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## Quality indicators of fish from the water of the southern region of Ukraine

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A study of the fish caught in the reservoirs of the Khadzhibey estuary (Odesa region) was conducted in order to determine its quality and safety according to microbiological indicators. No pathogenic or conditionally pathogenic microorganisms were found in all the fish samples studied – mirror carp (*Cyprinus carpio*) and round goby (*Neogobius melanostomus*). During the study of physico-chemical indicators of water quality and safety of the estuary, water samples were taken for the content of pesticides, insecticides and heavy metals. The content of cadmium, copper, lead and mercury does not exceed the permissible level for fish farms, zinc exceeds the maximum permissible concentration by 2.3 – 3.0 % (depending on the period of the year). The insecticide dichlorodiphenyltrichloromethylmethane was found in the water, the content of which exceeds the maximum allowable concentration for sea fishing ponds by 18 %, and the pesticide beta-hexachlorocyclohexane – by 5.2 %. It has been studied and established that the fish caught in the estuary, according to its microbiological and physicochemical indicators, is safe, does not pose a threat to the health of people and animals, and is suitable for further use and consumption.

**Key words:** *Cyprinus carpio*, *Neogobius melanostomus*, Khadzhibey estuary, veterinary and sanitary examination, physical and chemical indicators, water quality, organoleptic evaluation, microbiology of meat, fish.

### Introduction

Improving the conditions for growing and quality of fish in the reservoirs of the Southern region of Ukraine is possible only with a detailed study of all factors that significantly affect this aspect. Only with a comprehensive study of the physico-chemical indicators of water quality, the content of heavy metals, pesticides and insecticides in water resources where fish are grown, it is possible to influence the output of the final product, its quality and safety indicators, to exclude the main sources of pollution, which include: 1) the “Northern” biological treatment station, which loads the Khadzhibey estuary ecosystem with wastewater from the central and northeastern part of the city of Odessa; 2) burial from the dry cargo ship “Mozdok” (near the estuary, not far from the village of Paliyeva) of dichlorodiphenyltrichloromethylmethane units, which were exposed to corrosion and DDT enters the soil and water together with the rains; 3) farms located on the banks of the estuary pollute the estuary with pesticides and insecticides, which are washed away by rains

and enter surface and underground waters; 3) solid human waste (plastic bottles, garbage bags, tires, etc.); 4) atmospheric pollution and acid rain. All these factors have a negative impact on the ecological situation of the Khadzhibey estuary (Gupta & Singh, 2019; Tien et al., 2020; Vehanen et al., 2020; Sayed-Lafi & Al-Budairy, 2023).

Today's strategic issue is ensuring the quality and safety of food products within the framework of the concept “from farm to table”. Much attention is paid to the study of water (the habitat of hydrobionts), which is in the primary link of this chain – the cultivation of high-quality fish products (Breitburg et al., 2018; Matvienko et al., 2020; Tien et al., 2020; Lakra et al., 2022; Arun & Midhun, 2023).

In the Southern region of Ukraine there is a large number of natural and artificially created reservoirs, the presence of which has a positive effect on the existence and breeding of fish. Fish farming is one of the most widespread industries in our country, this is due to the fact that many types of fish do not require special conditions for cultivation and feeding, have a tendency to rapid

growth, reproduction and restoration of the population, are endowed with high nutritional properties and play an important role in human and animal nutrition (Longo et al., 2015; Derome, 2019; Burhaz & Soborova, 2020; Alderman & Clayton, 2021).

The Khadzhibey estuary is located on the northwestern coast of the Black Sea and northwest of the city of Odesa (Ukraine), and is of great fisheries importance for the entire Southern region of the country. The estuary is separated from the Black Sea by the Kuyalnytskyi-Khadzhibey isthmus, which is 4.5 kilometers wide. On the banks of the estuary are the settlements of Nerubayske, Usatove, Blonske and a number of others, country estates, livestock farms, which affect the level of water pollution by pesticides and mineral fertilizers. The main source of pollution is the “Northern” biological treatment station, which receives wastewater from the central and northeastern part of the city of Odessa, this has led to a decrease in the level of water salinity to 5–7 ‰. This factor had an impact on the fishing industry and made it possible to grow such types of fish as mirror carp and round goby in the reservoir (Sutinen & Andersen, 1985; Bentzon-Tilia et al., 2016; Gupta & Singh, 2019; Zhang et al., 2021; Frouz & Frouzová, 2022; Roberts, 2022; Liasota et al., 2023).

Sanitary and hygienic requirements for water at all stages of breeding carp and goby fish require quality control and regulation. The efficiency of cultivation in fish farms depends on the extent to which they provide ecological conditions for the existence of fish. The contamination of fish meat with microorganisms and their number depends on the level of water pollution, the diversity of microorganisms from water pollution, the geographical location of the reservoir, the season, the method of catching and storing fish (Kar, 2020; Sheng & Wang, 2020; Visciano et al., 2020; Mensah et al., 2021).

In order to obtain high-quality products, it is necessary to pay attention to the creation of measures regarding the optimal physical and chemical parameters of the water environment and the use of high-quality feeds (supplements). Special attention should be paid to the control of the content of pesticides in water and their impact on the safety of fish meat, which is subject to research (Fogarty & Collie, 2020; Lupo & Angot, 2020; Felix & Menaga, 2021; Gosling, 2021).

Fish, which is planned to be released for sale and used as food, must undergo a thorough microbiological and physicochemical study (Vehanen et al., 2020; Kurup et al., 2022; Dara et al., 2023; Sayed-Lafi & Al-Budairy, 2023).

### The purpose of the study

The purpose of the study is to determine the main hygienic, physico-chemical, toxicological parameters of the water of Khadzhibey estuary; carry out a study of caught fish (mirror carp and round goby) according to microbiological and organoleptic indicators.

### Materials and methods

Microbiological and physicochemical studies of water were carried out in the laboratory of water hygiene and ecology of the Ukrainian Research Institute of Transport Medicine and the Department of Veterinary Hygiene, Sanitation and Expertise of Odesa State Agrarian University.

Sampling of water and fish from the estuary was carried out in several places, taking into account the characteristics of each site (depth, wetlands, thickets, etc.). Samples were delivered to the laboratory no later than 2 hours from the moment of collection.

Water and fish samples were studied from three main points of the Khadzhibey estuary – near the village of Nerubayske (site No. 1), in its small wing near the village of Bolgarka (site No. 2) and in the village of Blonske (site No. 3). Samples were taken at a distance of 3–4 meters from the shore, at a depth of 10–15 cm from the surface and 10–15 cm from the bottom of the Khadzhibey estuary in a clean glass vessel, the volume of one sample was 3 liters (a total of 27 samples were taken). The selected water samples were divided into two parts – 1) measuring the content of heavy metals and was conserved by adding nitric acid to it at the rate of 10 ml/l (the initial HNO<sub>3</sub> concentration was equal to 56 ‰); 2) to study the value of the hydrogen index (pH) and organoleptic indicators, without changes.

Indicators of color, smell, transparency, temperature of water from the estuary were determined using organoleptic methods during sampling, and the amount of biochemical oxygen consumption (BSK<sub>5</sub>) using the glass method.

When conducting research on the content of heavy metals in water, the methods of atomic emission spectroscopy (AES) on the EMAS-200 CCD device were used to determine cadmium, copper, zinc and lead; for mercury – cold vapor atomic absorption spectroscopy (AAS-CV) “Yuliya-2M” with the help of a spectral buffer mixture. Pesticides and insecticides were determined by gas-liquid chromatography using the Crystal 2000 device. Potentiometric determination was used to determine the activity of hydrogen ions in the form of a hydrogen pH indicator.

The preparation and microbiological studies of fish, mirror carp and round goby, were performed in accordance with DSTU 4808:2007 and DSTU 7525:2014. A total of 24 samples of fish were taken (12 samples of bull and, accordingly, 12 samples of carp from three main areas. Each sample contains 15 kilograms). A number of serial tenfold dilutions in a sterile isotonic sodium chloride solution were prepared from the samples. The number of mesophilic aerobic and facultatively anaerobic microorganisms (MAFAnM), for bacteriological control, was examined in accordance with DSTU ISO 4833-2006, pathogenic microorganisms, including salmonella – in accordance with DSTU EN12824:2004, bacteria of the *Escherichia coli* group – in accordance with DSTU 30726-2002, *Staphylococcus aureus* – according to DSTU 8446:2015 and *Listeria monocytogenes* – according to DSTU ISO 11290-1:2003.

**Results and discussion**

The results of the organoleptic evaluation of water, which was sampled from three sections of the Khadzhibey estuary in September 2023, are presented in Table 1.

It was established that the water temperature in the Khadzhibey estuary in the autumn period fluctuates between 21.6 and 21.7 °C (the air temperature at the time of sampling was 24 and 25 °C). The color of the water (according to the 21-piece color scale – from blue-yellow No. 1–11 to yellow-brown No. 12–21) corresponded to No. 14 – a greenish-yellow color, weakly pales, the smell

is weak, characteristic of this type of reservoir. BOS<sub>5</sub> is 0.5 O<sub>2</sub>/dm<sup>3</sup> in area #1, and 0.6 O<sub>2</sub>/dm<sup>3</sup> in areas #2 and #3. The water quality meets the sanitary standards for water bodies used for fishing and does not exceed the MPC.

The level of water pollution with metals, insecticides, and pesticides affects not only the quality of biological processes in the fish pond, but also affects the quality and vital activity of fish. The purpose of the study was to conduct a physical and chemical study of water from the Khadzhibey estuary, the results of the study are shown in Table 2.

**Table 1**  
Organoleptic evaluation of water (M ± m, n = 9)

№ p/p	Indexes	Area 1	Area 2	Area 3
1	Temperature, °C	21.6	21.7	21.7
2	Color	Greenish yellow	Greenish yellow	Greenish yellow
3	Smell	Very weak	Very weak	Very weak
4	Transparency	weakly opalescent	weakly opalescent	weakly opalescent
5	BOS <sub>5</sub> , O <sub>2</sub> /dm <sup>3</sup>	0.5	0.6	0.6

**Table 2**  
Assessment of physical and chemical indicators of water, content of heavy metals and pesticides (M ± m, n = 9)

№ p/p	Indexes	Sample 1	Sample 2	Sample 3	Relative standard measurement error, S <sub>r</sub>	The norm for sea fishing ponds
		Found	Found	Found		
1	pH	8.3	8.0	8.2	0.0418	6.5–8.5
2	Plumbum, mg/l	0.0055 ± 0.01	0.0059 ± 0.01	0.0047 ± 0.01	0.0361 ± 0.011	0.1
		0.0055	0.0060	0.0045		
		0.0056	0.0058	0.0049		
3	Cadmium, mg/l	0.00145 ± 0.01	0.00271 ± 0.01	0.00115 ± 0.01	0.0383 ± 0.01	0.005
		0.00147	0.00270	0.00114		
		0.00143	0.00273	0.00116		
4	Zinc, mg/l	0.0275 ± 0.01	0.0231 ± 0.01	0.0284 ± 0.01	0.0250 ± 0.01	0.01
		0.0276	0.0233	0.0284		
		0.0275	0.0230	0.0281		
5	Kuprum, mg/l	0.00022 ± 0.001	0.00023 ± 0.001	0.00021 ± 0.001	0.0379 ± 0.01	0.001
		0.00021	0.00025	0.00024		
		0.00023	0.00024	0.00020		
6	Mercury, mg/l	0.000055 ± 0.01	0.000057 ± 0.01	0.000061 ± 0.01	0.0430 ± 0.01	0.0001
		0.000055	0.000057	0.000062		
		0.000054	0.000057	0.000061		
7	Beta-HCCH, mg/l	0.0394 ± 0.01	0.0382 ± 0.01	0.0376 ± 0.01	0.0390 ± 0.01	0.002
		0.0393	0.0385	0.0377		
		0.0394	0.0380	0.0375		
8	DDT, mg/l	0.541 ± 0.002	0.540 ± 0.003	0.547 ± 0.0021	0.544 ± 0.01	0.1
		0.539	0.541	0.545		
		0.541	0.539	0.549		
		0.542	0.540	0.548		

Statistical processing of measurement results was carried out for n = 3 and P = 0.95.

It was established with due research that the oxygen regime (pH) was stable, did not exceed the maximum allowable concentration for fish farms and was within 8.0 – 8.3 mg/l (norm 6.5–8.5 mg/l), which fully meets the

requirements for the cultivation of carp and goby in the estuary.

The obtained results indicate that the zinc content in water samples exceeds the MPC by 2.6 % (in sample No. 1 by 2.7 %; in sample No. 2 – 2.3; in sample No. 3 – 2.8). The content of lead, cadmium, copper and mercury

in the water of the Khadzhibey estuary is within the normal range and does not exceed the MPL.

The content of the insecticide DDT (dichlorodiphenyltrichloromethylmethane) exceeds the MPL by 5.2 %, the pesticide Beta- HCCH (hexochlorocyclohexane) by 18 %.

Thus, during the study of water samples from the Khadzhibey estuary, it was established that the content of

heavy metals, except for zinc, does not exceed the norm for sea fishing reservoirs. The insecticide dichlorodiphenyltrichloromethylmethane and the pesticide beta-hexochlorocyclohexane were detected in the water.

A microbiological study of mirror carp and round goby fish caught in the water of the Khadzhibey estuary is presented in Table 3.

**Table 3**

Microbiological studies of carp and goby (M ± m, n = 3)

Samples	QMA&OAMO in 1 g, not more	<i>Staphylococcus aureus</i> in 0.01 g	<i>Escherichia coli</i> in 0.01 g	Pathogenic m. o., including salmonella in 25 g
№1 carp	3,5± 0,07×10 <sup>4</sup>	-	-	-
№2 carp	3,4± 0,06×10 <sup>4</sup>	-	-	-
№3 carp	3,3± 0,08×10 <sup>4</sup>	-	-	-
№4 goby	3,7± 0,08×10 <sup>4</sup>	-	-	-
№2 goby	3,5± 0,06×10 <sup>4</sup>	-	-	-
№3 goby	3,1± 0,03×10 <sup>4</sup>	-	-	-
MDL for current ND	not >5×10 <sup>4</sup> DSTU ISO 4833-2006	not allowed DSTU 8446:2015	not allowed DSTU 11290-1:2003	not allowed DSTU EN12824:2004

According to official laboratory tests of carp and bullhead samples, it was established that the total number of mesophilic aerobic and facultatively anaerobic microorganisms in all fish samples that were caught in the Khadzhibey estuary meet the current requirements. Pathogenic and opportunistic microorganisms (*Staphylococcus aureus* and *Escherichia coli*) were not detected in the samples of the studied fish.

**Conclusions**

1. The research established that the total number of mesophilic aerobic and facultative anaerobic microorganisms in all samples of the studied fish does not exceed the norm. Pathogenic microorganisms *Staphylococcus aureus* and *Escherichia coli* were not detected in the samples.

2. It has been experimentally proven that the maximum allowable concentration of heavy metals in the Khadzhibey estuary does not exceed the norm (except for zinc, its content is 2.6 % higher than the MPC) and is favorable for the cultivation of carp and goby.

3. According to physical and chemical studies, it was established that the content of DDT (dichlorodiphenyltrichloromethylmethane) in the water exceeds the MPL by 5.2 % and the pesticide Beta-HCCH (hexochlorocyclohexane) by 18 %.

4. Fish caught in the Khadzhibey estuary is microbiologically safe and can be used for further sale as food for humans and animals.

**Conflict of interest**

The authors declare that there is no conflict of interest in this work.

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