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# Spatio-Temporal Study of the Ecological State of Water Bodies Located within the Detached Objects of the Urbanized Territory of Ukraine

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**ABSTRACT**

The paper considers the impact of urbanized areas on the state of water bodies. The impact of various types of anthropogenic activities on water bodies located in cities was shown. In towns, there is worse water resource management than in large cities and the necessity of conducting more detailed research. Using the method of direct conductometry, a spatio-temporal study of the ecological state of water bodies located within the detached objects of the urbanized territory of the Ukraine was carried out using the example of Popasna town.

It was shown that fluctuations in the electrical conductivity of these bodies are mainly due to the influence of surface runoff. It was found that in all studied ponds there was a significant drop in the electrical conductivity of water in March 2021, followed by an increase and stabilization in April and May 2021, the characteristic values of electrical conductivity range from 200 to 2900 μS, the relative standard deviation did not exceed 1.5%. The necessity of conducting further, more detailed study of the features of the influence of surface runoff on the water condition in the studied ponds was shown for the purpose of rational management of these water bodies.

**Keywords:** urbanized area, ecological state of water, electrical conductivity, water body, urban surface runoff, pollution

## INTRODUCTION

Today, the issue of the state of the environment is a basic element of the national and international policy of the overwhelming majority of states. The increasing pollution in atmospheric air [Popov et al., 2020], water objects [UNESCO-IHP, 2014; Ding et al., 2021] and soils [Al-Taai, 2021; UN. Environment programme, 2018], the deterioration of the state of biological resources [Palmer et al., 2021; Mahmoud et al., 2016] indicates the need to search for more environmentally friendly technologies [Kustov et al., 2019] and materials [Danchenko et al., 2017; Fabre et al., 2021]. Another consequence of understanding the need to improve the quality of the environment is the transition of states to other environmentally friendly models of industrial and economic development [Zachura, 2016; Georgeson et al., 2017].

Water resources are one of the critical elements of the existence of any living organism. The presence of pollutants in water affects health, including the reproductive capacity of people [Ustaoğlu et al., 2021; Rashtian et al., 2019], and providing the population with water of the required quality is a top priority for any modern state. It should also take into account the use of water in various areas of industry [Lu et al., 2015; Shireli et al., 2021], agriculture [Lap, et al., 2021], for recreational purposes [Breen et al., 2018], as well as the possibility of using recycled water [Hess et al., 2019].

Taking into account the number of natural and man-made disasters and emergencies [Insurance Information Institute, 2020; Swiss Re Institute, 2021], first of all, fires [Mygalenko et al., 2018] and floods [Sun et al., 2016] in the world, a separate issue is the deterioration of water quality in emergency situations [Loboichenko et al., 2018] or water consumption during emergencies in the form of fires both by spraying the water [Dubinin et al., 2018; Semko et al., 2017], and using it to cool equipment [Abramov et al., 2018]. However, in this direction, there is also a tendency to use the environmentally friendly, waterless, methods of extinguishing fires by using the acoustic effect [Levterov, 2019; Kalugin et al., 2019], including the implementation of acoustic fire extinguishers [Stawczyk et al., 2021; Wilk-Jakubowski, 2019].

As a consequence of the above, today there is a need for the rational use of water resources and their expedient distribution.

In urbanized areas, the problem of environmental pollution [Yang, 2020], ineffective management of water resources being one of its elements, is becoming especially acute due to the increase in the number of pollutants [Strokal et al., 2021], significant need of the population for drinking water, as well as due to the need for further correct disposal of sewage and wastewater [Ao et al., 2021] and the availability of non-revenue water [Murugan Sakthi et al., 2021]. Climate change also contributes to the quality of urban surface water [Rui et al., 2018].

Today, the issue of the state of urbanized waters has been considered quite widely. Thus, the impact of urbanization on river systems [Zhao et al., 2020; Phong, 2015] and urban river watersheds is being investigated [Horta Ribeiro Antunes et al., 2021]; there is a shortage of drinking water and deterioration in its quality [Hassan Rashid et al., 2018]. At the same time, for developing countries, urbanization does not keep pace with environmental pollution, which leads to significant pollution of groundwater [Dhania et al., 2014; Shaharoona et al., 2019], microbiological pollution of drinking-quality water [Balthazard-Accou et al., 2019] and a shortage of drinking water for city residents [Farid et al., 2012]. At the same time, human economic activity requires the intake of a significant part of the river runoff, which, in turn, leads to the discharge of large amounts of wastewater into natural water bodies and disruption of the hydrochemical and hydrological regimes of water bodies in urbanized areas [Kurochkina, 2020]. It was shown that the rate of formation and the volume of bottom sediments in such reservoirs can be used to assess the anthropogenic load on these reservoirs over a certain period of time [Kurochkina, 2019].

An assessment of groundwater recharge in an urbanized area showed a significant impact of the urban component compared to natural recharge (precipitation) which suggests that urban pollutants seep into the aquifer [Wakode et al., 2018]. At the same time, the role of climatic conditions, peculiarities of the land use and features of the land surface on water yield in urbanized territories is also noted which should be taken into account to minimize the negative hydrologic impacts of urbanization [Li et al., 2020]. A systematic study of the relationship between the land use and the water quality showed that urban development activities have a greater impact on water quality through the changes in hydrological processes (runoff and erosion) [Camara et al., 2019]. The impact of the accelerated urbanization of territories was studied [Yuan et al., 2019] on the example of Suzhou city (China). Thus, there was a significant increase in the content of multiple nutrient parameters, microbial load, fecal markers and bacterial pathogens in the surface water of the locations with high urban intensification compared to those with medium and low urban intensification. It was shown that the intensification of urbanization strongly affects the water, sediment, and macrobenthos [Wang et al., 2020].

A separate issue includes the parameters required to assess the state of water bodies located in urbanized areas. Thus, the need of a minimum sufficient set of indicators to perform a rapid diagnosis of the ecological state of such reservoirs was noted in the article [Krasnogorskaya et al., 2011] – the concentration of dissolved oxygen, electrical conductivity, saprobity index, COD, and pH. In the article [Loboichenko et al., 2020] the authors proposed using TDS and conductivity as parameters for rapid assessment of the state of urban water bodies.

At the same time, the issue of water supply and quality in small towns remains open due to worse access to drinking water in comparison with large cities [Marks et al., 2020; Muniruzzaman et al., 2017]. The complexity of water supply, lack of funding and lack of experience in water resources management in small towns was also noted [Ndaw, 2014]. Monitoring the water services in small towns is different from testing the rural resilience and systems of urban benchmark analysis [Adank, et al., 2018]. Under the conditions of limited economic and technical capabilities of small towns, the local or constant influence of natural or anthropogenic factors on water bodies cannot always be identified in time, which can have a significant negative impact on both the object itself and the adjacent territories. The importance of the impact of certain anthropogenic factors on water sources in small towns and the peculiarities of water management in these ones should also be noted [Loboichenko et al., 2021]. Thus, the above indicates the need for a more detailed study of the state of water bodies in small towns.

The purpose of this work was to study the ecological state of the separate water bodies located within the detached objects of the urbanized territory (Popasna town, Lugansk region, Ukraine).

## MATERIALS AND METHODS

The study of the state of water objects in Popasna town (Luhansk region, Ukraine) was carried out by using the conductometric method. The water samples were taken from a number of water bodies located within Popasna town. Pond I, pond II, pond III, pond IV, pond V, pond VI, pond VII were selected for research, the water was taken to be compared from additional points – spring I' and well II' (Fig. 1) and tap water of Popasna town.

The water samples were taken from the surface of the ponds at a distance of 0.5–1.0 m from the shore during February – May 2021 in accordance with [ISO 5667–4:2016, DSanPiN 2.2.4–171–10].

The conductivity index was used as a research parameter in the work. The number of measurements for a single sample was 5, the standard statistical approaches were used to process data [Dvorkin, 2001]. The error of determination in the form of the relative standard deviation does not exceed 1.5%. Electrical conductivity was

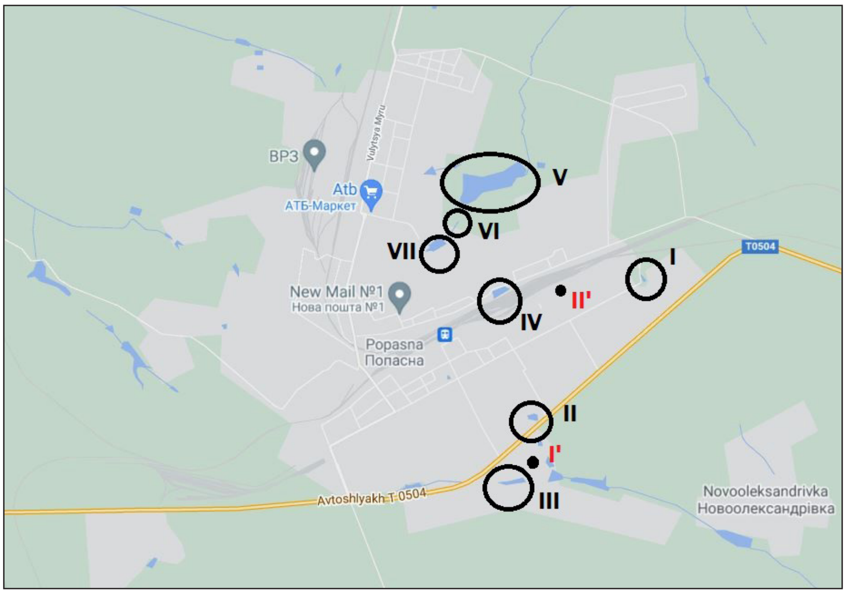


**Figure 1.** Researched water objects of Popasna town: pond I, pond II, pond III, pond IV, pond V, pond VI, pond VII and reference points – spring I' and well II'

measured by using an EZODO 7021 conductivity meter with automatic temperature control. It is allowed to use any other model with manual or automatic temperature control [Andronov et al., 2016].

## RESULTS AND DISCUSSION

A spatio-temporal study of the ecological condition of water bodies located within the detached objects of the urbanized territory of Luhansk region (Ukraine), in particular, in Popasna town, was carried out.

The area of the water mirror of the studied ponds is 1.2–6 km$^2$, depth – 1–5 m. Ponds V, VI, VII are connected by a network of streams – water from pond VI enters pond VII and then to pond V.

The study was performed according to the electrical conductivity parameter (conductivity) by using the method of direct conductometry. This is an express, inexpensive and fast indicator that allows tracking changes in the state of the reservoir in real time. The conductivity parameter is directly proportional to the total content of dissolved salts [Loboichenko et al., 2020]. Accordingly, the increase in electrical conductivity indicates the growth of dissolved impurities in water and vice versa.

According to the data obtained for pond I (Fig. 2), it can be see that in February the value of electrical conductivity was equal to 1500 µS, and in March it decreased almost in half. This is probably due to the dilution of the pond water with pure meltwater. In April and May, there is an increase in electrical conductivity to values of 1760–1800 µS which are probably characteristic of this pond.

According to the results of the analysis of data as per the pond II (Fig. 3), a high value of electrical conductivity in February (almost 2000 µS) can be noted, which further decreases by 2.6 times. In April and May there is a gradual increase in values from 2150 to 2300 µS. When it comes to the pond I, it is likely that the decrease in the water conductivity of the pond in March is due to its dilution with pure meltwater.

The analysis of the electrical conductivity of water in the pond III (Fig. 4) shows that, as for most of the studied ponds, its electrical conductivity in February differs sharply from the electrical conductivity in March, which is probably due to the melting snow. In May, there is a slight decrease in electrical conductivity compared to April.

The water in pond VI (Fig. 5) in February has the lowest electrical conductivity of all studied reservoirs (720 µS), then there is a significant decrease in electrical conductivity in March and an increase in electrical conductivity almost twice compared to the values in February to 1400 – 1350 µS.

Pond V (Fig. 6) is the largest studied body of water and is located in the recreational area. The water flows into the reservoir from the ponds VI and VII. As can be seen, a characteristic decrease in electrical conductivity in March with a further increase in April – May to 2000 – 1900 µS is observed in this case.

The pond VI is designed to protect the town against sewage and is combined with the pond VII, so their electrical conductivity (Fig. 7, Fig. 8)

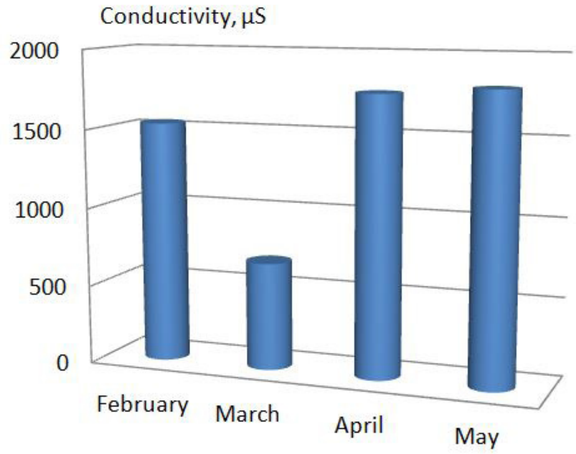


**Figure 2.** Dynamics of oscillations of the electrical conductivity values of the pond I water, µS

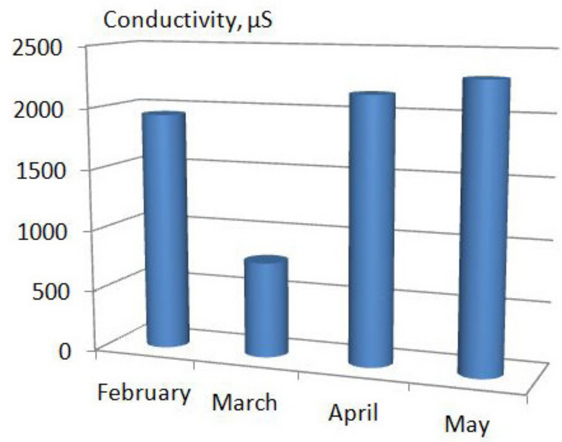


**Figure 3.** Dynamics of oscillations of the electrical conductivity values of the pond II water, µS

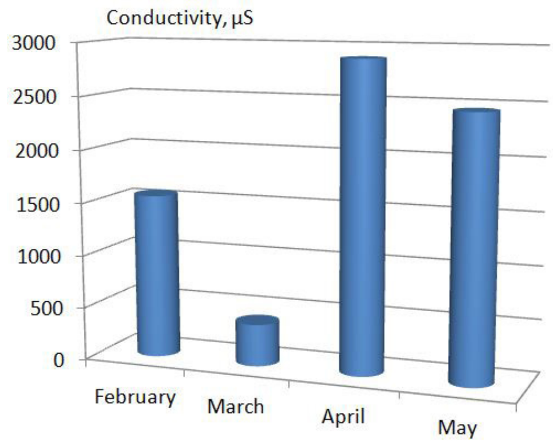


**Figure 4.** Dynamics of oscillations of the electrical conductivity values of the pond III water, µS

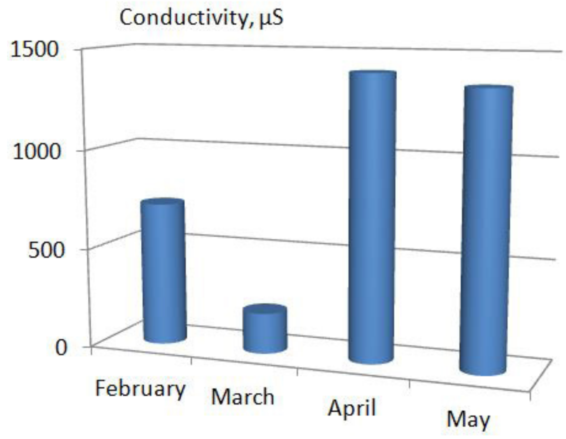


**Figure 5.** Dynamics of oscillations of the electrical conductivity values of the pond IV water, µS

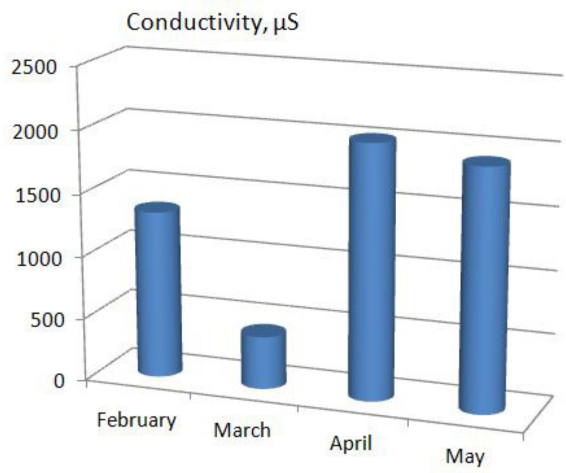


**Figure 6.** Dynamics of oscillations of the electrical conductivity values of the pond V water, µS.

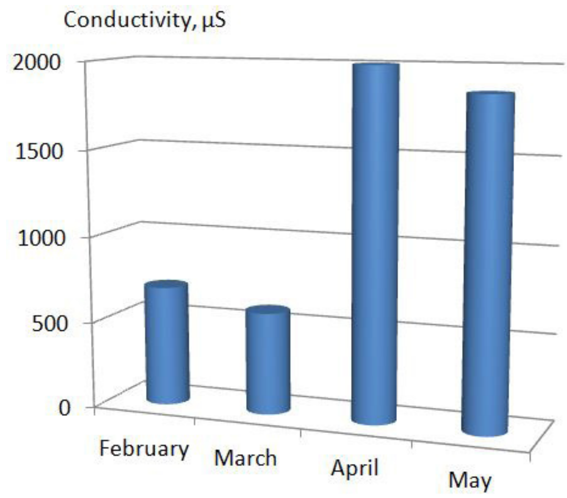


**Figure 7.** Dynamics of oscillations of the electrical conductivity values of the pond VI water, µS

differs most significantly only in February. This is probably due to the fact that there is no significant freezing water in pond VI. The increase in water conductivity in pond VII in May compared to April is probably due to the flow of the contaminated water from pond VI into the pond VII.

Some fluctuations in electrical conductivity in April and May in the studied ponds are probably due to the peculiarities of their location and surface runoff in the surrounding areas.

In addition to the surface waters, the electrical conductivity of reference samples in the spring I’, in the well II’ and the tap water was performed. The general dynamics of the values of electrical conductivity of the water in the studied ponds and reference samples is shown in Fig. 9.

As can be seen, as per the water in spring I’, well II’ (Fig. 9), there are slight fluctuations in electrical conductivity from February to May, probably due to the additional influence of the geological structure of the soil. The increase of conductivity of the water in spring I’ in April is probably due to the infiltration of contaminated surface water into its supply zone.

The similarity of the values of electrical conductivity of the water in spring I ’and well II’ indicates the proximity of the location of their power sources (possibly from the same aquifer).

As it can be seen (Fig. 9), the electrical conductivity of the tap water is approximately the same throughout the study, with a small increase in May, probably due to the additional addition of reagents in water purification.

In the studied ponds, the electrical conductivity ranges from 200 to almost 3000 µS from February to May 2021. In all studied ponds, there is

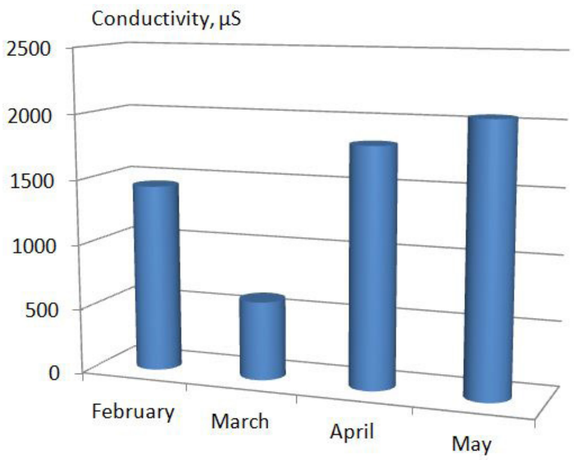


**Figure 8.** Dynamics of oscillations of the electrical conductivity values of the pond VII water, µS

a significant drop in water conductivity in March with further growth and stabilization in April and May. The greatest similarity of water quality in terms of electrical conductivity (in April and May) is observed in pond V, pond VI and pond VII with this parameter which confirms their combination. Significant fluctuations in the conductivity values of the water in pond I, pond II, pond III, pond IV and the systems of reservoirs (pond V - pond VII) indicate a significant impact of surface runoff and they are individual. The highest values of electrical conductivity, and, accordingly, pollution, are characteristic in pond II and pond III, whereas the lowest ones are in pond IV.

The obtained data indicate the need for a more detailed study of the impact of surface runoff on the water status of the studied ponds and further rational management of these water bodies.

## CONCLUSIONS

The study of the ecological status of separate water bodies located within the detached objects of the urbanized territory of Ukraine according to the parameter of electrical conductivity was performed. Temporary regularities of fluctuations of the electrical conductivity for a number of water bodies in Popasna town (Luhansk region) were obtained.

It was shown that the fluctuations in the electrical conductivity of the studied water bodies are associated mainly with surface runoff. It was found that in all studied ponds there was a significant drop in electrical conductivity in March with further growth and stabilization in April and May.

The water objects of Popasna town are characterized by electrical conductivity values in the range from 200 to 2900 µS.

The highest values of electrical conductivity, and, accordingly, pollution, are characteristic in pond II and pond III, whereas the lowest – for pond IV.

It was found that in the water samples from spring I' and well II' there were slight fluctuations in electrical conductivity from February to May, probably due to the additional influence of the geological structure of the soil in Popasna town. The similarity of the electrical conductivity values of spring I' and well II' (2100–2200 µS) indicates the proximity of the location of their power sources.

The necessity of further more detailed study of the peculiarities of the influence of surface

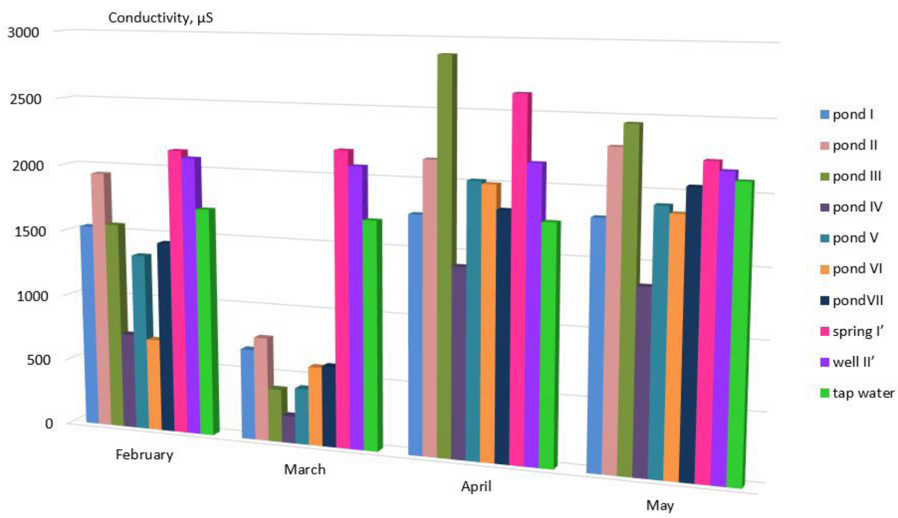


**Figure 9.** Dynamics of oscillations of the electrical conductivity values of water in the studied ponds (pond I – pond VII) and reference samples (spring I', well II', tap water), µS

runoff on the water condition in the studied ponds for the purpose of rational management of these water bodies was shown.

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