Comprehensive assessment of water management situation in the water bodies of Simferopol

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Abstract. The article presents the results of comprehensive analysis of water management situation at the water storage facilities of the Simferopol city. The study included digitization of reservoirs, survey of these water bodies and their coastal zones, determination of accumulated water composition and properties in field and laboratory conditions, assessment of their environmental sustainability. In the course of the work a list of ponds was identified, primarily in need of measures, aimed at improving their level of environmental safety and maintaining a comfortable urban environment.

1 Introduction

Since the middle of the last century, the issues of the consequences of the construction and operation of water storage facilities have become particularly relevant. This is justified by the influence of these types of anthropogenic activities on river ecosystems, adjacent territories, and the interests of the population living nearby.

Although the creation of dams makes it possible to redistribute the emerging river flow over time, develop hydropower, reduce the likelihood of floods and mudslides, caused by snowmelt or heavy precipitation, develop fisheries, increase the territory recreational attractiveness, the attitude towards them remains controversial [1-3].

In modern practice, the issues of operation of already created dams have come to the fore. At the same time, special attention has been paid to water storage hydroelectric facilities, located in urbanized area, characterized by a large concentration of people and infrastructure facilities that may suffer as a result of emergency situations. Quite a lot of research is devoted to assessing the quality of water, accumulated in the urban area, and determining its safety for the population and vacationers. Such scientists as Liu Y., Smith C.D., Li W., Yin L., Yang L., Zhang M., Meng H., Zhang J., Mecnakshi P., Sriram G., Rodrigues A., Calheiros C.S.C., Sharip Z., Mohamad M.F., Saha A., Ahweyevu J.O., Ferreira V., Magalhaes R., Tamrakar A., Upadhyay K. and many others worked in this direction [4-15]. The results of the studies indicate a high level of anthropogenic pressure, exerted on water bodies, which causes a deterioration in the quality of water resources. For

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example, Tamrakar A., Upadhyay K., Bajpai S. when examining ponds, located on the territory of Raipur, recorded a high content of phosphates and nitrates in the accumulated runoff, which, in their opinion, is due to the entry of sewage and untreated stormwater into these facilities. In their article, the authors emphasized that these reservoirs require measures, aimed at preventing their further degradation and increasing the level of environmental safety [13].

Besides, according to a number of scientists, it is necessary to conduct regular monitoring of these water facilities technical condition, as this allows for timely implementation of management decisions, aimed at ensuring their sustainable functioning. This is the conclusion that Fomenko I., Dinh H., Kozlov D. V., Yurchenko A. N., Golebiowski T., Piwakowski B., Ekram A. R. M., Kong F., Prieto C. J. L., Martinez-Alegria L. R., Abu-Abdullah M. M., Youssef A. M., Du L.-Y., Wang Z. L. and many others came to in their publications [16-22].

Based on above, the purpose of this work was formulated – to conduct a comprehensive analysis of water management situation at the water storage facilities in Simferopol city.

2 Materials and methods

During the study, the following works were carried out:

- Digitization of water storage facilities in Simferopol using QGIS 2.18 software, QuickMapServices module, digitization tools.
- Field survey of water storage facilities and their coastal zones.
- Determination of waters chemical composition and properties in the field. The following indicators were monitored: temperature, electrical conductivity (Es), pH, mineralization, dissolved oxygen. To determine them, the following were used: "Hanna Instruments-98195", "Aktakom ATT-3010").
- Conducting an extended chemical analysis (certified laboratory of the FSBI "NIISH of Crimea").
- Assessment of the qualitative composition of the accumulated runoff based on comparison with the maximum permissible concentrations (MPC), prescribed in the regulatory and legislative documentation of the Russian Federation, calculation of the integral index of the ecological state (IIES) [23].

3 Results

According to reference data, 27 reservoirs are located on the territory of Simferopol, represented by 1 reservoir (the water mirror area at a normal retaining level is 323 hectares, and the volume is 36,0 million. m^3) and 26 ponds (the total area of water mirror is 35 hectares, the volume is 1.1 million m^3). The location of these water management facilities is shown in Figure 1.

During the digitization of reservoirs, 9 ponds were identified that were not included in the water register. These are small objects, the water mirror area of which ranges from 0,02 to 0,20 hectares. More detailed information about their placement is shown in the Figure 1. The total area of water mirror of these water management facilities according to the results of digitization is 0,66 hectares.

During the visual inspection of large ponds in Simferopol, violations were recorded that led or in the future may lead to a change in the operational regime of these structures. These include:

- Erosion of the shoreline of pond 21 due to the inflow of water from the spring feeding it and destruction of this hydraulic structure lining.

- Flooding of the dam downstream of the water storage facility 13, associated with the construction of the Abdalka river embankment in the area of the 27th street of Collective Gardens. This, in turn, in conjunction with the features of the geological structure of the territory (the presence of karst) contributed to the drying of the pond 14.
- Absence of spillway structure on reservoir 2, which at the time of its inspection led to flooding of the coastal zone.
- Erosion of the shoreline of the reservoir 3, due to its overflow, and as a result, the waterflow into the pond 2.
- Unsatisfactory technical condition of the spillway structure of reservoir 16, which caused filtration through the body of the dam.

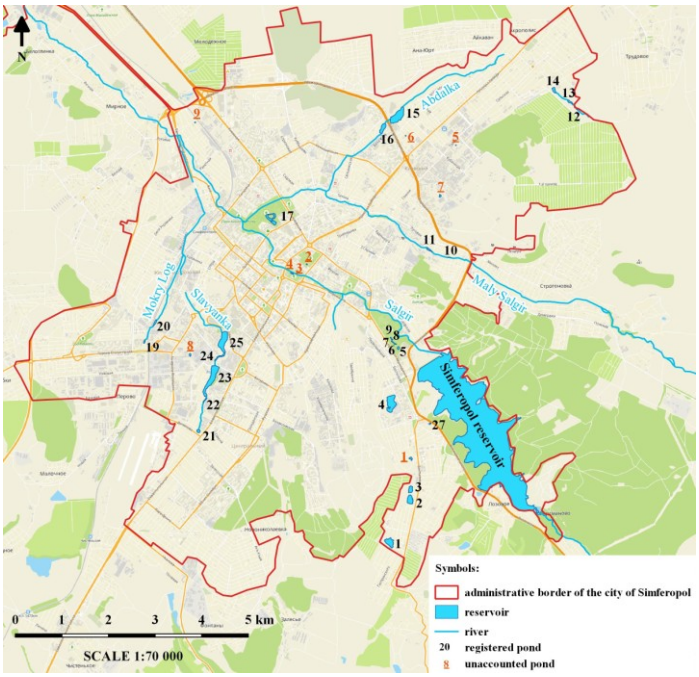

Fig. 1. Scheme of location of water storage facility on the territory of Simferopol.

Figures 2 and 3 below show examples of violations of the technical condition of structural elements and the operating mode of water storage facilities, recorded during the survey.

a) b)

Fig. 2. Violations recorded on pond 21, located in the upper reaches of the Slavyanka river: a) erosion of the coastline; b) destruction of the bottom lining.

a) b)

Fig. 3. Violations recorded at reservoirs 13 and 14 located in the upstream of the Abdalka river: a) flooding of the dam lower reaches of the pond 13; b) view of the pond 14.

During the research, water samples were taken from the largest reservoirs. The results of chemical analyses of these samples are presented in Tables 1 and 2. For a number of water bodies excess of the maximum permissible concentrations of pollutants in the accumulated water samples was recorded, according to the most stringent requirements for the quality of water resources, used for municipal and fisheries purposes. These mainly include: sulfates, nitrates, zinc and copper.

Table 1. Salt composition of water, accumulated in reservoirs of Simferopol city.

Places of water sampling	Es, mSm/cm	Indicators, mg/dm^3							
		NO_3^-	Cl^-	SO_4^{2-}	HCO_3^-	K^+	Mg^+	Ca^{2+}	Na^+
Salgir river basin									
Simferopol reservoir	0.56	11.1	28.4	58.8	207.4	5.7	10.9	68.0	18.4
2	1.4	124.5	134.9	283.8	225.7	15.7	41.3	84.0	87.4
3	1.1	110.8	74.6	186.9	268.4	12.1	25.5	96.0	48.3
4	1.2	8.9	53.3	355.2	128.1	8.54	26.7	86.00	34.5
5	1.1	7.1	46.2	96.9	262.3	2.85	9.7	102.0	29.9
Maly Salgir river basin									
17	0.9	14.2	81.7	96.9	219.6	10.0	18.2	74.0	52.9
Abdalka river basin									
12	1.4	153.7	72.8	100.8	390.4	5.7	12.2	200.0	47.2
13	1.2	106.3	67.5	101.4	323.3	7.12	13.4	164.0	43.7
15	1.5	65.6	127.8	225.9	372.1	4.98	19.4	158.0	82.8
16	1.4	62.5	124.3	202.8	286.7	4.98	15.8	156.0	78.2
Slavyanka river basin									
21	1.1	116.5	71.0	89.1	89.1	4.27	13.4	130.0	46.0
23	1.0	111.2	53.3	95.1	95.1	4.3	20.7	76.0	34.5
26	0.8	35.0	39.1	77.1	77.1	5.0	12.2	62.0	14.3
MPC	n/r*	40.0	300.0	100.0	n/r	50.0	40.0	180.0	120.0

* – not regulated

The analysis of the state of water bodies is based on the calculation of the IIES (Integral index of ecological state), an indicator that takes into account the hazard class and the ratio of pollutant concentration to its maximum permissible value. The results of the calculations are presented in Table 3.

Table 2. Results of chemical analyses of water samples for pH, dissolved oxygen, and heavy metal content.

Places of water sampling	pH	Dissolved oxygen, mg/dm^3	Indicators, mg/dm^3				
			Cu	Pb	Zn	Cd	Fe
Salgir river basin							
Simferopol reservoir	7.9	7.1	<0.001	<0.004	<0.001	<0.0005	0.017
2	7.9	8.0	<0.001	<0.004	0.003	<0.0005	0.047
3	7.8	7.9	<0.001	<0.004	0.003	<0.0005	0.034
4	7.9	8.1	<0.001	<0.004	0.004	<0.0005	0.032
5	7.8	8.7	<0.001	<0.004	0.005	<0.0005	0.103
Maly Salgir river basin							
17	7.5	8.8	0.004	<0.004	<0.001	<0.0005	<0.002
Abdalka river basin							
12	7.9	9.6	<0.001	<0.004	0.009	<0.0005	0.086
13	7.9	8.6	<0.001	<0.004	0.001	<0.0005	0.016
15	7.8	7.7	0.003	<0.004	0.002	<0.0005	0.053
16	7.9	7.0	0.005	<0.004	0.009	<0.0005	0.066
Slavyanka river basin							
21	8.1	9.5	0.004	<0.004	0.015	<0.0005	0.042
23	8.0	10.1	0.003	<0.004	0.017	<0.0005	0.093
26	8.2	7.5	0.008	<0.004	0.021	0.0067	0.059
MPC	6.0–9.0	≥6.0	0.001	0.006	0.010	0.0010	0.100

Table 3. Results of comprehensive assessment of the ecological state of reservoirs.

Places of water sampling	$IIES_{av}$	$IIES_{min}$	Ecological state identification
Salgir river basin			
Simferopol reservoir	0.16	-0.60	With centers of instability
2	-1.63	-4.83	unstable
3	-1.04	-2.93	–//–
4	-0.77	-4.33	–//–
5	-0.17	-1.24	–//–
Maly Salgir river basin			
17	-1.03	-3.35	unstable
Abdalka river basin			
12	-1.51	-4.60	unstable
13	-0.66	-1.99	–//–
15	-1.79	-4.37	–//–
16	-2.40	-7.12	–//–
Slavyanka river basin			
21	-2.04	-7.83	unstable
23	-1.87	-7.41	–//–
26	-2.96	-11.91	–//–

4 Discussions

During the study, a number of factors were identified that need to be paid special attention to when developing and implementing measures, aimed at improving the environmental safety of reservoirs in Simferopol:

- The presence of unaccounted ponds. Although these water management facilities are represented by small water storage facilities. with water mirror area of no more than 0.2 hectares. and do not pose a significant threat to infrastructure facilities and population. they are part of the urban environment and require the implementation of operational measures aimed at caring for these reservoirs.
- The need for repair and maintenance work. Particularly unfavorable conditions were recorded at ponds 14. 16 and 21. In addition. it should be noted that littering of the

coastal zone is characteristic of almost every surveyed water storage facility. which affects the quality of accumulated runoff and the recreational attractiveness of these water bodies.

- Unfavorable environmental situation. From the point of view of the content of pollutants in the water. the greatest danger is the reservoir 26. located in the middle reaches of the Slavyanka river. It should be noted that this pond is used for recreational purposes. At the time of survey. a high concentration of cadmium was recorded in the water of this facility. which was 6.7 times higher than the MPC for household and drinking facilities.

5 Conclusions

Based on the conducted research, the following conclusions can be drawn:

- In order to maintain a favorable urban environment. it is advisable to conduct an inventory of reservoirs. not included in the water register.
- In order to increase the recreational attractiveness of reservoirs and ensure sustainable functioning. it is necessary to provide for maintenance and repair work. and arrangement with drainage structures for ponds 2 and 3.
- The main indicators for which the excess of the maximum permissible concentrations of pollutants in the accumulated runoff is recorded include: sulfates. nitrates. zinc and copper.
- The most favorable environmental situation was recorded for the Simferopol reservoir ($IIES_{av}$ was 0.16). and the worst – for pond 26 ($IIES_{av}$ was 2.96).
- It is advisable to start the implementation of actions. aimed at improving the environmental safety of water storage facilities in Simferopol with reservoirs 14. 16. 21 and 26.

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