

CHEMICAL MONITORING OF WATER IN ZOLOTONOSHKA RIVER

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Purpose. Complex analysis of the factors of the current ecological state of the Zolotonoshka River. **Methodology.** Water quality was evaluated in accordance with the compliance of individual indicators of water quality with the standard requirements of the maximum allowable concentration of harmful substances in the waters of fishery water bodies, with the water contamination factor and the environmental index. **Results.** The long-term data on key indicators of hydrochemical state of the Zolotonoshka River are presented. It is shown that the main pollutants are nitrogen ammonia (1,5-6,1 MAC) and nitrite nitrogen (1,1-28,3 MAC), heavy metals, oil products. The pollution level of water by ammonium nitrogen by frequency is estimated as unstable but high. The pollution level of water by nitrites is indicative, high. The permanent pollution by ammonium nitrogen leads to the disruption of ecological balance and of self-purification processes in the river. The level of dissolved oxygen is significantly below the allowable values (3,6-4,6 mg/dm³). The constant deficiency of dissolved oxygen in the water does not provide the proper process of nitrification. The level of dissolved oxygen is significantly below the allowable values. The water of the Zolotonoshka River is characterized as "moderately polluted" according to contamination factor and according to environmental quality index is in "satisfactory condition, polluted". There is a tendency of water quality impairment due to the combined effect of anthropogenic and natural factors. *References 12, tables 2, figures 3.*

Key words: land water, polluting substances, anthropogenic activities, water quality

ГІДРОХІМІЧНИЙ МОНІТОРИНГ РІЧКИ ЗОЛОТОНОШКА

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Представлені багаторічні дані щодо основних показників гідрохімічного стану р. Золотоношка. Показано, що пріоритетними забруднювачами є азот амонійний (1,5-6,1 ГДК) і нітритний (1,1-28,3 ГДК), важкі метали, нафтопродукти. Рівень забруднення води азотом амонійним за повторюваністю оцінюється як нестійкий, але високий, рівень забруднення нітритами – характерний, високий. Хронічне забруднення амонійним азотом призводить до порушення екологічної рівноваги і процесів самоочищення у річці. Вміст розчинного кисню значно нижче допустимих значень (3,6-4,6 мг/дм³). Постійний дефіцит розчинного у воді кисню не забезпечує нормального протікання процесів нітрифікації. За величиною коефіцієнта забруднення вода р. Золотоношка характеризується як «помірно забруднена», за екологічним індексом якості – «стан задовільний, забруднена». Спостерігається тенденція до погіршення якості води, що обумовлено сукупною дією техногенних і природних чинників.

Ключові слова: поверхневі води, забруднюючі речовини, господарська діяльність, якість води

PROBLEM STATEMENT. The problem of technogenic and ecological safety of hydro-geological environment is important for Ukraine. There is a significant reduction of water quality in all river basins of Ukraine [1-7].

The object of our research was the Zolotonoshka River water system, undergoing a significant anthropogenic impact and is the most polluted river in Cherkasy region due to the unsatisfactory work of treatment facilities of Zolotonosha, built in 1983. In 2002 a major accident occurred at the wastewater treatment plants and the cycle water ceased to operate normally. Currently the city treatment facilities perform only primary treatment of sand traps and dirt pockets. As a result, polluted water gets into the river often leading to mass fish death. The contaminated water from the Zolotonoshka gets into the Dnieper. Therefore it is a danger to the public Dnieper region which is the main source of water use and water consumption.

Thus a comprehensive analysis of the reasons of the current status of the Zolotonoshka River, scientific substantiation of rational water use and development of measures to protect its waters from pollution is necessary. The purpose of our research is a thorough assessment of water quality, which became the first step in this direction. The goal is achieved in solving the following problems: 1) the analysis of changes in the chemical composition of the water in time and space; 2) evaluation of water pollution in accordance with certain indicators; 3) a generalized assessment of contamination of water according to the factor of contamination; 4) assessment of water quality for environmental classification.

EXPERIMENTAL PART AND RESULTS OBTAINED. The Zolotonoshka River flows through the territory of Drabiv and Zolotonosha district of Cherkasy region, belongs to the Dnieper River Basin and its left tributary of the first order. The river has two tributaries that are Kropyvna and Sukha Zgar, the total

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length of which is 80.9 km. The Zolotonoshka River basin is located within the steppe zone of the Middle Dnieper lowland terraced plains. The length of the river is 97.3 km, water intake area is 1077 km², swamps constitute 14%, tillage is 73.2%.

Rain and snow fill the river. The valley is in the shape of trough with the width of 4 km. The river banks are meadowed and forested. The floodplain has a width of 400 meters with marshy places. The riverbed with the width of 5 meters is weakly meandering. The ratio of water density is 0.17 km/km². The river fall is 45 meters; the average slope is 0.297 m/km². The river flow is regulated with the ponds moderately. The total number of ponds and reservoirs regulating the local flow is 69, and their total volume is 18.726 million m³. Aquifers are confined to Paleolithic, Cretaceous and Jurassic systems. The water of the river belongs to the hydrocarbon class, its hardness constitutes 5.66 mg-eq/dm³, the total mineralization is 492-534 mg/dm³. The river water is used for agriculture and fishing. In dry years the available water resources of the Zolotonoshka River do not provide enough water for agriculture in its pool. The basin of the Zolotonoshka River is highly populated, it is located within 2 towns and 2 urban settlements, 51 villages. The river-basin is the home for about 40.000 people [8].

For the statistical analysis to establish the basic laws and factors of the changes of the water chemical composition a data bank on the results of water quality control of the Zolotonoshka by the sanitary and epidemiological station on 3 controlled alignment was recorded - that is alignment 1 (1 km above Zolotonoshka city), 2 (0.5 km below Zolotonoshka city) and 3 (0.5 km above the Zolotonoshka mouth) for the period of 2000-2014. The baseline data for each indicator of water quality were grouped in blocks and subjected to treatment: the mean value was calculated, the maximum, and minimum values were determined characterizing together the variability of the quantities of each of the indicators of water quality in time and space. Data bank contains 300 values according to the following criteria: components of salt composition block – the amount of ions, the content of sulfate and chloride ions; tropho-saprobiological quality criteria – content of suspended solids, pH value, nutrient content (NH₄⁺, NO₂⁻, NO₃⁻, PO₄³⁻), dissolved oxygen, chemical oxygen demand (COD), biochemical oxygen demand (BOD₅); the block of specific substances with the toxic effect – heavy metals (Fe, Cr, Zn, Cu, Mn), phenols, petrochemicals, synthetic surfactants (detergents).

Water quality was evaluated in accordance with the compliance of individual indicators of water quality with the standard requirements of the maximum allowable concentration of harmful substances in the waters of fishery water bodies (MAC), with the water contamination factor (CF) [9] and the environmental index (Ie) [10].

Processing and systematization of long-term data on the components of the salt block showed that according to the sum of the ions the water of the Zolotonoshka can be classified as category two (very good condition, clean) class II of water quality (good, clean). The

concentration ranged within 492-601 mg/dm³, the average value was 524 mg/dm³.

The content of sulfate ions ranged from 29.5 mg/dm³ to 390 mg/dm³, the mean value was 147.0 mg/dm³. 72% of samples had an excess in MAC. During the period of 2003-2013 there was a systematic excess of regulatory values (1.1-3.9 MAC). There was a variability of the sulfate ions content both in time and in space. In accordance with the environmental assessment water quality category by sulfate ion ranged from 1 (excellent condition, very clean) to 7 (very poor condition, very polluted), a class of water quality – from I (excellent, very clean) to V (very bad, much polluted). The mean value of water quality category – 4.5 (satisfactory condition, slightly polluted) quality class – III (satisfactory, polluted).

The content of chloride ions varied in the range of 37 to 278 mg/dm³, the mean value was 138.5 mg/dm³. Water quality category by chloride ions ranged from 3.1 (good condition, satisfactorily clean) to 6.8 (very poor condition, very polluted), water quality class – from II (good, clean) to V (very bad, much polluted water). The mean arithmetic value: quality category – 4.8 (medium condition, moderately polluted water), class III (satisfactory, polluted). There were no overruns in MAC recorded.

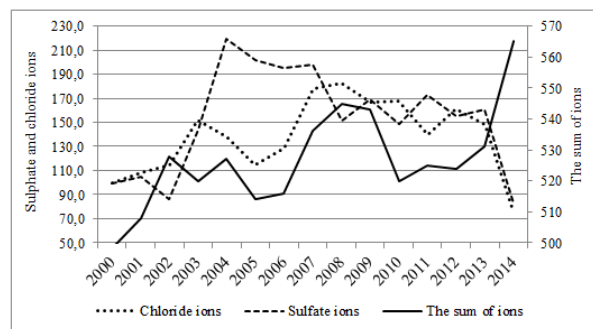


Figure 1 – Average annual performance of the salt block components

The increased content of sulfate and chloride ions in water of the Zolotonoshka can be caused by both natural factors (saline groundwater discharge) and technological (sewage JSC “Zolotonoshka Butter Factory” and distillery “Zlatogor”) [11]. In recent years, there has been a tendency to reduction of sulfates and chlorides concentration in water of the Zolotonoshka River. The sum of ions shows the reverse trend (Fig. 1).

The Zolotonoshka river condition can be assessed in accordance with the arithmetic average value of the index contamination with the salt components block (Ie^{sol}=3.9) as satisfactory, slightly polluted water, water quality class III (satisfactory, polluted), the worst – category 7 (very poor condition, very polluted) water quality class V (very bad, much polluted water).

The content of suspended solids over the entire observation period ranges from 11.2 to 19 mg/dm³, the arithmetic average is 14.6 mg/dm³. There is a tendency to increase the content of suspended solids (table 1). The water quality category varied within 3.0-3.9 with the mean value of 3.4 (good condition, satisfactorily clean water), water quality class II (good, clean).

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Table 1 – Average water values in the Zolotonoshka River according to the tropho-saprobiological criteria of water quality, mg/dm³

Year	Suspended solids	pH	NH ₄ ⁺	NO ₂ ⁻	NO ₃ ⁻	PO ₄ ³⁻	Dissolved oxygen	COD	BOD ₅
2000	11,5	7,40	0,75	0,31	7,17	0,38	4,50	11,63	4,95
2001	11,3	7,35	0,93	0,27	9,63	0,37	4,28	12,37	4,92
2002	13,6	7,70	1,18	0,31	9,02	0,49	4,05	12,32	6,03
2003	14,2	7,80	1,07	0,61	5,07	0,31	4,07	12,83	5,97
2004	15,1	7,80	1,08	0,36	7,99	0,39	3,99	13,33	6,06
2005	15,0	7,60	1,33	0,37	7,95	0,45	4,10	13,83	5,57
2006	15,3	7,65	1,53	0,36	7,80	0,48	4,10	14,67	5,80
2007	15,3	7,70	1,53	0,44	7,67	0,51	4,06	13,42	5,73
2008	16,0	7,70	1,23	0,33	5,65	0,55	4,10	17,00	5,86
2009	16,6	8,00	2,12	0,41	8,57	0,71	3,97	30,33	5,99
2010	16,5	7,40	1,84	0,40	9,20	0,58	4,00	24,48	5,60
2011	16,0	7,65	1,30	0,41	9,43	0,53	4,02	23,67	5,69
2012	16,0	7,90	1,21	0,36	7,02	0,64	4,00	30,33	6,05
2013	16,4	8,10	1,56	0,40	7,70	0,70	3,87	35,50	5,98
2014	17,8	7,30	2,38	1,09	5,68	0,36	3,73	15,27	7,46

According to the pH value the water of the Zolotonoshka River is slightly alkaline (pH = 7.65) and belongs to quality category 2. Limits of pH level for the entire period were: the lowest – 7.0, the highest – 8.5. The mean value of water quality category is 2.3 (very good condition, clean water) quality class II (good, clean).

There are nutrients, especially nitrogen compounds that is ammonium ions, nitrite and nitrate ions. They determine the level of biological productivity of water bodies. However, high concentrations of these compounds indicate the likely anthropogenic water pollution. The ammonium compounds in concentrations of about 1 mg/dm³ reduce the ability of fish hemoglobin to bind oxygen.

Exceeding maximum allowable concentration according to the content of ammonium ions (MAC = 0.60 mg/dm³) was recorded in 97% of samples for monitoring of all alignments (Fig. 2), a particularly significant exceeding is in alignment below the city, indicating the initial contamination with the household waste. The highest concentration of ammonium ions 3.67 mg/dm³ (6.1 MAC) was recorded in the spring of 2013 in alignment 2, the minimum concentration – 0.29 mg/dm³ in autumn of 2008 in alignment 1. Before 2008 the ammonium ion content had no difference throughout the stretch of the river between alignments 1 and 3. In the period of 2008-2014 there was an increase in the concentration of ammonium ion by 1.7-7.8 times in alignment 2, due to the inefficient operation of water treatment facilities of Zolotonosha. In alignment 3 the content of ammonium ion decreased by 1.3-3.4 times due to the self-cleaning processes. According to the environmental classification the water quality category by ammonium ion ranged from 3.1 (good condition, the water is clean enough) to 7 (very poor condition, the water is very polluted), the mean arithmetic average value was 5.5 (medium condition, moderately polluted), corresponding to third grade quality (satisfactory, polluted).

Nitrite ions have sufficient information about the pollution of natural waters [6]. Nitrite nitrogen is the most toxic of all nitrogen compounds and can adversely affect the life of living organisms. Nitrites are non-conservative compounds and are rapidly oxidized by the dissolved oxygen to nitrate; their concentration is leveled up and reaches a natural background. However, such processes are violated in contaminated waters. Thus, they are found in the Zolotonoshka River. NO₂ content ranged within 0.03-1.98 mg/dm³. There was deterioration in water quality in alignment 3 by 1.1-30 times as compared to other monitoring alignments, located upstream. It was caused by ammonium oxidation, high concentrations of which were observed in the upper parts of the river (Fig. 2).

Exceeding MAC=0.07 mg/dm³, mainly in alignment 3, was 1.1-28.3 times. But in 2014 a high content of nitrite ions (average 15.6 MAC) was observed in all three alignments both in spring and autumn, indicating a significant amount of domestic sewage and slow process of oxidation of nitrite to nitrate. Water quality category according to nitrite ion ranged from 4 (satisfactory condition, slightly polluted) to 7 (very poor condition, very polluted) the mean value constituted 6 (bad condition, polluted), corresponding to the fourth quality grade (bad, polluted water).

The content of nitrate ions varied within the range of 1.1 to 19.4 mg/dm³, the mean value was 7.9 mg/dm³. Nitrate and nitrite ions were found. There was a multidirectional nature of the changes by the content of nitrate and nitrite ions, in particular, in alignment 3 the nitrite content increased and nitrate content decreased (Fig. 2).

Water quality category by nitrate-ions ranged from 2 (very good condition, clean) to 7 (very poor condition, very polluted), water quality class – from II (good, clean) to V (very bad, very polluted), the mean value of water quality category 5.5 (satisfactory condition, moderately polluted) quality class III (satisfactory, polluted). There were no recorded overruns in MAC (40.0 mg/dm³).

The level of water contamination with ammonia nitrogen on repeatability is assessed as unstable, but high, the level of water contamination with nitrites is typical, high.

High concentrations of ammonium and nitrate ions indicate the adverse conditions of the chemical composition of the Zolotonoshka River water and its poor quality, especially in recent years. The level of the dissolved oxygen is related to level of the ammonia and nitrite ions (correlation ratio *r* equals to 0.76 and 0.61 respectively).

The content of phosphate ions in the water was 0.2-1.0 mg/dm³, the mean value was 0.5 mg/dm³. The water quality category ranged from 4.2 (satisfactory condition, slightly polluted) to 7 (very poor condition, very polluted), water quality class – from III (satisfactory, polluted) to V (very bad, very polluted), the mean value of water quality was 5.5 (satisfactory condition, moderately polluted) quality class III (satisfactory, contaminated). MAC overruns were not recorded.

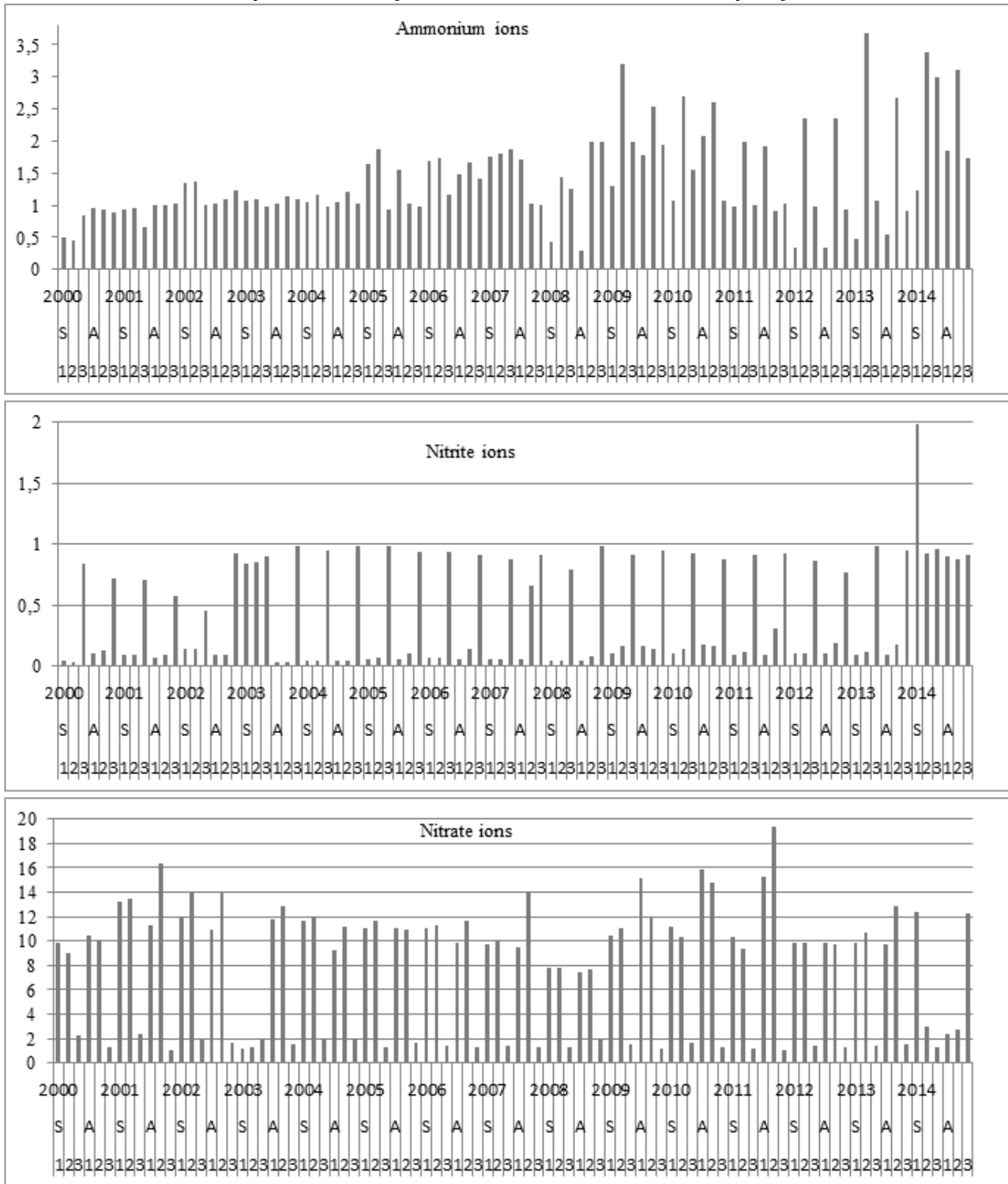


Figure 2 – Dynamics of mineral nitrogen compounds in the Zolotonoshka River in alignments in spring (S) and autumn (A)

Dissolved oxygen, the content of which in water characterizes the oxygen regime of water and determines its environmental and sanitary conditions, appeared to be quite low in all alignments. Over the entire period of observations oxygen concentration fluctuated in the range of 3.6-4.6 mg/dm³.

The content of dissolved oxygen less than 4 mg/dm³ was recorded in 30% of samples. The concentration of dissolved oxygen in waters according to fishing regulations must be greater than 6 mg/dm³.

This quantity is sufficient to provide conditions for aquatic breathing and normal process of water self-cleaning. The worst factors were observed in the years 2013-2014 (3.6-3.9 mg/dm³). Water quality category ranged between 6 (poor condition, polluted) and 7 (very poor condition, very polluted) water quality class - between IV and V, the mean values were 6.4 (poor condition, polluted) and IV (bad, polluted water) respectively.

Natural waters usually have insignificant BOD₅ values showing unstable, easily oxidative organic

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compounds, (less than 0.5-2.0 mg/dm³). Higher BOD₅ values indicate contamination of natural waters. Throughout the observation period BOD₅ values in water of the Zolotonoshka River were higher than normal.

Variability of BOD₅ values during the observation period was slightly different in different alignments and only in 2014 in spring and autumn in alignment 2 there was a rise by 1.8 and 1.3 times respectively as compared with 1. The maximum value was 9.96 mg/dm³ (3.3 MAC) in spring of 2014 in alignment 2; minimal – 3.80 mg/dm³ (1.3 MAC) in autumn of 2000 in alignment 3. The mean value was 5.80 mg/dm³. Water quality category according to BOD₅ ranged from 4.8 (medium condition, moderately polluted) to 6.6 (poor condition, polluted) water quality class – from II (good, clean) to V (very bad, polluted), mean value amounted to 5.5 (satisfactory condition, moderately polluted) quality class III (satisfactory, polluted).

COD value, which characterizes the total content of dissolved organic matter in the water of water bodies with the MAC overrun was recorded twice – in spring of 2009 and 2013 in alignment 2 and constituted 59 and was 69 mg/dm³ respectively (1.2 and 1,4 MAC).

Water quality category by COD ranged from 2 (very good condition, clean) to 7 (very poor condition, very polluted) water quality class – from II (good, clean) to V (very bad, polluted). In accordance with the mean value of water quality category was 3.2 (good condition, satisfactorily clean) quality class II (good, clean).

According to the mean value of the pollution index with the components of tropho-saprobiological block ($I_e^{tr-sap} = 4.9$), the Zolotonoshka condition can be rated as category 5 of water quality (average, moderately polluted) water quality class III (satisfactory, polluted), the worst – 7 category (a very bad condition, very polluted) water quality class V (very bad, much polluted water).

There is overrun in MAC in a number of heavy metals – manganese, copper and iron. The maximum

concentration of manganese (0.090 mg/dm³, 9 MAC) was observed in autumn of 2007 in alignment 2, the minimum – in autumn of 2000 in alignment 3 (0.002 mg/dm³). The mean value was 0.043 mg/dm³. 90% of samples in all alignments had MAC excess. High concentrations of manganese are likely related to natural factors. Manganese is known to get into the surface water due to leaching of minerals containing this element. Significant quantities of manganese may come due to the decomposition of aquatic animals and plant organisms. Increased concentrations of manganese in water to a large extent depend on the content of dissolved oxygen.

Oxygen reduction in water to its complete deficiency leads to a significant increase in the concentration of manganese by manganese receipt of sediment [3, 4]. Water quality category for manganese ranged from 1 (excellent, very clean) to 4.8 (medium condition, moderately polluted) water quality class – from I (excellent, very clean) to III (satisfactory, polluted). The mean values of water quality categories were 3.4 (good condition, satisfactorily clean), water quality class II (good, clean).

Due to the extensive use of pesticides containing copper there is a problem of environmental pollution with this element, including water. The content of copper in the Zolotonoshka River ranged from 0,001 - 0.006 mg/dm³, the mean value – 0.003 mg/dm³. Before 2002 MAC overruns were not recorded, in 2003-2014 MAC stated 2.0-6.4 in all alignments. In comparison with 2000 the content of copper in 2014 increased by 6 times (tab. 2). Water quality category ranged from 2 (very good condition, clean) to 4 (satisfactory condition, slightly polluted), a class of water quality – from II (good, clean) to III (satisfactory, polluted) the mean value was 3 (good condition, satisfactorily clean) and II (good, clean), respectively.

Table 2 – Average water values according to the specific substances with toxic action

Year	Mn	Cu	Fe _{3ar}	Zn	Cr	Oil products	Phenols	SSAS
2000	0,013	0,001	0,170	0,001	0,001	0,094	0,001	0,071
2001	0,019	0,001	0,237	0,001	0,001	0,086	0,001	0,086
2002	0,033	0,002	0,228	0,002	0,001	0,117	0,001	0,046
2003	0,040	0,002	0,183	0,002	0,001	0,057	0,001	0,056
2004	0,039	0,002	0,180	0,002	0,001	0,015	0,001	0,093
2005	0,049	0,002	0,192	0,003	0,001	0,019	0,001	0,090
2006	0,056	0,003	0,230	0,003	0,001	0,017	0,001	0,109
2007	0,075	0,003	0,230	0,002	0,001	0,018	0,001	0,110
2008	0,057	0,003	0,290	0,004	0,001	0,189	0,001	0,085
2009	0,056	0,004	0,358	0,004	0,001	0,313	0,001	0,088
2010	0,047	0,004	0,367	0,004	0,001	0,193	0,001	0,116
2011	0,054	0,004	0,420	0,003	0,001	0,157	0,001	0,108
2012	0,050	0,004	0,472	0,004	0,001	0,148	0,001	0,090
2013	0,051	0,003	0,585	0,004	0,002	0,176	0,002	0,095
2014	0,019	0,006	0,165	0,005	0,002	0,075	0,002	0,078

Iron content was significantly higher in MAC. The highest concentration was 1.2 mg/dm³ (12 MAC) in autumn of 2013 in the alignment 2, the minimum – in

autumn of 2014 in alignment 1 (0.11 mg/dm³ 1.1 MAC). If during the period of 2000-2008 the fluctuations of the concentration among the alignments

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was insignificant (10-40%), starting from 2009 there was a tendency in the iron increase in the water in alignment 2 – in 2013 it increased by 4.4 times as compared to 2008.

High concentrations of iron can be caused by both natural content of this element in surface waters, leaching of elements from the soil and forest litter and human impact. Water quality category by iron content ranged from 4 (satisfactory condition, slightly polluted) to 6 (poor condition, polluted), a class of water quality – from III (satisfactory, polluted) to IV (bad, polluted water) the mean value was 4 and III respectively.

Data analysis of the zinc and chrome content showed no samples with the maximum allowable concentration. There was a tendency to increase zinc (Table 2), in particular in alignment 2. Zinc fluctuated between 0.001 – 0.006 mg/dm³, the mean value is 0.003 mg/dm³, chrome from 0.001 to 0.003 mg/dm³, the mean value is 0.003 mg/dm³. The water quality category in the zinc and chrome content 1 (excellent, very clean) and quality class I (excellent, very clean).

Oil products are the most common and dangerous pollutants in natural waters. The maximum concentration of oil products (0.8 mg/dm³, 16 MAC) was recorded in autumn of 2009 in alignment 2, the minimal one was 0.001 mg/dm³, the average value was 0.001 mg/dm³. The maximum allowable concentration was recorded primarily in alignments 1 and 2 in the period of 2000 – 2003 and 2008 – 2014, in alignment 3 the maximum allowable concentration was recorded only in 2014 (autumn and spring).

Water pollution in alignments 1 and 2 with oil products causes superficial washout and wastewater treatment by the industrial facilities, particularly in wastewater of JSC “Zolotonosha Butter Factory” the exceeding of maximum allowable concentration of petroleum products is 40% [11]. In alignment 2 during 2008 – 2014 there is an increase in the concentration of oil products (by 1.2-8.2 times). This fact proves the impact of urban agglomeration. The water quality category according to the oil products content ranged from 2 (very good condition, clean) to 7 (very poor condition, very dirty) water quality class – from II (good, clean) to V (very bad, dirty). The mean value is 4 quality category (satisfactory condition, slightly polluted), class III of water quality (satisfactory, polluted).

There is periodical rise in maximum allowable phenol concentration. Thus, the double excess of MAC (0.002 mg/dm³) was recorded in alignment 2 in spring of 2008, 2009, 2012, in autumn of 2014, in spring of 2013 in all three alignments. Three times maximum allowable concentration (0.003 mg/dm³) was recorded in alignment 2 in spring of 2014. In other years the phenol content was 0.001 mg/dm³. The water quality category ranged from 3 (good condition, satisfactorily clean) to 5 (medium, moderately polluted) water quality class – from II (good, clean) to III (satisfactory, polluted) the mean value amounted to 3.2 (good condition, satisfactorily clean) and II (good, clean), respectively.

The toxic compounds in water of the organic nature (phenols, synthetic surface-active substance, oil products) cause the dissolved oxygen reduction.

According to the arithmetic mean of the environmental index by the components of toxic action specific substances ($I_e^{spec.} = 3.3$) the water quality category is rated as 3 (good condition, satisfactorily clean) quality class II (good, clean), according to the worst – category 7 (very bad condition, very dirty) water quality class V (very bad, very dirty water).

The averaged environmental index I_e according to three units was 3.9 and the value of the integral index of water quality of the Zolotonoshka River can be assessed as category 4 (satisfactory condition, slightly contaminated) water quality class III (satisfactory contaminated), according to the worst criteria – 7 category (rather poor condition, greatly contaminated) water quality class V (very bad, very dirty water). Insignificant values of the salt composition $I_e^{sol.} = 3.9$ and a block of specific toxic substances $I_e^{spec.} = 3.3$ neutralize the existing pollution by the tropho-saprobiological block components (environmental and health) ($I_e^{tr-sap.} = 4.9$). Under these circumstances the water quality of the Zolotonoshka is appropriately to classify according to the tropho-saprobiological block as category 5 of water quality (medium, moderately polluted) water quality class III (satisfactory contaminated).

According to the contamination factor (CF) there is significant water quality deterioration. The value of CF varies from a maximum value 5.6 (contaminated) in spring of 2014, in alignment 1, to the minimum – 1.2 (slightly contaminated) in spring of 2000 in alignment 2. The contamination factor receives maximum value primarily in alignment 2. Average annual values of contamination factor for the period of 2000-2014 in the investigated area of the Zolotonoshka River changed from 2.1 (slightly polluted water) to 4.3 (moderately polluted) (Fig. 3), due to the cumulative effect of anthropogenic and natural factors that is climatic, hydrodynamic and physical-chemical processes. Human activity has the greatest negative impact on the level of contamination of the river [11, 12].

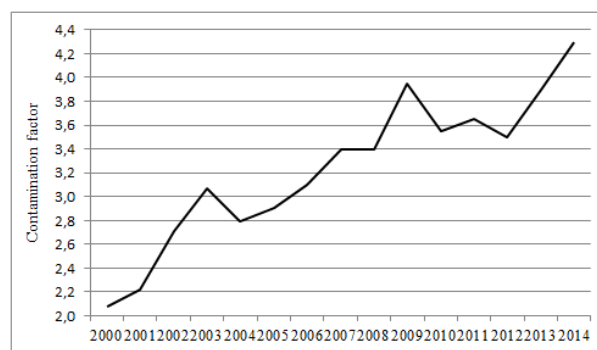


Figure 3 – Dynamics of average annual values of contamination factor

An examination of bank areas of the Zolotonoshka recorded many landfills, wastewater discharges from cesspools. In some areas the river is muddy, overgrown with reeds and clogged with chopped cane, resulting in deteriorating of both chemical and bacteriological water

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condition greatly affecting the quality and recovery of fish stocks.

CONCLUSIONS. The Zolotonoshka River is under a serious anthropogenic impact, the level of which is close to the limit of the ecosystem stability. The priority pollutants are ammonia and nitrite nitrogen, heavy metals, petroleum products. The concentration of dissolved oxygen is significantly lower. This anthropogenic pressure on the river affects both the dynamics of nutrients and oxygen regime. Chronic pollution with ammonia nitrogen leads to disruption of the ecological balance and self-purification processes in the river. As a result, there is a constant shortage of dissolved oxygen, which in turn, does not provide the normal course of nitrification process.

The main causes of deterioration of water quality are the lack of efficiency of treatment facilities in Zolotonosha.

The sources of river pollution of Zolotonoshka are runoff and discharges of untreated wastewaters in its upper reaches, as evidenced by the high level of water pollution also above Zolotonosha town. Water intake increase, channel silting, a highly tilled basin of the river, banks pollution, often filled with illegal dumping, failure mode in the bank and water protection zones enhance the degradation of aquatic ecosystems.

The situation requires detailed research, development and implementation of special measures to ascertain the strength, character, sources and factors of the process. The problem of ecological and dangerous condition of the Zolotonoshka River should be a priority, otherwise the process of degradation of the aquatic ecosystem will become irreversible and the river will disappear from the map of Ukraine.

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ГИДРОХИМИЧЕСКИЙ МОНИТОРИНГ РЕКИ ЗОЛОТОНОШКА

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Представлены многолетние данные по основным показателям гидрохимического состояния р. Золотоношка. Оценка качества воды проводилась на соответствие отдельных показателей качества воды нормативным требованиям предельно допустимых концентраций для водоемов рыбохозяйственного значения, по коэффициенту загрязнения воды и по величине экологического индекса. Показано, что приоритетными загрязнителями являются азот аммонийный (1,5-6,1 ПДК) и нитритный (1,1-28,3 ПДК), тяжелые металлы, нефтепродукты. Уровень загрязнения воды азотом аммонийным оценивается как неустойчивый, но высокий, уровень загрязнения нитритами – характерный, высокий. Хроническое загрязнение аммонийным азотом приводит к нарушению экологического равновесия и процессов самоочищения в реке. Содержание растворимого кислорода значительно ниже допустимых значений (3,6-4,6 мг/дм³). Постоянный дефицит растворенного в воде кислорода не обеспечивает нормального протекания процессов нитрификации. По величине коэффициента загрязнения вода р. Золотоношка характеризуется как «умеренно загрязненная», по экологическому индексу качества – «состояние удовлетворительное, загрязнённые». Наблюдается тенденция к ухудшению качества воды, что обусловлено совокупным действием техногенных и природных факторов.

Ключевые слова: поверхностные воды, загрязняющие вещества, хозяйственная деятельность, качество воды.