Asian Journal of Water, Environment and Pollution, Vol. 17, No. 2 (2020), pp. 15–21.
DOI 10.3233/AJW200015

Study of the State of Water Bodies Located within Kharkiv City (Ukraine)

Valentyna Loboichenko*, Vladimir Andronov[1], Victor Strelets[2], Oleksii Oliinykov[3] and Mikhailo Romaniak[4]

Department of Occupational, Technogenic and Environmental Safety, National University of Civil Defence of Ukraine, Chernishevska Street, 94, Kharkiv, 61023, Ukraine
[1]Centre for Scientific Research, National University of Civil Defence of Ukraine Chernyshevska Street, 94, Kharkiv, 61023, Ukraine
[2]Scientific Department on Problems of Civil Defence, Technogenic and Ecological Safety, National University of Civil Defence of Ukraine, Chernishevska Street, 94, Kharkiv, 61023, Ukraine
[3]Department of Extramural and Distant Training of Civil Defense, National University of Civil Defence of Ukraine, Chernyshevska Street, 94, Kharkiv, 61023, Ukraine
[4]Institute of Public Administration of Ukraine, Kyiv National Taras Shevchenko University Volodymyrska Street, 60, Kyiv, 01033, Ukraine
✉ vloboichm@gmail.com

Received April 21, 2019; revised and accepted September 6, 2019

Abstract: The state of the water bodies located within the city has been analyzed in the paper. The factors influencing the physicochemical and microbiological composition of the urban surface water bodies have been considered. An experimental study of the state of the surface water bodies located within the large industrialized city of Kharkiv (Ukraine) has been carried out. The water of five reservoirs located within the city (Lake Komsomolskoe, Lake Ocheret, Pavlovskiy reservoir, Pond No. 1 in the gorge Hlybokiy Yar, Petrenkiv reservoir) and two reservoirs located outside the city (Lake Glubokoe No. 1 and Lake Glubokoe No. 2) have been analysed in terms of conductivity and mineralization. It has been found that for the urban water bodies, these parameters, in general, have higher values compared to the water bodies located in the recreational zone outside the city. The water of Petrenkiv reservoir and Lake Komsomolskoe is characterized by the highest values of conductivity and mineralization, while Lake Komsomolskoe and Pavlovskiy reservoir, due to the supply peculiarities, are most vulnerable to the influence of the external factors. The average values of conductivity for the studied reservoirs of Kharkiv are 590-910 μS/cm, for Lakes Glubokoe No. 1 and Glubokoe No. 2 they are equal to 500 μS/cm. The typical average mineralization values for the studied urban reservoirs are 400-670 mg/l, and for Lakes Glubokoe No. 1 and Glubokoe No. 2 are 345 mg/l. The error of values in all cases does not exceed 2%.

Key words: Water bodies, anthropogenic load, electrical conductivity, mineralization.

Introduction

The human influence on the state of the environment has been increasing in recent times and is beginning to take catastrophic proportions. One of the components that is being harmed is the aquatic environment. Water is an indispensable component of life of all living organisms, and the qualitative state of water determines these organisms' standards of living. Contaminated water can cause damage to organisms, populations, biogeocoenoses, ecosystems or lead to their destruction.

*Corresponding Author

On condition of the ever-increasing population, the demand for water also increases, while the quantity of water resources of the satisfactory quality decreases. The main factors influencing the water quality today are agriculture, industry and municipal sewage.

According to the United Nations report, about 80% of the sewage is released into the environment untreated, most cities do not have a satisfactory sewage management system, and 1.8 billion people use contaminated drinking water, which increases the risk of diseases (United Nations). According to the WHO, 700 million people do not receive drinking water from the improved water sources (WHO).

In large cities, which serve as the centres of industrial activity and have a significant number of population, the negative impact on the environmental components is much greater than in small settlements. There is a direct link between the degree of urbanization and, accordingly, the various components of urban environmental pollution, and climate changes. Urbanization is currently one of the environmental contamination factors (Chakraborty, 2018) and causes gradual deterioration of water quality within the city (Zambrano). This is especially true for the surface waters, which are under considerable man-induced load and are negatively affected by the city life (Hall and Ellis, 1985). At the same time, there is a significant negative impact of the urban territories on the quality of groundwater (Acharya et al., 2018).

Direct factors of the urban waters contamination include surface runoff, rainwater, sewage discharge by the enterprises, household activities (Khatri and Tyagi, 2015). Indirectly, water quality is influenced by diffusive soil contamination within the urban ecosystem. For each city, a combination of the factors affecting the state of the water bodies and the degree of this impact varies.

Deterioration of the quality of urban water bodies makes them difficult and sometimes impossible to use as a source of drinking water, for fish-husbandry utilization or with the recreational purposes. This, in turn, can lead to the drinking water shortage and the viral diseases increase (Abo ul Hassan Rashid et al., 2018). In case of the emergencies, in particular, fires (Mygalenko et al., 2018), the use of water from the urban water bodies, which have high level of the heavy metals content, to localize and eliminate the flames can also be the cause of the special equipment damage (Dubinin et al., 2018).

Understanding the possible consequences of urban water pollution emphasizes the need for effective preventive measures – the introduction of the retention reservoirs, the elimination of the unauthorized sewage connections, etc. (Zambrano). Identification of the spatial and temporal patterns of pollutants flooding in the urban rivers allows local authorities and public utilities to better manage city water cycle and urban lands use (McGrane, 2016), and in turn, determine the further possible impact on the natural water objects outside the city (Bezsonnyi et al., 2017; Loboichenko et al., 2017).

Taking into consideration the aforementioned, the issue of studying the state of the water bodies located within the city and determining the factors influencing them is relevant.

The impact of urban areas on the objects located within is generally broadly covered and may be multidirectional. However, the issue of the detailed impact of the individual components of the city in each case serves as the subject of an in-depth study.

Another paper (Ezeabasili et al., 2014) discusses the pollution of the urban water with such a dangerous metal as arsenic, which negatively affects both human health and the environment. It is specified that pollution sources in Onitsha, the most urbanized city in Southeastern Nigeria, are wastes, sewage, fuel spills, agricultural materials, fossil fuel combustion, metallurgical industries, electronic components and semi-conductors, batteries, pigments and paints. The necessity of strengthening the work of the state bodies and improving the technical state of the control laboratories (Ezeabasili et al., 2014) is also considered. During research of the water bodies in Onitsha area of Anambra state (Nigeria) (Akudinobi and Okolo, 2013), the authors admitted an increased risk of contamination due to the man-induced impact of the nearby water supply sources.

Agrawal and Panda (2018) studied the impact of the urban wastewater on the quality of water in the adjacent rivers using the Water Quality Index. The index, in its turn, is calculated with the help of such indicators as pH, TDS, total hardness, chloride, DO, BOD, nitrate and phosphate. It has been noted that water quality improvement mainly happens due to the natural factors.

In a paper by Yogendra and Puttaiah (2008), the possibility of using the urban water bodies for various purposes with the help of Water Quality Index is defined. It is stated that high electrical conductivity indicators, TDS, nitrate content, low dissolved oxygen, and, accordingly, the high value of the Water Quality Index (96 – 106.3) make it impossible to use waterbody in Shimoga Town, Karnataka.

The content of heavy metals (Cr, Ni, Cu, As, Cd and Pb) in the water and bottom sediment of the urban river

Korotoa (Bangladesh) is determined in a work (Islam et al., 2015). It is proven that the level of the river water pollution by these metals makes it dangerous for drinking water consumption and is marked by gradual accumulation in the dregs.

The study of the impact of construction on chemical and biological indicators of water quality was carried out for the Park River, in Connecticut (USA) by Zhu et al. (2018). The increase of turbidity as a result of construction works and its subsequent reduction were observed. The authors note the high sensitivity of urban water ecosystems to the impact of small-scale hydromodification projects and the need for their environmental assessment.

The study of the water reservoirs in Kyiv (Ukraine) points out a significant impact of the man-induced sources of pollution. The pollution of these reservoirs and bottom sediments with heavy metals in soluble and suspended forms has been analyzed, the predomination of the soluble forms has been also admitted. According to Akimova et al. (2015), the main form of nickel, cobalt, copper and zinc migration in the surface waters are the hydrated metal ions and their complex compounds with organic matter. Later on, these water bodies serve as the basis for the development of anthropogenic streams of dispersion of polluting chemical elements.

Sado-Inamura and Fukushi (2018) noted an unpleasant smell of water as an important factor of the urban rivers deterioration. Their study shows the relationship between the type of odour and the content of overall dissolved oxygen in Tokyo. The study was carried out with the use of the quantitative analysis of the odour nuisance using hedonic odour tones. The authors point out the external causes of the odour deterioration.

Rakh and Mule (2019) emphasized the need to study the physicochemical parameters of wastewater to evaluate and predict the potential load on the purification system and necessity of the further balance to improve the environment in the cities. In the study of sewage from the open sewer system of Aurangabad city (India), the authors point out the higher values of most parameters in the pre-monsoon period compared with the after-monsoon period. The total hardness, turbidity, chlorides, total solids, total dissolved solids, total suspended solids, chemical oxygen demand, biological oxygen demand, dissolved oxygen, phosphate, nitrate and sulphate were used as the wastewater quality indicators.

The quality of urban waters is also determined by the microbiological indicators. Irda Sari et al. (2018) used the Quantitative Microbial Risk Assessment to study the state of the Cikapundung River in Taman Sari sub district (Indonesia). It was defined that the well slots and spring water would cause the expected highest annual risks of infection due to faecal contamination, since most households did not use septic tanks and disposed waste products directly into the river. There is a need to improve water cleaning and storage at the places of use to prevent the risk of diseases transmitted through water.

Bastaraud et al. (2018) used a discriminant statistical approach and agglomerative hierarchical clusters to research the state of water in 32 cities of Madagascar according to the microbiological indicators. A 16-year study identified a gradual deterioration of water quality. As the main driving forces of pollution, the authors indicate the location of the site, type of water source, population growth, lack of protection, agriculture, implemented treatment, urbanization, sanitation and flooding threats.

The method of multi-criteria decision-making was used by Hashim et al. (2015) to study the water of a number of Chinese urban rivers. Such rivers as Xuxi River (Wuxi City), Gankeng River (Shenzhen City), Xia Zhang River (Yixing City), Fenghu and Song Yang Rivers (Ruian City), and Jiu Haogang River (Hangzhou City) were examined. Their condition was analysed by the parameters of temperature, chemical oxygen demand, dissolved oxygen, total phosphorus, and ammonia nitrogen. It was determined that these rivers were under considerable man-induced load and had the worst class of water quality according to the Chinese national standard. As the source of their pollution, the authors note the sewage discharge, including untreated. The same paper shows the positive experience of using Bacterial Technology for the water purification of the urban rivers.

The objective of this paper is to study the state of the surface water sources located within one of the largest cities of Ukraine, Kharkiv.

Kharkiv is an industrialised scientific and technical centre of Ukraine, the number of inhabitants is almost 1.5 million. Within the city, there is a number of industrial enterprises – polluters of the environment (Ekologicheskiy passport, 2017). As a result, water bodies located in the city suffer from the considerable anthropogenic influence.

Experimental

For this paper, the state of five city reservoirs – Lake Komsomolskoe, Lake Ocheret, Pavlovskiy reservoir, Pond No. 1 in the gorge Hlybokiy Yar, Petrenkiv reservoir was studied. The reference samples are water samples from the reservoirs Lake Glubokoe No. 1 and Lake Glubokoe No. 2, located in a recreational zone outside the city.

The study of the state of reservoirs in Kharkiv was carried out using the conductometric method. The samples of the surface water were selected during April–May 2017 in accordance with (ISO 5667-4: 2016). The sampling points are presented in Figure 1.

For each water sample, measurements of the conductivity and mineralization (TDS) were carried out five times. All measurements were made with the automatic temperature compensation (to 25 °C). If necessary, the external devices to control the temperature of the solution can be used (Andronov et al., 2016).

The values obtained were processed with the help of the standard statistical methods with a probability of *P* = 0.95 (Dvorkin, 2001). For all the results obtained, the error of measurement, expressed in terms of the relative mean square deviation, did not exceed 2%. The cost of defining the above parameters is low. The techniques used are inexpensive and environmentally friendly, since they do not involve the use of chemical reagents and dangerous equipment.

Results and Discussion

Mineralization and electrical conductivity (conductivity) are a reflection of the amount of soluble salts in water (Andronov, 2005; Loboichenko et al., 2016). These parameters allow to expressly track the changes in the content of soluble ions in the studied water body, and, using the coefficient of identification (Loboichenko et al., 2018; Vasyukov et al., 2016), to prevent the development of a possible emergency associated with the deterioration of water quality, or to react to the emergency on time (Loboichenko and Strelec, 2018).

The given work studies the state of the urban water bodies during the spring period to track the possible maximum fluctuations of the indicators caused by the contamination that gets into the reservoir with melt waters.

The values of conductivity and mineralization of the water samples under study are presented in Figures 2 and 3. There was no opportunity to take samples for Pavlovskiy reservoir and Pond No. 1 in the gorge Hlybokiy Yar at the end of April. For Petrenkiv reservoir two samples of water were selected, closer to the highway (point 1) and near the beach (point 2).

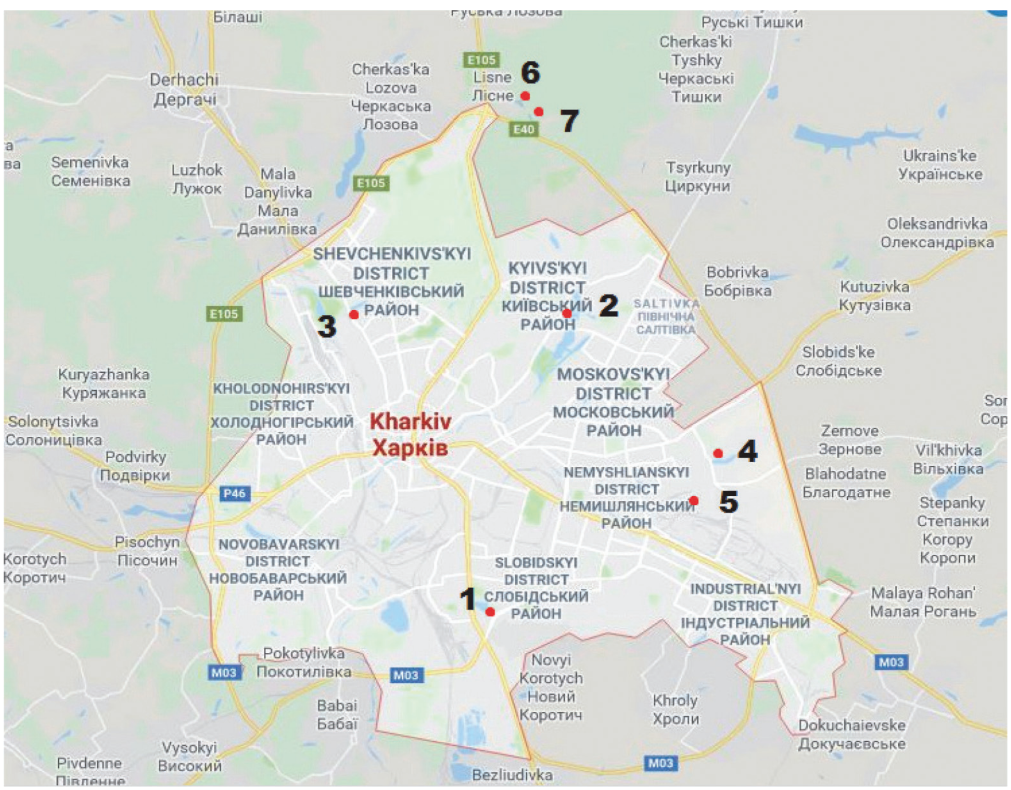

Figure 1: Water sampling points: Lake Komsomolskoe (1), Lake Ocheret (2), Pavlovskiy reservoir (3), Pond No. 1 in the gorge Hlybokiy Yar (4), Petrenkiv reservoir (5), Lake Glubokoe No. 1 (6), Lake Glubokoe No. 2 (7).

As can be seen from Figures 2 and 3, in water of Lake Komsomolskoe there was a decrease of conductivity and, consequently, mineralization, 1.5 times during the studied period. That is, the lake water was diluted. In the beginning of May, there were rains in Kharkiv and, probably, there was a diluting of the lake water with the rainwater. This testifies to the predominant nature of the rainwater supply of the lake. The values of mineralization and conductivity of water in Lake Ocheret did not change much; most likely, it was supplied by the ground water, and the rainwater did not affect its composition.

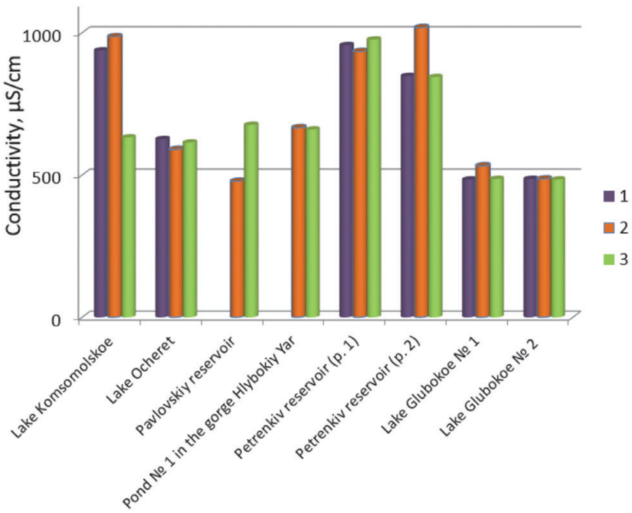

Figure 2: The values of the conductivity of the studied water samples of the water bodies at the end of April (1), in mid-May (2), at the end of May (3).

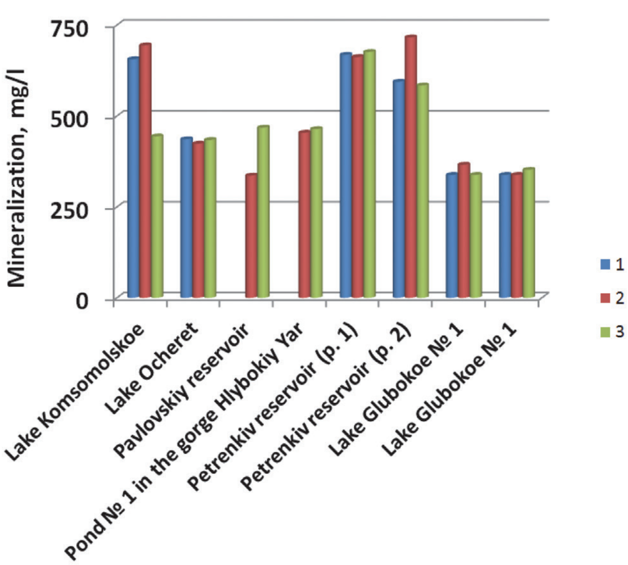

Figure 3: The values of mineralization of the studied water samples of the water bodies at the end of April (1), in mid-May (2), at the end of May (3).

Petrenkiv reservoir was researched at point 1 (near the highway) (Figures 2, 3, p. 1) and point 2 (non-disrupted area) (Figures 2, 3, p. 2). At point 1, the measured values of electrical conductivity and mineralization are higher than at point 2. In our opinion, the reason for these consistently high values is that water at point 1 undergoes a greater man-induced load compared to point 2. At p. 2 in early May, most likely, there was a chance pollution.

In May, there was an increase in the content of the dissolved substances in Pavlovskiy reservoir (Figures 2, 3). Probably this was due to the washing of pollutants from the private sector located nearby, and the rainwater with a surface runoff into the water of the reservoir. In Pond No. 1 in the gorge Hlybokiy Yar, the values of the measured parameters remained almost unchanged at the time of the study, that is, it most likely had an underground supply, and the pond's composition of water was not significantly influenced by the rainwater and surface runoff.

Lake Glubokoe No. 1 and Lake Glubokoe No. 2 had almost the same values of mineralization and conductivity parameters during the study period, which may indicate their supply from one aquifer. Moreover, their supply had the underground source, since rainwater in May did not significantly affect the state of water of these reservoirs during the study period.

The average values of the studied parameters of water bodies are presented in Figures 4 and 5. It is evident that for Kharkiv water bodies conductivity ranges from 590 to 910 µSm/cm, while for water bodies located in the recreational zone near Kharkiv (Lake Glubokoe

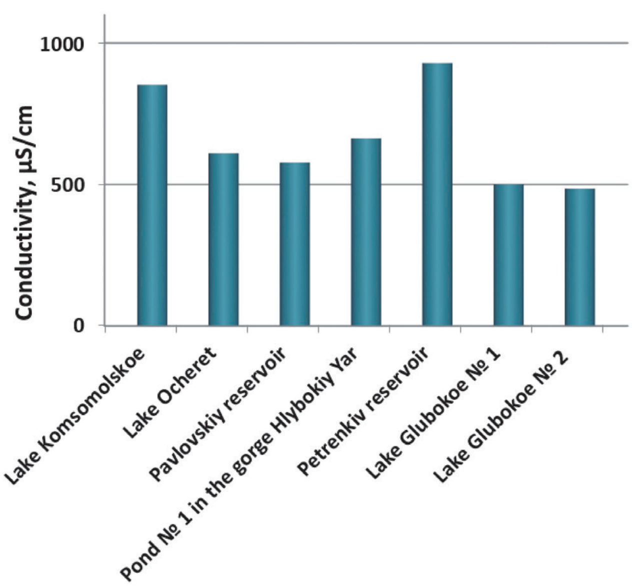

Figure 4: Average values of conductivity of the studied water bodies.

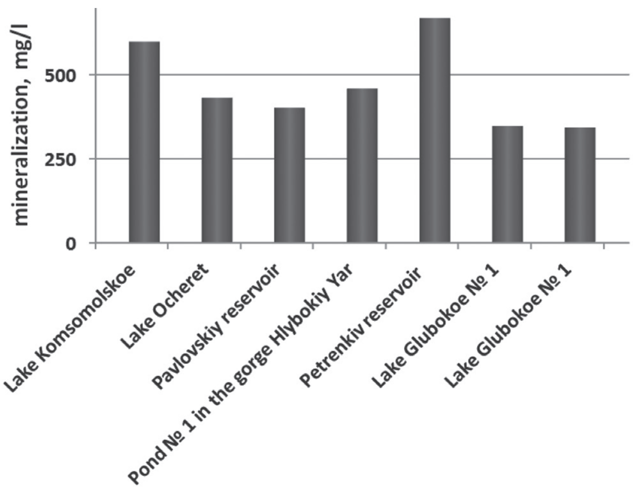

Figure 5: Average values of mineralization of the studied water bodies.

No. 1 and Lake Glubokoe No. 2), its value is 500 μSm/cm. The typical averaged mineralization values for the studied urban reservoirs are 400-670 mg/l, and for Lakes Glubokoe No. 1 and Glubokoe No. 2 the value is 345 mg/l.

Conclusions

Thus, it has been shown that water bodies located within the city are under constant man-induced load. The combination of factors that make this negative influence varies in each individual case. Understanding possible impacts of pollution allows carrying out preventive measures and making the necessary decisions for the management of the city water cycle.

While researching the state of the water bodies of the large industrialized city of Kharkiv (Ukraine) according to mineralization and electrical conductivity parameters, it was found that these parameters, in general, have higher values compared to the water bodies located outside the city in the recreational zone. In our opinion, this is associated with the constant man-induced influence of the urban ecosystem of Kharkiv. The water of Petrenkiv reservoir and Lake Komsomolskoe is characterized by the highest values of conductivity and mineralization that may be associated with the additional local anthropogenic influences. From our point of view, among the water bodies under study, Lake Komsomolskoe and Pavlovskiy reservoir are the most vulnerable to the external influences as a result of the peculiarities of the supply. Lakes Glubokoe No. 1 and No. 2, which are located in the recreational zone, are the purest and the least exposed to the anthropogenic load.

It was found that for the studied water bodies of Kharkiv, the average values of conductivity vary in the range from 590 to 910 μSm/cm, for Lakes Glubokoe No. 1 and No. 2, located in the recreational zone near Kharkiv, it is 500 μSm/cm. The typical average mineralization values for the studied urban reservoirs are 400-670 mg/l, and for Lakes Glubokoe No. 1 and Glubokoe No. 2 the value is 345 mg/l.

References

Abo ul Hassan Rashid, M., Manzoor, M.M. and S. Mukhtar (2018). Urbanization and Its Effects on Water Resources: An Exploratory Analysis. *Asian Journal of Water, Environment and Pollution*, **15(1):** 67-74. DOI: 10.3233/AJW-180007.

Acharya, S., Sharma, S.K. and V. Khandegar (2018). Hydrogeochemical assessment of groundwater quality in vicinity of Dwarka, Delhi. *Pollution Research*, **37(1):** 209-220.

Agrawal, K.K. and Ch. Panda (2018). Assessment of water quality of river Daya at Bhubaneswar City, Odisha by using Water Quality Index method. *Pollution Research Paper*, **37(1):** 117-126.

Akimova, O.R., Kurayeva, I.V. and A.I. Samchuk (2015). Assessment of the water pollution degree in Kiev. *Technogenic and Ecological Safety and Civil Protection*, **9:** 37-43 (in Ukrainian).

Akudinobi, B.E.B. and C.M. Okolo (2013). Qualitative evaluation of urban water sources in Onitsha area of Anambra state, Nigeria. *International Journal of Environment, Ecology, Family and Urban Studies*, **3(1):** 35-44.

Andronov, V.A. (2005). Salt content of water in sensing water systems of blast furnace gas purification units. *Khimya I Tehnologiya Vody*, **27(1):** 80-84.

Andronov, V., Pospelov, B. and E. Rybka (2016). Increase of accuracy of definition of temperature by sensors of fire alarms in real conditions of fire on objects. *Eastern European Journal of Enterprise Technologies*, **4(5-82):** 38-44. DOI: 10.15587/1729-4061.2016.75063.

Bastaraud, Al., Rakotondramanga, J.M., Mahazosaotra, J., Ravaonindrina, N. and R. Jambou (2018). Environmental Factors and the Microbial Quality of Urban Drinking Water in a Low-Income Country: The Case of Madagascar. *Water*, MDPI, **10(10):** 1450. DOI: 10.3390/w10101450.

Bezsonnyi, V., Tretyakov, O., Khalmuradov, B. and R. Ponomarenko (2017). Examining the dynamics and modeling of oxygen regime of Chervonooskil water reservoir. *Eastern European Journal of Enterprise Technologies*, **5(10-89):** 32-38. DOI: 10.15587/1729-4061.2017.109477

Chakraborty, D. (2018). Environmental pollution in India and its relationship with urbanization: An enquiry. *Pollution Research*, **37(3):** 729-735.

Dubinin, D., Korytchenko, K., Lisnyak, A., Hrytsyna, I. and V. Trigub (2018). Improving the installation for fire extinguishing with finely dispersed water. *Eastern European Journal of Enterprise Technologies*, **2(10-92):** 38-43. DOI: 10.15587/1729-4061.2018.127865

Dvorkin, V.I. (2001). Metrology and quality assurance of quantitative chemical analysis. *Chemistry*, Moscow. 263 pp. (in Russian).

Ekologicheskiy pasport Khar'kovskoy oblasti. Khar'kovskaya oblastnaya gosudarstvennaya administratsiya (2017). 156 pp. http://old.menr.gov.ua/protection/protection1/kharkivska (in Ukrainian).

Ezeabasili, A.C.C., Anike, O.L., Okoro, B.U. and C.M. U-Dominic (2014). Arsenic pollution of surface and subsurface water in Onitsha, Nigeria. *African Journal of Environmental Science and Technology*, **8(9):** 491-497. https://doi.org/10.5897/AJEST2014.1588

Irda Sari, S.Y., Sunjaya, D.K., Shimizu-Furusawa, H., Watanabe, Ch. and A.S. Raksanagara (2018). Water Sources Quality in Urban Slum Settlement along the Contaminated River Basin in Indonesia: Application of Quantitative Microbial Risk Assessment. *Journal of Environmental and Public Health*, **2018:** Article ID 3806537, 7 p. https://doi.org/10.1155/2018/3806537.

Islam Md., S., Ahmed Md, K., Raknuzzaman, M., Habibullah-Al-Mamun Md and M.K. Islam (2015). Heavy metal pollution in surface water and sediment: A preliminary assessment of an urban river in a developing country. *Ecological Indicators*, **48:** 282-291.

ISO 5667-4:2016. Water quality – Sampling - Part 4: Guidance on sampling from lakes, natural and man-made, 34 p.

Hashim, S., Yuebo, X., Saifullah, M., Nabi Jan, R. and A. Muhetaer (2015). Integrated Evaluation of Urban Water Bodies for Pollution Abatement Based on Fuzzy Multicriteria Decision Approach. *Biomed Res Int.*, **2015:** 327280.

Hall, M.J. and J.B. Ellis (1985). Water quality problems of urban areas. *GeoJournal*, **11(3):** 265-275. https://doi.org/10.1007/BF00186340.

Khatri, N. and S. Tyagi S. (2015) Influences of natural and anthropogenic factors on surface and groundwater quality in rural and urban areas. *Frontiers in Life Science*, **8(1):** 23-39. DOI: 10.1080/21553769.2014.933716.

McGrane, S.J. (2016). Impacts of urbanisation on hydrological and water quality dynamics, and urban water management: A review. *Hydrological Sciences Journal*, **61(13):** 2295-2311. DOI: 10.1080/02626667.2015.1128084.

Mygalenko, K., Nuyanzin, V., Zemlianskyi, A., Dominik, A. and S. Pozdieiev (2018). Development of the technique for restricting the propagation of fire in natural peat ecosystems. *Eastern European Journal of Enterprise Technologies*, **1(10-91):** 31-37. DOI: 10.15587/1729-4061.2018.121727.

Loboichenko, V., Andronov, V. and V. Strelec (2018). Evaluation of the Metrological Characteristics of Natural and Treated Waters with Stable Salt Composition Identification Method. *Indian Journal of Environmental Protection*, **38:** 724-732.

Loboichenko, V. and V. Strelec (2018). The natural waters and aqueous solutions express-identification as element of determination of possible emergency situation. *Water and Energy International*, 201861/RNI **(9):** 43-51.

Loboichenko, V.M., Tishakova, T.S. and A.E. Vasyukov (2016). Application of direct coulometry for rapid assessment of water quality in Krasno-Oskol Reservoir (Kharkiv Region, Ukraine). *Der Pharma Chemica*, **8(19):** 27-34.

Loboichenko, V.M., Vasyukov, A.E. and T. Tishakova (2017). Investigations of Mineralization of Water Bodies on the Example of River Waters of Ukraine. *Asian Journal of Water, Environment and Pollution*, **14(4):** 37-41. DOI: 10.3233/AJW-170035.

Rakh, G.B. and M.B. Mule (2019). Physico-chemical Parameters Study of Sewage from Open Sewerage System of Urban Areas of Aurangabad City. *Indian Journal of Environmental Protection*, **39(1):** 3-16.

Sado-Inamura, Y. and K. Fukushi (2018). Considering Water Quality of Urban Rivers from the Perspectives of Unpleasant Odor. *Sustainability*, **10(3):** 650. doi:10.3390/su10030650

Vasyukov, A., Loboichenko, V. and S. Bushtec (2016). Identification of bottled natural waters by using direct conductometry. *Ecology, Environment and Conservation*, **22(3):** 1171-1176.

United Nations. Water Quality and Wastewater. http://www.unwater.org/water-facts/quality-and-wastewater/.

WHO. UN-Water Global Analysis and Assessment of Sanitation and Drinking-water (GLAAS). http://www.who.int/water_sanitation_health/monitoring/investments/glaas/en/.

Yogendra, K. and E.T. Puttaiah (2008). Determination of water quality index and suitability of an urban waterbody in Shimoga Town, Karnataka. Proceedings of Taal 2007: The 12th World Lake Conference, pp. 342-346.

Zhu, B., Smith, D.S., Benaquista, A.P., Rossi, D.M., Kadapuram, B.M., Yu, M., Partlow, A.S. and N.R. Burtch (2018). Water quality impacts of small-scale hydromodification in an urban stream in Connecticut, USA. *Ecological Processes*, **7:** 11. https://doi.org/10.1186/s13717-018-0122-z.