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THE STATUS OF THE SURFACE WATERS OF THE BUZKY ESTUARY WITHIN MYKOLAIV CITY: PRE-WAR AND WARTIME PERIODS

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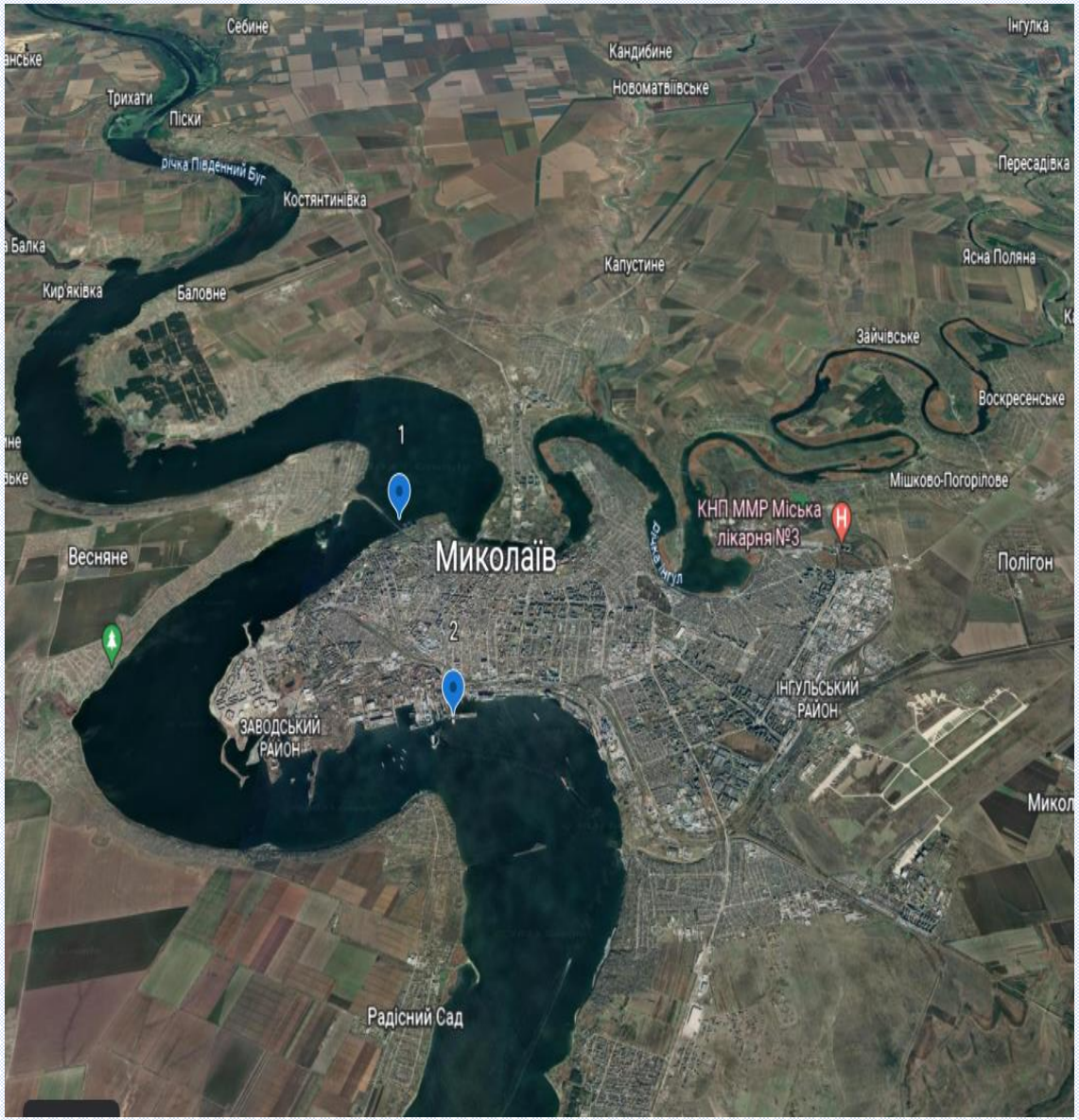
The object of the research is the water problem of the city during military operations and surface waters within the Mykolaiv city, namely the waters of the Buzky Estuary.

The subject of the study is the assessment of the surface waters state of the Buzky Estuary within the city of Mykolaiv based on integrated hydrochemical indicators.

Mykolaiv region is located in the southern of Ukraine. Its area (24,600 km²) comprises about 4.07% of the total area of Ukraine.

Mykolaiv region borders upon Odesa region in the west-southwest, Kirovohrad region in the north, Dnipropetrovsk region in the northeast, and Kherson region on the southeast.

To the south, the region is also bordered by the Black Sea. To Mykolaiv region belong Kinburn Peninsula, Berezan Island in the Black Sea, Pervomaisky Island in the Dnieper Estuary.



The Buzky Estuary is an estuary of the Southern Buh.
It is 82 km long and up to 11 km wide.
Together with Dnieper Estuary it makes Dnieper–Buzky Estuary on the northern coast of the Black Sea.
The city of Mykolaiv is located on the Buzky Estuary.
A picture of the Buzky Estuary within the city of Mykolaiv:
1, 2 – observation points.
1 – Varvarivsky bride district (46.988920, 31.965766);
2 – Sea port (Cabotage Mall) (46.94488, 31.98788).

Water quality indicators were divided on three blocks:

- salt composition (I_C);
- tropho-saprobiological (ecological-sanitary) (I_{TC});
- specific toxic effect (I_T).

Assessment of the surface water state resources involved the analysis of the components of the salt composition (namely chlorides and sulfates).

The trophic-saprobiological (ecological-sanitary) index was calculated on the basis of the absolute components of the following components: dry residue, pH, phosphates, dissolved oxygen, BOD_5).

To determine the index of specific indicators of toxic action, the absolute values of the following components were used: copper, zinc, and petroleum products.

To determine the integral characteristic (I_E), calculations were carried out within each of the three blocks (formula):

$$I_E = \frac{(I_C + I_{TC} + I_T)}{3}$$

Table 1. - Ecological indexes of the Buzky Estuary water quality

Year	I_C	I_{TC}	I_T	I_E
2016	5.5	4.2	4.7	4.80
2017	6	4.4	4.7	5.03
2018	6	4.4	4.7	5.03
2019	6	4.2	4.7	4.97
2020	6	4.2	4.7	4.97
2021	6.5	4.4	4.7	5.20
2022	6.5	5.2	5.0	5.57
2023	6.6	5.3	5.1	5.67

According to the EU Water Framework Directive 2000/60/EU, one of the ways of presenting the results of the assessment of the ecological state of surface waters can be the ecological quality index EQ:

$$EQI = \sum_{i=1}^{N} \frac{P_e}{P_i},$$

where Pi – the value of the indicator in the ith creation;

Pe – the value of the indicator in the reference frame;

N – the total number of indicators.

To calculate the ecological assessment index of water quality (I_E) to the range from 1 to 0, which is accepted for *EQI*, we use formula:

$$\boldsymbol{I_{Ec} = 1 - \frac{I_E}{7}}.$$

Gradations of the *EQI* index according to water quality classes are given in the EU guidance document «Common Implementation Strategy for the Water Framework Directive» (2000/60/EU)

Table 2. - Water Quality Index

Water quality class	1	2	3	4	5
	High	Good	Moderate	Poor	Bad
EQI value	>0.83	0.82¬0.62	0.61¬0.41	0.40¬0.20	<0.20

Table 3. - The index of ecological assessment of water quality (EQI) to the range from 1 to 0

	2016	2017	2018	2019	2020	2021	2022	2023
I_E	4.80	5.03	5.03	4.97	4.97	5.20	5.57	5.67
EQI	0.31	0.28	0.28	0.29	0.29	0.26	0.20	0.19
Water quality class	Poor	Poor	Poor	Poor	Poor	Poor	Bad	Bad

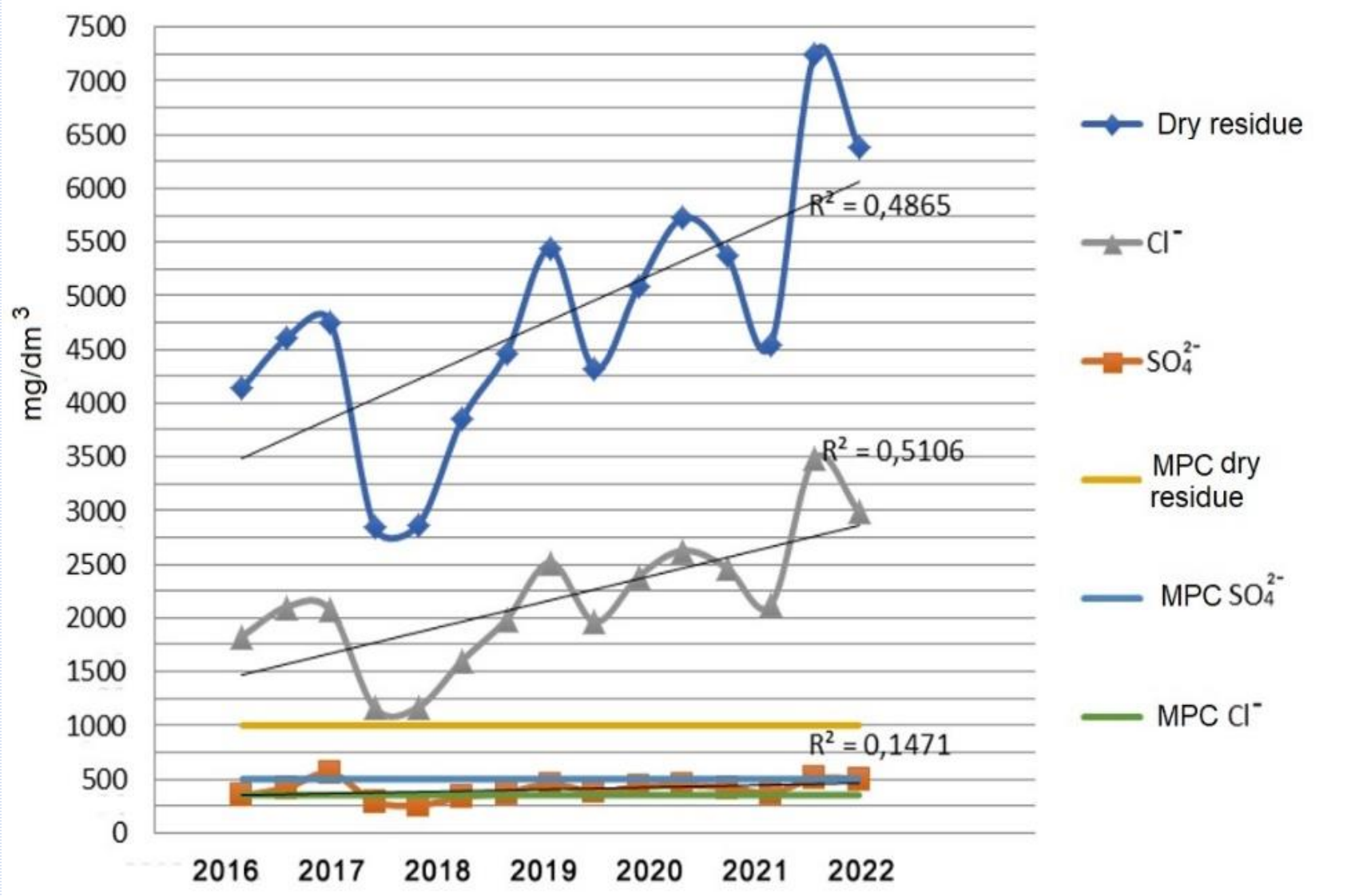


Fig. 1 - Trends of dry residue, sulfates and chlorides.

During the studied period, there is a steady trend towards a gradual increase in hardness, dry residue, sulfates, and chlorides in surface waters.

The level of pH, BOD_5, dissolved oxygen fluctuates within the normal range with minor deviations.

As of the second half of 2022 – the present time, the city actually remained without a stable water supply system.

Centralized water supply stopped on April 12, 2022, when russian troops damaged the water pipeline that supplied water from Kherson region.

A Dnipro-Mykolaiv waterworks has a length of 73 km and was located in the temporarily occupied territory.

After the destruction of the Dnipro-Mykolaiv water supply system, it was only possible to start water in the city on May 9, 2022, and only for technical needs.

Table 4. - The average values of water quality indicators of the centralized water supply system of Mykolaiv city compared to the standards of Ukraine and EU

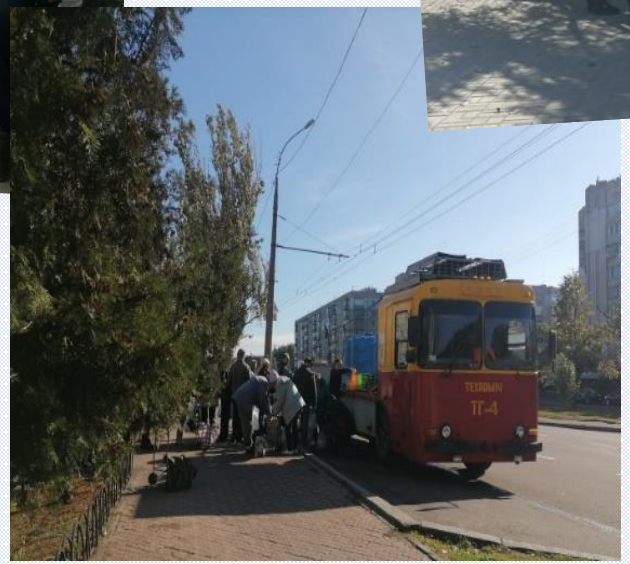
Indicator	Unit of measurement	Value	MPC, Ukraine	MPC, EU
pH		8.1	6.5 – 8.5	6.5 – 8.5
Smell, 20°C	points	1	until 2	until 2
Color	points	14	until 20	until 20
E.coli	CFU/dm^3	0	0	0
Microbial number	KOE/dm^3	12	until 100	
Phytoplankton	cells/dm^3	5000		
Dry residue	mg/dm^3	10408	1000	1500
Hardness general	**mg-equivalent/dm^3**	**32**	**1.5–7**	**1.2**
Alkalinity	mg-equivalent/dm^3	4.1	0.5–6.5	
Chlorides	**mg/dm^3**	**4400**	**350**	**250**
Nitrates	**mg/dm^3**	**81.1**	**45**	**50**
Nitrite	mg/dm^3	0.015	3	0.5
Sulfates	mg/dm^3	712	500	250
Phosphates	mg/dm^3	0.43	3.5	0.7
Cyanides	mg/dm^3	0	0.035	0.05
Phenols	mg/dm^3	0	0.001	0
General iron	mg/dm^3	0.2	0.3	0.2
Ammonium nitrogen	mg/dm^3	0.1	2.0	0.5
Aluminum	mg/dm^3	0	0.5	0.2
Sodium	**mg/dm^3**	**4380**	**1000**	
Carbon organic	mg/dm^3	18.3		
Manganese	mg/dm^3	0	0.1	0.05
Molybdenum	mg/dm^3	0	0.25	
Cobalt	mg/dm^3	0	0.1	
Copper	mg/dm^3	0.065	1.0	2.0
Lead	mg/dm^3	0	0.03	0.01
Silicon	mg/dm^3	1.16	10.0	-
Chrome general	mg/dm^3	0	0.55	0.05
Zinc	mg/dm^3	0.048	5.0	5.0

How does Mykolaiv city solve the issue of drinking water supply?

Currently, the sources of the city's drinking water supply are

- wells located on the territory of the private sector, some enterprises and institutions;
- imported water from other cities;
- bottled water.

The Mykolaiv city's drinking water supply under wartime conditions



CONCLUSION

- All defined surface water quality classes correspond to the degree of pollution "dirty" or "very dirty" and the state "poor" or "very poor".
- Water of this quality is absolutely not suitable for household use, as it has an active destructive power to damage the water supply system and all the mechanisms and devices that serve it.
- The issue of complex assessment of the quality of drinking water during martial law remains open.
- The quality of drinking water distribution points remains outside state control due to the lack of means of operational control, specialists, and a low level of public awareness.

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Further proposals for collaboration

- Exchange of experience regarding operational monitoring of the state of water resources;
- Study of the influence of anthropogenic factors and climatic factors on the surface water resources state;
- Study of effective methods of operational control of the water resources state;
- Offer to British colleagues to publish research results in an International collective monograph «European Green Dimensions: Fundamental, Applied, and Industrial Aspects» (plan in 2025); Proceedings of the Conference «European Green Dimensions: Fundamental, Applied, and Industrial Aspects»

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