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SURFACE WATER QUALITY IN KHARKIV RECREATIONAL AREAS: 2006-2020

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Keywords: surface water quality, recreational area, chemical analysis, dissolved oxygen, BOD_5, total mineralization, biogenic substances content, oil products, surfactants, heavy metals.

Introduction

Kharkiv is the second largest city in Ukraine with population more than 1.5 million people. There are several types of recreational areas where residents can spend their free time. Areas located near rivers and lakes are the most popular among residents during May - September period. For such types of recreational area, water quality and available infrastructure are very crucial. Every year, before the start of the summer season, local authorities make control field trips for assessment of water quality.

The main four rivers that flow through Kharkiv territory are: (i) the Udy River, which belongs to the medium-sized rivers (catchment basin – 3864 km^2, length – 164 km) and is a tributary of the Seversky Donets; (ii) the Lopan River, a tributary of the Udy River, which also can be classified as a middle river (catchment basin – 2000 km^2, length – 96 km), (iii) the Kharkiv River, a tributary of the Lopan River, which belongs to small rivers (catchment basin – 1160 km^2, length – 71 km), (iv) the Nemyshlya River – a small river (catchment basin – 72.2 km^2, length – 27 km) that flows into the Kharkiv River. The total length of rivers within the city territory is about 58 km. Kharkiv's rivers are shallow, with a low flow velocity, and are subject to significant anthropogenic impact. There are many natural and man-made reservoirs, associated with these rivers – more than 20 reservoirs are located on the territory of Kharkiv. Local population usually use them for recreation purposes: swimming, sunbathing, fishing etc. [1]. All surface waters suffer from various pollution sources, the most significant ones are discharges of treated and insufficiently treated municipal and industrial wastewaters, urban and agricultural surface run-off, runoff from landfills [2, 3]. The main pollution sources in Kharkiv are Dykanivski WWTP (138,92 mln m^3 per year) and Bezludivski WWTP (51,03 mln m^3 per year). They both belong to KharkivVodokanal Municipal Company and their discharges amount 46 % from total discharges for the whole river basin [4]. Surface water quality is very important for both recreation activity and economic activity of the city. This topic is very popular in other countries and scientists are preforming various types of projects [5 – 8].

The aim of the paper is to assess dynamics of water quality in four main recreational areas in Kharkiv and to develop recommendations for improvement of water quality.

Main part

Description of water bodies

There are several recreational areas in Kharkiv, but most popular are Zhuravlevskiy Hydropark, Oleksiivskiy Lugopark, Udyanskiy Hydropark and Osnovyanske Lake. They are located in different districts of Kharkiv. (Fig. 1) [9].

Zhuravlevskiy Hydropark is located on the Kharkiv River, it was constructed together with small dam and was opened in 1962. The reservoir has semi-closed aquatorium with low water exchange in the low-water period; this fact explains why the water in some years has very poor quality especially on organo-optical parameters. The water mirror area is 1 340 000 m^2. Its aquatoria is completely located within the residential area of the Kharkiv City in Kievskiy District [1].

Oleksiivskiy Lugopark is located on the Lopan River, it was created due to construction of Pavlivska dam in 1965 (dam was reconstructed in 2009). The reservoir has low water exchange in low-water periods. The water mirror area is 230 000 m^2. Aquatoria is located on the territory of six residential parts of the Kharkiv City within Shevchenkivsky and Holodnogirsky Districts [1].

Udyanskiy Hydropark was set up in 1971 due to construction of Novobavarska dam, is located on the Udy River (dam was reconstructed in 2010). The reservoir has also a low water exchange during low-water periods. The water mirror area is 350 000 m^2. Aquatoria is located on in the residential part of the city in Novobavarskiy District [1].

Osnovyanske Lake was created due to sand mining activity. The water mirror area is 430 000 m^2. Aquatoria is located on in the residential part of the city in Osnovyanskiy District [1].

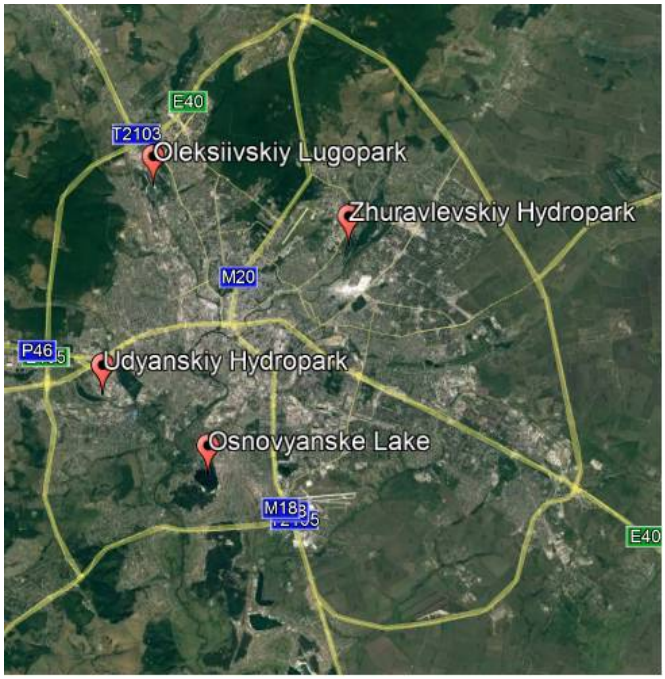

Figure 1 – Location of four main recreational areas in Kharkiv: Zhuravlevskiy Hydropark, Oleksiivskiy Lugopark, Udyanskiy Hydropark and Osnovyanske Lake

Description of experiment and results

Water sampling was performed during 2006–2020. The time and season of sampling correspond to the periods of high and low water periods. According to hydrological parameters for Kharkiv, the spring flood period is April-May (rarely also includes the first decade of June), and the summer low water period is August – September. These periods are interested because local population use recreational areas, thus anthropogenic pressure is increasing and water quality is very important. Water quality is controlled by State Company "Kharkiv

Oblast Center for Control and Prevention of Diseases" (under the Ministry of Health of Ukraine) and by local environmental authorities [10].

Water samples analysis were performed in a certified Laboratory of Analytical Chemical Research of the Institute of Environmental Sciences, V. N. Karazin Kharkiv National University, we analysed the following parameter: pH, transparency, nitrates, nitrites, ammonia, dissolved oxygen, chlorides, total hardness, alkalinity, BOD_5, COD, total mineralisation, phosphates, oil products, surfactants, heavy metals. Laboratory methods and equipment were used [11]. For evaluation of water quality we used national standard "Hygienic requirements to composition and peculiarities of surface water bodies used for recreational and municipal purposes", MAC values were taken for recreational areas, used for swimming, sport and rest of population [12]. Also EU Directive 2006/7/EC concerning the management of bathing water quality was used for assessment of water quality [13]. Obtained average data for all periods are presented in Tables 1–4.

Table 1 – Water quality in Zhuravlevskiy Hydropark, data of chemical analysis, average data

Parameter	Unit	Sampling period						MAC, Ukraine [8]	MAC, EU [9]
		2006-2010		2011-2015		2016-2020			
		15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.		
Transparency	cm	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≤ 100
pH	pH units	8,1	8,6	7,8	8,2	7,3	8,4	6,5-8,5	6-9
Dissolved oxygen	mgO_2/dm^3	3,8	4,6	4,0	4,3	3,2	4,2	≤ 4,0	-
BOD5	mgO_2/dm^3	4,2	4,0	4,4	4,1	4,4	3,6	≥ 4,0	-
Total mineralization	mg/dm^3	688	734	650	742	624	746	≤ 1000	≤ 1000
Ammonim nitrogen	mg/dm^3	0,8	1,2	0,65	1,85	0,5	2,2	≤ 2,0	1,0
Nitrite nitrogen	mg/dm^3	1,15	2,62	1,92	3,3	1,48	2,6	≤ 3,3	0,1
Nitrate nitrogen	mg/dm^3	18,2	24,7	15,8	26,7	22,3	34,1	≤ 50,0	30
Phosphates	mg/dm^3	1,2	1,45	0,85	1,2	0,24	0,29	≤ 3,5	3,5
Oil products	mg/dm^3	0,12	0,23	0,15	0,21	0,01	0,12	≤ 0,3	0,5
Surfactants	mg/dm^3	0,15	0,24	0,2	0,22	0,05	0,1	≤ 0,5	0,3
Cd	mg/dm^3	0,0009	0,001	0,0004	0,001	0,0005	0,0009	≤0,001	0
As	mg/dm^3	0,0012	0,002	0,002	0,0018	0,001	0,002	≤ 0,05	0
Hg	mg/dm^3	0,0002	0,0003	0	0,0001	0,0001	0,0001	≤0,0005	0
Pb	mg/dm^3	0,011	0,021	0,004	0,005	0	0	≤ 0,03	0

Discussion of results

Dissolved oxygen and BOD_5 are main criteria for assessment of organic pollution. There are various natural and anthropogenic sources making inputs of organic pollutants. In surface water BOD_5 should vary from 0,5 to 5,0 mg/dm^3 depending on season and physiological and biochemical activity of microorganisms. As we see, there are deviations from norms in water samples from Zhuravlevskiy Hydropark and Udyanskiy Hydropark during all 15 year period: higher by 0.6-0.9 mg/dm^3 for dissolved oxygen and lower by 0.3-1.2 mg/dm^3

for BOD_5. We also can see violation of dissolved oxygen norms for dissolved oxygen and BOD_5 in Oleksiivskiy Lugopark during last 5 years. These can be a signal of excessive amount of organic pollution of water bodies as a result of an increase pressure on the recreational area and the creation of illegal beaches with a large number of people around the studied water bodies.

Table 2 – Water quality in Oleksiivskiy Lugopark, data of chemical analysis, average data

Parameter	Unit	Sampling period						MAC, Ukraine [8]	MAC, EU [9]
		2006-2010		2011-2015		2016-2020			
		15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.		
Transparency	cm	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≤ 100
pH	pH units	7,32	7,56	7,68	7,80	7,67	7,85	6,5-8,5	6-9
Dissolved oxygen	mgO_2/dm^3	3,2	3,4	3,6	4,0	4,0	4,9	≤ 4,0	-
BOD5	mgO_2/dm^3	5,2	4,7	4,4	4,2	4,9	3,85	≥ 4,0	-
Total mineralization	mg/dm^3	483	548	516	591	504	532	≤ 1000	≤ 1000
Ammonim nitrogen	mg/dm^3	0,68	0,82	0,93	0,11	1,2	1,9	≤ 2,0	1,0
Nitrite nitrogen	mg/dm^3	2,1	2,4	1,96	2,85	1,85	2,3	≤ 3,3	0,1
Nitrate nitrogen	mg/dm^3	15,3	21,2	16,1	19,7	12,1	18,6	≤ 50,0	30
Phosphates	mg/dm^3	2,42	2,85	1,64	1,67	0,48	0,62	≤ 3,5	3,5
Oil products	mg/dm^3	0,06	0,1	0,11	0,12	0,07	0,11	≤ 0,3	0,5
Surfactants	mg/dm^3	0,08	0,11	0,04	0,06	0,07	0,08	≤ 0,5	0,3
Cd	mg/dm^3	0,0009	0,001	0,0004	0,001	0,0005	0,0009	≤0,001	0
As	mg/dm^3	0,0012	0,002	0,002	0,0018	0,001	0,002	≤ 0,05	0
Hg	mg/dm^3	0,0002	0,0003	0	0,0001	0,0001	0,0001	≤0,0005	0
Pb	mg/dm^3	0,011	0,021	0,024	0,025	0,022	0,029	≤ 0,03	0

Total mineralization in water bodies is average 695 mg/dm^3 for Zhuravlevskiy Hydropark, 523 mg/dm^3 for Oleksiivskiy Lugopark, 930 mg/dm^3 for Osnovyanske Lake and 850 mg/dm^3 for Udyanskiy Hydropark. It corresponds to normal mineralization level.

Biogenic substances content (namely nitrogen and phosphorus compounds) is the key parameter for hydrochemical characteristic of water quality and water ecosystem state. These parameters shows the eutrophication level and velocity, that is the cause of sharp deterioration of water quality and death of water life. Our data shows that in spring they are 1.5–2.2 times lower than in summer, that can be explained by the season, lighting and temperature. On the concentration of nitrogen-containing substances, the most polluted (in terms of the content of ammonium nitrogen and nitrite nitrogen) during the 15-year period is Udyanskiy Hydropark (the average is 2.02 mg/dm^3 and 2.23 mg/dm^3, respectively); we see also the highest pollution

by nitrate nitrogen of the water in Udyanskiy Hydropark (28.63 mg/dm^3) and Osnovyanske Lake (24.29 mg/dm^3). Excess of the MAC on ammonium nitrogen was identified in waters from Zhuravlevskiy Hydropark and Udyanskiy Hydropark during the low-water period, that indicates an excessive anthropogenic load on these objects, since the number of local population during this period increases in more than 10 times compared to the spring period. However, we should note a positive tendency in water quality: decrease phosphates by 5 times in all four water bodies during 15 years of research.

Table 3 – Water quality in Udyanskiy Hydropark, data of chemical analysis, average data

Parameter	Unit	Sampling period						MAC, Ukraine [8]	MAC, EU [9]
		2006-2010		2011-2015		2016-2020			
		15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.		
Transparency	cm	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≤ 100
pH	pH units	7,42	7,67	7,75	7,91	7,63	7,84	6,5-8,5	6-9
Dissolved oxygen	mgO_2/dm^3	4,26	4,28	4,15	4,23	4,25	4,62	≤ 4,0	-
BOD5	mgO_2/dm^3	4,22	4,35	4,02	3,88	4,8	3,24	≥ 4,0	-
Total mineralization	mg/dm^3	798	853	847	875	842	864	≤ 1000	≤ 1000
Ammonim nitrogen	mg/dm^3	2,0	1,94	2,11	2,18	1,83	2,06	≤ 2,0	1,0
Nitrite nitrogen	mg/dm^3	1,44	1,80	2,35	2,66	2,24	2,91	≤ 3,3	0,1
Nitrate nitrogen	mg/dm^3	28,41	19,65	24,5	29,4	30,5	39,3	≤ 50,0	30
Phosphates	mg/dm^3	1,71	1,86	1,54	1,63	0,46	0,84	≤ 3,5	3,5
Oil products	mg/dm^3	0,11	0,31	0,05	0,05	0,04	0,14	≤ 0,3	0,5
Surfactants	mg/dm^3	0,41	0,38	0,14	0,21	0,21	0,33	≤ 0,5	0,3
Cd	mg/dm^3	0	0	0	0,00051	0,0007	0,001	≤0,001	0
As	mg/dm^3	0	0	0,00011	0	0,0005	0,0002	≤ 0,05	0
Hg	mg/dm^3	0	0,0001	0	0,0000	0	0	≤0,0005	0
Pb	mg/dm^3	0,001	0,0012	0,006	0,007	0,011	0,015	≤ 0,03	0

Oil products and surfactants

During the study period, we have identified oil films and oily stains on the water surface only three times in Zhuravlevskiy Hydropark and two times in Osnovyanske Lake. These were associated to washing of cars and animals. At the same time chemical analysis have shown that oil products were lower than MAC and surfactants were two times lower than MAC.

Toxic heavy metals

Fortunately, we can indicate a constant decrease of pollution by As and Hg during last 15 years in all four water bodies. On the contrary, the content of Pb and Cd in the waters of the Zhuravlevskiy Hydropark and Oleksiivskiy Lugopark has increased by 2.5–3 times over the last 5 years, that is the result of anthropogenic pressure. These reservoirs are located very

closed to key highways, and the number of vehicles over the last 5 years has increased in 4 times, therefore, the surface runoff from adjacent roads inputs much more toxic pollutants. Exceeding the MAC for the content of toxic metals has not been determined.

For improvement of water quality we have developed recommendations.

Table 4 – Water quality in Osnovyanske Lake, data of chemical analysis, average data

Parameter	Unit	Sampling period						MAC, Ukraine [8]	MAC, EU [9]
		2006-2010		2011-2015		2016-2020			
		15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.	15 May – 15 June	15 Aug. – 15 Sept.		
Transparency	cm	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≥ 30	≤ 30	≤ 100
pH	pH units	8,0	8,34	8,16	8,26	8,1	8,45	6,5-8,5	6-9
Dissolved oxygen	mgO_2/dm^3	3,1	3,9	3,34	3,96	3,07	4,0	≤ 4,0	-
BOD5	mgO_2/dm^3	4,6	4,22	5,2	4,16	4,91	5,02	≥ 4,0	-
Total mineralization	mg/dm^3	829	947	913	944	956	984	≤ 1000	≤ 1000
Ammonim nitrogen	mg/dm^3	0,44	1,21	0,85	0,93	1,1	1,96	≤ 2,0	1,0
Nitrite nitrogen	mg/dm^3	1,85	1,96	2,17	2,46	1,44	2,23	≤ 3,3	0,1
Nitrate nitrogen	mg/dm^3	22,8	26,15	28,45	29,31	26,2	32,8	≤ 50,0	30
Phosphates	mg/dm^3	2,84	3,15	1,18	1,51	0,51	0,62	≤ 3,5	3,5
Oil products	mg/dm^3	0,04	0,005	0,07	0,09	0,08	0,15	≤ 0,3	0,5
Surfactants	mg/dm^3	0,19	0,11	0,06	0,15	0,24	0,26	≤ 0,5	0,3
Cd	mg/dm^3	0,0004	0,0005	0,0006	0,007	0,001	0,001	≤0,001	0
As	mg/dm^3	0	0	0	0	0	0	≤ 0,05	0
Hg	mg/dm^3	0	0	0,0001	0	0,0002	0,0003	≤0,0005	0
Pb	mg/dm^3	0,005	0,007	0,006	0,006	0,015	0,024	≤ 0,03	0

Conclusions and recommendations

1. Local population actively use four reservoirs (Zhuravlevskiy Hydropark, Oleksiivskiy Lugopark, Udyanskiy Hydropark and Osnovyanske Lake) for recreation. This causes increase in anthropogenic pressure on water ecosystem.

2. ***Dissolved oxygen and BOD_5***: there are deviations from norms in water samples from Zhuravlevskiy Hydropark and Udyanskiy Hydropark during all 15 years period: higher by 0.6-0.9 mg/dm^3 for dissolved oxygen and lower by 0.3–1.2 mg/dm^3 for BOD_5. We also can see violation of norms for dissolved oxygen and BOD_5 in Oleksiivskiy Lugopark during last 5 years. ***Total mineralization*** in water bodies is average 695 mg/dm^3 for Zhuravlevskiy Hydropark, 523 mg/dm^3 for Oleksiivskiy Lugopark, 930 mg/dm^3 for Osnovyanske Lake and 850 mg/dm^3 for Udyanskiy Hydropark. It corresponds to normal mineralization level for rivers within city. ***Biogenic substances content***: on the concentration of nitrogen-containing substances, the most polluted (in terms of the content of ammonium nitrogen and

nitrite nitrogen) during the 15-year period is Udyanskiy Hydropark (the average is 2.02 mg/dm^3 and 2.23 mg/dm^3, respectively); we see also the highest pollution by nitrate nitrogen of the water in Udyanskiy Hydropark (28.63 mg/dm^3) and Osnovyanske Lake (24.29 mg/dm^3). Excess of the MAC on ammonium nitrogen was identified in waters from Zhuravlevskiy Hydropark and Udyanskiy Hydropark during the low-water period. However, we should note a positive tendency in water quality: decrease phosphates by 5 times in all four water bodies during 15 years of research. ***Oil products and surfactants:*** chemical analysis have shown that oil products were lower than MAC and surfactants were two times lower than MAC. ***Toxic heavy metals:*** a constant decrease of pollution by As and Hg during last 15 years in all four water bodies. On the contrary, the content of Pb and Cd in the waters of the Zhuravlevskiy Hydropark and Oleksiivskiy Lugopark has increased by 2.5–3 times over the last 5 years, that is the result of anthropogenic pressure. Exceeding the MAC for the content of toxic metals has not been determined.

3. Recommendations for improvement of water quality in recreational areas: (i) to preform regular monitoring of water quality; (ii) to introduce regular and systematic control by one local authority; (iii) to improve infrastructure of recreational areas; (iv) to introduce regular cleaning of the recreational areas; (v) to install bio-WC; (vi) to install additional waste containers (preferably with separate waste collection); (vii) plant trees for better isolation from highways; (viii) to improve level of water treatment on WWTP; (ix) to create nature protected areas along rivers.

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ЯКІСТЬ ПОВЕРХНЕВИХ ВОД В РЕКРЕАЦІЙНИХ ЗОНАХ М. ХАРКОВА: 2006–2020 РОКИ

Мета. Оцінка динаміки якості води в чотирьох основних рекреаційних зонах м. Харкова та розробка рекомендацій щодо покращення якості води. **Методи**. Польові, лабораторні, аналітична обробка даних. **Результати.** У статті надано аналіз динаміки якості води для чотирьох основних рекреаційних зон м. Харкова: Журавлівського гідропарку, Олексіївського Лугопарку, Удянського гідропарку та Основ'янського озера. Період спостереження: 2006–2020 рр., час: травень-червень та серпень-вересень. Наведено середні дані. Зразки проаналізовано в сертифікованій лабораторії аналітичних хімічних досліджень Каразінського навчально-наукового інституту екології. Лабораторні дані порівнювали з національними стандартами України та Європи. Зроблено висновки за такими ключовими параметрами: розчинений кисень і БПК5, загальна мінералізація, вміст біогенних речовин, нафтопродукти та поверхнево-активні речовини, вміст токсичних важких металів. Відсутня певна динаміка досліджуваних місць за окремими забруднюючими речовинами. **Висновки.** Розроблено такі рекомендації щодо покращення якості води: проводити регулярний моніторинг якості води; запровадити регулярний та систематичний контроль з боку місцевих органів влади; покращити інфраструктуру рекреаційних зон; проводити регулярне прибирання зон відпочинку; встановити біотуалети; встановити додаткові контейнери для сміття (бажано із роздільним збором); висадити дерева для забезпечення кращої ізоляції від автомагістралей; покращити рівень очищення води на очисних спорудах; створення природоохоронних територій вздовж річок.

Ключові слова: якість поверхневих вод, рекреаційна зона, хімічний аналіз, розчинений кисень, БПК5, загальна мінералізація, вміст біогенних речовин, нафтопродукти, ПАР, важкі метали.

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КАЧЕСТВО ПОВЕРХНОСТНЫХ ВОД В РЕКРЕАЦИОННЫХ ЗОНАХ Г. ХАРЬКОВА: 2006–2020 ГОДА

Цель. Оценка динамики качества воды в четырех основных рекреационных зонах г. Харькова и разработка рекомендаций по улучшению качества воды. **Методы**. Полевые, лабораторные, аналитическая обработка данных. **Результаты.** В статье пред-

ставлен анализ динамики качества воды для четырех основных рекреационных зон, расположенных в Харькове: Журавлевский гидропарк, Алексеевский лугопарк, Удянский гидропарк и Основянское озеро. Период исследования: 2006-2020 гг., время: май-июнь и август-сентябрь. Представлены средние данные. Образцы были проанализированы в сертифицированной лаборатории аналитических химических исследований Каразинского учебно-научного института экологии. Лабораторные данные сравнивались с национальными стандартами Украины и Европы. Выводы сделаны по следующим ключевым параметрам: растворенный кислород и БПК5, общая минерализация, содержание биогенных веществ, нефтепродукты и ПАВ, содержание токсичных тяжелых металлов. Отсутствует определенная динамики исследуемых мест по отдельным загрязняющим веществам. **Выводы.** Разработаны следующие рекомендации по улучшению качества воды: проводить регулярный мониторинг качества воды; ввести регулярный и систематический контроль со стороны местных органов власти; улучшение инфраструктуры рекреационных зон; проводить регулярную уборку зон отдыха; установить био-туалеты; установить дополнительные контейнеры для мусора (желательно с раздельным сбором); высадить деревья для обеспечения лучшей изоляции от автомагистралей; улучшить уровень очистки воды на очистных сооружениях; создание охраняемых природных территорий вдоль рек.

Ключевые слова: качество поверхностных вод, рекреационная зона, химический анализ, растворенный кислород, БПК5, общая минерализация, содержание биогенных веществ, нефтепродукты, ПАВ, тяжелые металлы.

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SURFACE WATER QUALITY IN KHARKIV RECREATIONAL AREAS: 2006-2020

The aim of the paper is to assess dynamics of water quality in four main recreational areas in Kharkiv and to develop recommendations for water quality improvement. **Methods**. Field and laboratory methods and analytical data processing. **Results.** The paper presents analysis of dynamics in water quality for four main recreational areas located in Kharkiv: Zhuravlevskiy Hydropark, Oleksiivskiy Lugopark, Udyanskiy Hydropark and Osnovyanske Lake. Period of study: 2006-2020, time: May-June and August-September. Average data are presented. Samples were analysed at certified Laboratory of Analytical Chemical Research of the Karazin Institute of Environmental Sciences. Laboratory data were compared with national UA standards and European ones. Conclusions were made for the following key parameters: dissolved oxygen and BOD_5, total mineralization, biogenic substances content, oil products and surfactants, toxic heavy metals content. There is no specific dynamics on the pollution level. **Conclusions.** The following recommendations for improvement of water quality were developed: (i) to preform regular monitoring of water quality; (ii) to introduce regular and systematic control by one local authority; (iii) to improve infrastructure of recreational areas; (iv) to introduce regular cleaning of the recreational areas; (v) to install bio-WC; (vi) to install additional waste containers (preferably with separate waste collection); (vii) plant trees for better isolation from highways; (viii) to improve level of water treatment on WWTP; (ix) to create nature protected areas along rivers

Keywords: surface water quality, recreational area, chemical analysis, dissolved oxygen, BOD_5, total mineralization, biogenic substances content, oil products, surfactants, heavy metals.