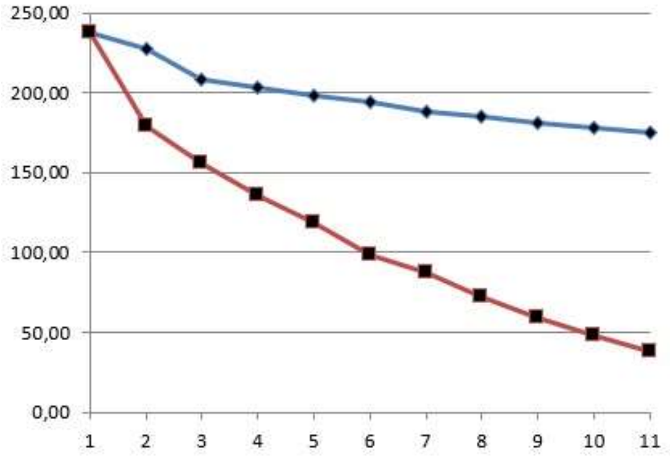

Fig. 2. Changes in sulfate concentrations in the technogenic and municipal parts of Lake Kenon t / g 1 variant

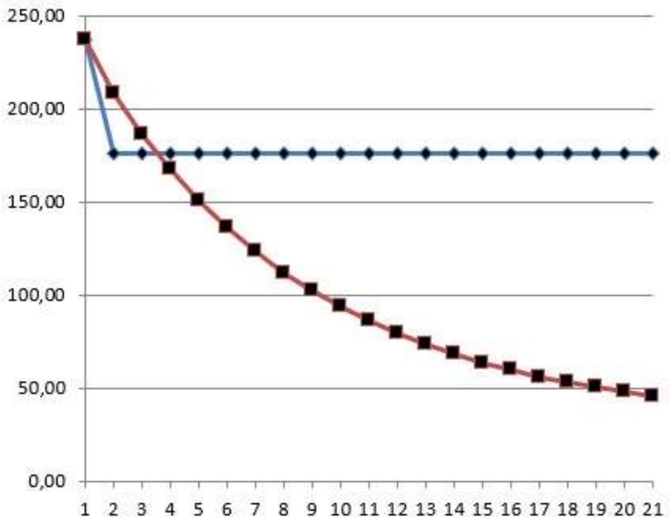

Fig. 3. Changes in sulfate concentrations in the technogenic and municipal parts of Lake Kenon t / g 2 variant

V. Conclusion

As a result, after performing calculations on the proposed variant for lowering the waters of the technogenic part of Lake Kenon it was found that in the first embodiment, a significant decrease can occur in 11 years in the technogenic part. Then it will reach the level of 174.96 mg / l. In the communal household during this time, flushing to the natural level - 38.30 mg / l will occur.

According to the second variant, the reduction of sulfates in the technogenic part will occur in the first year, after which this level will be maintained. This reduction will be due to the addition of a transfer from the Ingoda river, and flushing the utility part lengthened by 20 years. Since after the first year there will be no transfer to the technogenic part. Other variants are possible due to balancing between pumping from the Ingoda river to the technogenic part and transfer from the municipal part to the technogenic part.

Acknowledgment

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References

[1] G.O. Veselkov, "Ways of reducing the technogenic load on the reservoir-cooler – Lake Kenon Thermal Power Station-1", Post-graduate student. Supplement to the journal Bulletin of Transbaikal State University, vol. 2, pp. 20–28, 2018.

[2] A.P. Chechel, "Water management and technological problems in the operation of Lake Kenon as a reservoir-cooler of the Chita CHPP-1", Zapiski Zabaikalsky Branch of the Russian Geographical Society. vol. 131, pp. 142–147, 2012.

[3] L.V. Zamana, L.I. Usmanova, M.T. Usmanov. "Hydrochemistry of a sedimentation tank of ash dump of Chita CHPP-1 and composition of groundwater in the zone of its infiltration influence", Bulletin of Buryat State University. vol. 3, pp. 28–33, 2010.

[4] B.A. Shishkin. "Physical-geographical characteristics of Lake Kenon (reservoir-cooler of Chita SDPP)", Notes of the Trans-Baikal Branch of the Geographical Society, vol. 62. pp. 3–15, 1972.

[5] L.I. Usmanova, M.T. Usmanov, "Geochemical features of groundwater and surface water in the zone of influence of the ash dump of Chita CHPP-1", International Scientific Research Journal, vol. 77, pp. 91–95, 2018.

[6] L.I. Usmanova, M.T. Usmanov, "Influence of the ash dumps of Chita CHPP-1 and CHPP-2 on the natural waters of the adjacent territories" Vestnik KRAUNC. Earth Sciences, vol. 2, pp. 167–178, 2010.

[7] M.I. Itigilova, Ecology of city reservoir. Novosibirsk: Publishing House of Siberian Branch of the Russian Academy of Sciences, 1998.

[8] L.V. Tauson et al., Geochemistry of man-made processes, Moscow: Science, 1990, pp. 3–13.

[9] L.V. Zamana, L.I. Usmanova "Hydrochemistry of Lake Kenon – water reservoir-cooler of Chita TPP-1", Ecology of reservoirs-coolers of power stations, pp. 130–136, September 2017 [All-Russian. scientific and practical conf. from Intern. By engagement, p. 351, 2017].

[10] S.G. Tarasova, V.N. Zaslonovskiy, O. Yu. Tokareva, "Forecast of the restoration of the water quality of Lake Kenon by dividing it into two parts", Clean Water of Russia, pp. 322–325, April, 2017 [XIV International Scientific and Practical Symposium, p. 514, 2017].

[11] G.O. Veselkov, V.N. Zaslonovskiy, "On the modern approach to environmental safety of thermal power plants", pp. 254–257, November 2017 [XIV International Scientific and Practical Conference p. 308, 2017].