

# The effect of the external water cycle on certain water quality parameters of the Novosibirsk Reservoir in different water-content years

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**ABSTRACT.** The work describes the analysis of the influence of one of the most important hydrological factors characterizing the hydrological and hydrochemical regime of the Novosibirsk Reservoir, external water exchange, on certain water quality parameters of the reservoir for years of various water content (the extremely low-water year of 2012, the medium-water year of 2009, and high-water year of 2013). Daily water cycle factors were used for the Novosibirsk Reservoir for the first time. To investigate the dependence of chemical characteristics on the water quality on the water cycle factors, daily water cycle coefficients were calculated for specific dates, on which water samples for chemical analysis were taken. The strongest statistically significant correlations between water exchange coefficients and some chemical ingredients were obtained for the high-water year. We confirm the conclusion that in high-water years the water quality in the reservoir is more dependent on the hydrological characteristics, and in low-water years it is mainly determined by intra-water processes.

**Keywords:** Novosibirsk Reservoir, hydrological regime, water cycle coefficient, water quality, hydrochemical characteristics

## 1. Introduction

The Novosibirsk Reservoir created on the Upper Ob in 1959 was the only in the Ob basin among the seven hydroelectric power stations with reservoirs planned in the mid-50s of the 20th century (Vasiliev et al., 1990). It determined the hydrological and hydrochemical regime of water resources in the regulated area and ensured the comprehensive multipurpose use of river runoff and protection from floods in the downstream area. In the present work, we studied the influence of one of the main hydrological characteristics, external water cycle coefficients, on the formation of the hydrochemical regime of the reservoir using the example of the medium-water year of 2009, the extremely low-water year of 2012, and the next high-water year of 2013. This characteristic was chosen for analysis, because, as it was shown in (Dvurechenskaya et al., 2010), it is the intensity of water exchange that has a greater effect on the quality of water in the reservoir.

## 2. Material and methods

To identify the correlations between chemical indicators of water quality and water exchange characteristics, daily external water exchange coefficients were calculated for specific dates, on

which water samples were taken. Statistical analysis of observations was carried out using the STATISTICA 6.0 software package. The Spearman rank correlation coefficients ( $r$ ) were used for the identification and evaluation of the correlation between the series of comparable parameters. The coefficients of external water exchange ( $k_w$ ) of the Novosibirsk reservoir were calculated by the Dubrovin's formula (Matarzin, 2003) as the ratio of discharges through a hydroelectric station to the reservoir volume corresponding to actual average water level data for the considered periods.

## 3. Results and discussion

The formation of water quality in the upper part of the Novosibirsk Reservoir is mainly influenced by the hydrochemical runoff of the Ob River, and in the middle and lower parts of the reservoir's area the intra-water processes become dominant (Savkin et al., 2014). In separate hydrological seasons of the year, the water in the reservoir is polluted with oil products, phenols, as well as nitrites and compounds containing ammonium ions (Vasiliev et al., 1997). The investigation of the influence of the hydrological parameters of the Novosibirsk Reservoir on water quality is of certain interest.

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The Novosibirsk Reservoir belongs to reservoirs with the large water cycle. The average annual external water exchange coefficient of the reservoir is 6.67. In high-water years, the water exchange coefficient is 8.0–9.0 (in 1969 – 9.58, in 2010 – 8.32, in 2013 – 8.58, in 2017 – 7.45, and in 2018 – 7.56), in low-flow years – 4.0–5.0 (in 1974 – 4.70, in 1981 – 5.48, in 2008 – 5.10, and in 2012 – 4.35). The most intensive water exchange in the Novosibirsk Reservoir occurs in spring and reaches its maximum in May. In the low-water year of 2012, the water exchange coefficients for the spring period and the whole year were the lowest for the entire period of the reservoir operation.

A correlation analysis was carried out between the concentrations of the main hydrochemical indicators: the main ions ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$ , and  $\text{SO}_4^{2-}$ ), compounds containing biogenic elements (nitrates, nitrites, ammonium compounds, and phosphates), values of easily oxidized organic compounds (biochemical oxygen demands according to  $\text{BOD}_5$ ), phenols, oil products, and daily water exchange coefficients. The concentrations of chemical ingredients on specific dates during the studied years were taken into account. For the high-water year of 2013, strong statistically significant correlations between  $k_w$  and  $\text{HCO}_3^-$  ( $r = -0.63$ );  $k_w$  and oxygen ( $r = -0.51$ );  $k_w$  and  $\text{Ca}^{2+}$  ( $r = -0.42$ ),  $k_w$  and  $\text{NH}_4^+$ -ions ( $r = 0.41$ ) were revealed. For some chemical parameters ( $\text{BOD}_5$ , nitrates, nitrites, and sulfates), correlations with water exchange coefficients were also statistically significant but weaker ( $r < 0.4$ ). For the low-water year of 2012, strong statistically significant correlations were found only between  $k_w$  and oxygen ( $r = -0.52$ );  $k_w$  and  $\text{Cl}^-$  ions ( $r = -0.46$ ). For phenols, oil, ammonium compounds, sulfates, and pH-values, very weak correlations with water exchange coefficients were revealed; no reliable correlations were found for the remaining chemical parameters. For the medium-water year of 2009, strong correlations between  $k_w$  and chemical concentrations were not detected. However, we obtained statistically significant correlations ( $r < 0.5$ ) between  $k_w$  and pH,  $\text{BOD}_5$ ,  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cu}^{2+}$ , oil products, and phenols.

#### 4. Conclusions

The influence of external water exchange on the formation of the hydrochemical regime of the reservoir

was investigated for years with different water content (the low-water year of 2012, the medium-water year of 2009, and high-water year of 2013). For the first time, the daily water exchange coefficients were used for the analysis of the Novosibirsk Reservoir. The strongest statistically significant correlations between water cycle coefficients and some chemical ingredients were obtained for the high-water year. Thus, in high-water years, the water quality in the reservoir is more dependent on hydrological characteristics, and in low-water years, it is mainly determined by intra-water processes.

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#### References

- Dvurechenskaya S. Ya., Yermolaeva N. I., Savkin V. M. 2010. Complex monitoring and the environmental problems of the Novosibirsk reservoir. In: All-Russian Scientific-Practical Conference “Scientific basic foundation for environmental monitoring of reservoirs”, pp. 53-56. (in Russian)
- Matarzin Yu. M. 2003. *Gidrologiya vodokhranilishch* [Hydrology of reservoirs]. Perm: Publishing House of the Perm State University. (in Russian)
- Savkin V. M., Dvurechenskaya S. Ya., Yermolaeva N. I. et al. 2014. *Mnogoletnyaya dinamika vodno-ekologicheskogo rezhima Novosibirskogo vodokhranilishcha* [Long-term dynamics of the Novosibirsk reservoir water-ecological regime]. Novosibirsk: Siberian Branch of RAS Publishing House. (in Russian)
- Vasiliev O. F., Burakov D. A., Vostryakova N. V. et al. 1990. Prospects for flow regulation in the Ob-Irtysh basin in connection with land reclamation. Hydrological justification of water management activities. In: V All-Union Hydrological Congress, pp. 159-164. (in Russian)
- Vasiliev O. F., Savkin V. M., Dvurechenskaya S. Ya. et al. 1997. Water and ecological problems of the Novosibirsk reservoir. *Vodnyye Resursy* [Water Resources] 24(5): 581-589. (in Russian)