І. ТЕОРЕТИКО-МЕТОДОЛОГІЧНІ ДОСЛІДЖЕННЯ

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CITIZEN SCIENCE AND ENVIRONMENTAL MONITORING: WORLD TRENDS, SITUATION IN UKRAINE

The aim of the study was to characterize the main trends in the development of citizen science (CS), which has been attracting growing interest from society since the beginning of the 21st century, which is associated with the development of digital technologies, the ability to connect to the Internet. According to the Oxford Dictionary, "Citizenship Science is the collection and analysis of data related to the natural world by members of the general public, usually as part of a collaborative project with professional scientists". This movement has a significant activity in the countries of Western Europe, the USA, Australia, and in the last decade in China. An analysis of completed projects shows that citizen science has the greatest impact on research in the field of biology, ecology, and solutions to environmental problems and is mainly used for collecting and classifying data. The accuracy of the data obtained by CS representatives depends on the proper organization of research and requires constant monitoring and cooperation with professional scientists. Citizens' motivation to participate in research can also influence the results of CS projects. Three general aspects are highlighted as motivation for participation in CS: a) raising the individual scientific and educational level and the desire to increase public awareness; b) filling gaps in government monitoring and identifying local problems; c) harnessing scientific knowledge to inform policymakers and decision-makers and ensuring consistency of actions at different scales.

An important area of research in citizen science is monitoring the quality of water in water bodies, as evidenced by more than 800 works published during 2010–2020. In periodicals indexed by the Web of Science. It is relevant to involve representatives of citizen science in solving the tasks facing SDG 6 "Clean water and adequate sanitation", one of the 17 global goals that were adopted at the UN Summit on Sustainable Development (2015) for the period 2015–2030. The participation of citizen science can be significant in the context of SDG 6.3.2 "Identifying the proportion of water bodies with good water quality", as these studies relate to the monitoring of water bodies at the community level. The FreshWater Watch program, launched in 2012, is based on continuous monitoring of freshwater bodies. The program has both a global and a local level. Global level – citizen scientists in different countries participating in the program work according to the same methods and register a common set of parameters that are loaded into the same database. Local level – working with local groups and scientists who have scientific questions about their specific water bodies. Thus, using global approaches, it is possible to answer local questions about water quality and the state of ecosystems.

In Ukraine, the situation with citizen science is fundamentally different from that described above. There is no citizen science in the same form as in the countries of Western Europe, North America, Australia and East Asia in Ukraine. This is connected both with the general economic situation of the country and, accordingly, the constant reduction of scientific institutions, a decrease in the interest of citizens in science, and with moral and ethical aspects (from the skepticism of professional Ukrainian scientists regarding the activities of representatives of citizen science to the unwillingness of broad strata of citizens to spend their time on work in CS projects).But on Facebook (FB) there are groups of biological, hydrological and geological orientation in Ukraine, which have their own sites in FB and carry out certain work.Ukraine's integration into the structure of the European Union will contribute to the emergence of new opportunities for further development of citizen society, including participation in citizen science projects.

Keywords: citizen science, information accuracy, environment, environmental policy, sustainable development goals, water and sanitation,situation in Ukraine.

Introduction. In the 21st century, the world's trend of citizen participation in research projects has intensified, which became a means of encouraging their interest and a deeper understanding of science, while ensuring unprecedented interaction between professional scientists and the general public. Involving citizens often allows scientists to achieve goals more successfully than they would without their participation. In addition, such projects are aimed at encouraging public participation in research, as well as in science in general, which makes it possible to talk about such a phenomenon as *citizen science* (CS).

Citizen science is a concept of conducting scientific research with the involvement of a wide range of volunteers, many of whom can be amateurs, ie do not have previous scientific education and training in the speciality. As a rule, citizen science is associated with long-term programs, such as environmental monitoring, water management *(Firehock&West, 2001; Laird et al., 2012),* ornithology, and so on. Previous movements in citizen science have given impetus to industries such as amateur radio communication, amateur astronomy, and inventive activity. Today, citizen science can also be seen as one of the approaches to non-formal science education *(Bonney et al., 2009).*

To a large extent, the growing interest in citizen science projects today is associated with the development of digital technologies, the availability of low-cost sensors and the ability to collect data by citizens using smartphone applications and transmitting information on the Internet. However, there are some programs that have a long history. In particular, one of the longest-running projects in citizen science is the Christmas bird count, initiated in 1900 by the National Audubon Society (USA).

An example of a global CS project is the FreshWater Watch program, launched by the international environmental organisation Earthwatch in 2012 to study the quality of water in running water bodies *(Fresh Water Watch, 2022).* With a global methodological approach and integration of information into a single database, the state of water bodies at the local level is also addressed.

The relevance of research in the field of citizen science is evidenced by the fact that only on the topic of monitoring water quality in water bodies during 2010–2021,

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more than 850 works were published in periodicals indexed by the Web of Science.

Literature Review. Ideas that have become forerunners of recognition of citizen science in the world as a phenomenon was laid down in the works of P. Feyerabend *(Feyerabend, 1978)* and E. Chargaff *(Chargaff, 1978).* The conceptual provisions of citizen science are highlighted in the works of the British scientist A. Irwin *(Irwin, 1995)* and the American scientist R. Bonney *(Bonney, 1996).*

Various manifestations of citizen participation in research projects, which have become a means of encouraging interest and a deeper understanding of science while ensuring unprecedented interaction between professional scientists and the general public, are covered in various publications, such as C. Doyle *(Doyle et al., 2009)* et al. In 2010, the journal "Nature" published an article with the eloquent title "Citizen science: People power" *(Hand, 2010).*

The issue of reliability of the received information, one of the most sensitive issues of citizen science, is addressed in the works *(Thelen et al., 2008; Gardiner, 2012),* and economic aspects are covered in the publication *(Theobald et al., 2015).*

Citizen science's role in forming environmental policy is emphasised in the works *(Turbe et. Al., 2019).* Involvement of representatives of citizen science in implementing the provisions of the Sustainable Development Goals (SDGs), in particular. SDG 6 "Clean Water and Sanitation" is devoted to the work *(Hegarty et al., 2020).*

In Ukrainian scientific periodicals issues of citizen science are not considered.

The purpose of this study was: a) to identify the main trends in citizen science, which received a significant impetus to development in the world in the 21st century, and the areas of involvement of its representatives in the study of environmental issues, including water resources; b) make a cursory assessment of the situation regarding citizen science in Ukraine.

Used materials. The study used publications in international scientific journals and materials from the international environmental organization "Earthwatch", and the program "FreshWater Watch". Information from the Ukrainian information platforms Earth Day Ukraine, UkrBIN – National Biodiversity Information Network, and the world's largest social network Facebook was also used to study the existence of communities close to citizen science in Ukraine and the profile of their activities.

Results and Discussion.

History, theoretical background and terminology. "Citizen science" is a fairly new term, but it is followed by an old practice. Historically, this term refers to scientists who have not collaborated with research institutions or have not had a formal academic education. In the 17–19 centuries. science was often done by self-employed gentlemen, amateurs, or researchers such as Isaac Newton (1643–1727), Charles Darwin (1809–1890), and others *(Silvertown, 2009)*.

During the British colonization of North America, the first citizen scientists were American colonists who recorded weather data that remained in the archives and are now used to assess the climatic conditions of that time, or climate change today *(Fecko, 2014).*

In the 20th century, science became fully institutionalized. Researchers hired by universities and state research laboratories began to work in science. But in the 1970s, this situation was called into question. The philosopher P. Feyerabend called for the "democratization of science" *(Feyerabend, 1978)*. Biochemist E. Chargaff advocated the return to the science of nature lovers, because, in the traditions of Descartes, Newton, Leibniz, Buffon and Darwin, science was dominated by "amateurs, not money-oriented technical bureaucrats" *(Chargaff, 1978).*

The term "citizen science" has several sources, as well as different concepts. The first recorded use of the term dates back to 1989, in a political report by the Wilson Center (USA) entitled Citizen Science and Politics: A European Perspective, mentioned in a publication *(Haklay, 2015)*, and in an article by R. Kerson in "MIT Technology Review" *(Kerson, R., 1989).* The last one describes how 225 volunteers in the United States collected rain samples to help the Audubon Society implement an acid rain awareness project.

Conceptual definitions of the term appeared in the mid-1990s. The British sociologist A. Irwin defined "citizen science" as "a dynamic concept of scientific citizenship that highlights the need to open science and the processes of scientific policy to the public" *(Irwin, 1995).* He sought to restore two aspects of the relationship between citizens and science: 1) science must respond to the interests and needs of citizens; 2) citizens themselves can produce reliable scientific knowledge.

The American ornithologist R. Bonnie in the same period defined "citizen science" as projects in which non-scientists, such as lovers of ornithology, voluntarily receive scientific data, which is a contribution to ornithology *(Bonney, 1996)*. This approach narrows the role of citizens in research compared to Irwin's concept.

The terms "citizen science" and "citizen scientists" were included in the Oxford Dictionary of English in June 2014. "Citizen science – the collection and analysis of data relating to the natural world, by the general public, usually in a joint project with professional scientists" *(Citizen science, 2014).* "A citizen-scientist is a representative of the public who is engaged in scientific work, often in cooperation with professional scientists and scientific institutions or under their guidance; amateur scientist" *(Citizen science, 2014).*

Analysis of completed projects shows that citizen science has the greatest impact on research in biology, ecology and environmental issues and is used mainly for data collection and classification *(Kullenberg, Kasperowski, 2016).* Nowadays, scientists can participate in a variety of activities, such as crowdsourcing or analysis of historical scientific data (for example, the National Center for Rain Rescue Program, which aims to digitize precipitation by 1961 by crowdsourcing precipitation data). Great Britain), to perform voluntary photo-registration of meetings of species of birds, wild animals, butterflies, etc. *(Van Strien et al., 2013).*

There are three general aspects *(Carlson, Cohen, 2018)* as a motivation to participate in "citizen science": a) raising the individual educational level and the desire to expand public awareness; b) filling gaps in state monitoring and identifying local problems; c) the use of scientific knowledge to inform politicians and decision-makers and to ensure that actions are appropriate at different scales.

Reliability of the received information. Initially, academics were sceptical of citizen science about data quality. Thus, the paper (*Foster-Smith et al., 2003*) questioned the value of marine environmental data collected by volunteers. The work of a group of 13 volunteers recruited by the Earthwatch Institute to study the distribution of living organisms off the coast of Cumbre in Scotland was evaluated. Errors related to the estimation of the number of some species. It is likely that these problems arose due to: 1) lack

of experience in the field of volunteers; 2) inadequacy of instructions on the use of some scales; 3) insufficient preparation for the beginning of field surveys.

A study published by the US National Park Service mentions possible problems with the reliability of data obtained by volunteers (*Thelen et al.,2008*): 1) some projects may not be suitable for volunteers, for example, when complex research methods are used or a significant amount of repetitive work; 2) there is a risk of entering biased data if volunteers do not have proper training in research and monitoring protocols. According to the authors of one of the environmental projects of citizen science "Lost Sun" (about beetles), the economic efficiency of citizen science data can outweigh the problems of data quality with proper management *(Gardiner, 2012).*

M. Kosmala and others in research on data quality assessment in citizen science note that citizen science projects in the field of ecology and environmental issues have great potential for the development of science. In addition, these projects can influence policy and guide resource management by creating datasets that cannot otherwise be created (*Kosmala, 2016).* They draw the following conclusions: 1) data sets created by voluntary certification centres can be reliably high quality without compromising on quality created by professionals; 2) the accuracy of the data obtained by each volunteer varies depending on the complexity of the task and the experience of the volunteer; there are several methods to increase the accuracy to the required levels for this project; 3) most types of deviations detected in citizen science data sets are also found in professional data sets and can be eliminated with the help of existing statistical tools; 4) reviewers of citizen science projects should pay attention to standardization and compliance of protocols with data of volunteers, methods of data collection and accuracy assessment.

The reliability of CS data for water quality monitoring is discussed in *(Quinlivan et al. 2020).* This study included checking data on plant nutrients in freshwater bodies collected by citizen scientists by comparing the CS results with laboratory results obtained on the same samples. It was found that with proper preparation and appropriate organization of the study, the data collected by citizen scientists can be used to measure and monitor phosphates, nitrates, and conductivity.

In June 2019, a partnership between the Earthwatch Foundation and the Institute of Water Resources of the University of Dublin (Ireland) launched a program to monitor the water quality of the River Liffey (length 132 km, catchment area 1256 km^2, Irish Sea basin) flowing through Dublin and the suburbs. In September 2019, a WaterBlitz (sampling and analysis of water samples over the weekend) was conducted, during which more than 350 samples were taken at locations selected by citizens in the River Liffey Basin *(Hegarty et al., 2019)*. Data analysis showed a correlation between elevated nitrate concentrations in river water and the presence of agricultural land, as well as an increase in phosphate values in river water in urban areas after heavy rains. Due to the constant monitoring of phosphates, nitrates and turbidity of the River Liffey water, the CS representatives supplement the data collected by local authorities and the Environmental Protection Agency.

As citizen science continues to evolve, a key indicator of project success that is expected to be seen will be a growing awareness of data quality. Citizen science can become a common tool to help collect inaccessible high-quality data to support policy and resource management, environmental monitoring, and basic science *(Kosmala, 2016).*

Ethical aspects include, first and foremost, issues such as intellectual property. The Citizen Science Association (CSA), headquartered at the Cornell Ornithological Laboratory (Ithaca, USA), and the European Citizen Science Association (ECSA), headquartered at the Museum of Natural History (Berlin, Germany), have working groups on ethics and principles. In 2015, ECSA published the "Ten Principles of Citizen Science" (*European CSA, 2015*). Paragraph 10 of this document states that citizen science project managers take into account legal and ethical issues related to copyright, intellectual property, data sharing agreements, confidentiality, attribution and the impact of any activity on the environment.

At the same time, there are critical views on the use of citizen science volunteers as actual unpaid workers by some commercial organizations. In particular, D. Jemielniak and A. Przegalinska in the work devoted to the study of the impact of network technologies on the emergence of a new cooperation society, emphasize that the use of citizen science volunteers can be exploitative *(Jemielniak, Przegalinska, 2020).*

The group of authors, which in 2015 studied the work of about 390 unique projects related to biodiversity, concluded that they voluntarily participate annually from 1.36 million to 2.28 million people, and the range of in-kind contributions of volunteering in monetary terms range from $ 667 million to $ 2.5 billion per year *(Theobald et al., 2015).*

Citizen science and environmental policy. As noted by A. Turbe and others. *(Turbe et. Al., 2019),* the importance of the impact of citizen science projects on environmental policy can be understood by analyzing case studies of citizen science in three main aspects: the role of the citizen-scientist; the scientific dimension; socio-economic dimension (Fig. 1). This analysis shows that citizen science can contribute to each stage of the environmental policy process: *problem definition* (definition of a new environmental problem or formulation of a new hypothesis about known problems); *policy formation* (definition of structural elements of policy); *policy implementation* (policy implementation or description of their implementation); *compliance assurance* (measures to promote, monitor and ensure compliance with existing environmental standards, for example, through awareness-raising, inspections, warnings and fines); *policy evaluation* (evaluation of the results of citizen science intervention in environmental policy).

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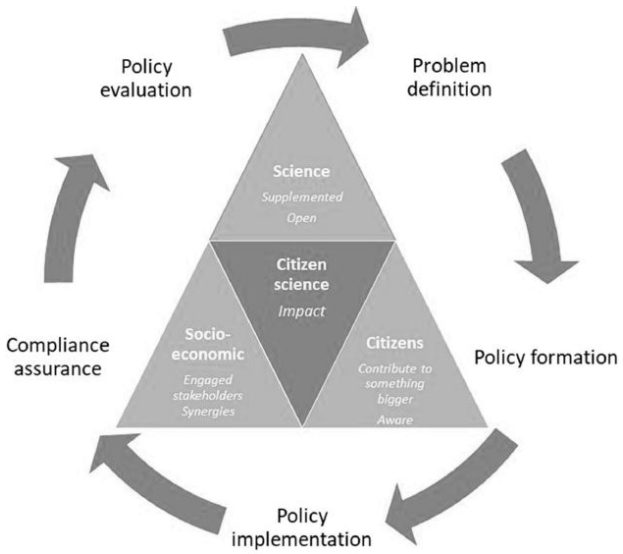

Fig. 1. Three key aspects of citizen science (citizen, scientific, socio-economic) that can affect the effectiveness of environmental policy *(Source:Turbe et al., 2019*)

Citizen Science and Sustainable Development Goals – ***SDG 6.*** Sustainable Development Goals (SDGs), or global goals – key areas of development of the world, which were adopted at the UN Summit on Sustainable Development in 2015 for the period 2015–2030 and number 17 global goals, which meet 169 tasks. SDG 6 "Clean Water and Sanitation" is about ensuring the availability and sustainable management of water resources and sanitation for all (*United Nations, 2018; Khilchevskyi, Karamushka, 2021*).

SDG 6 has eight tasks (Table 1). Six of them should be completed by 2030, task SDG 6.6 – by 2020, and for task SDG 6.6b – the year has not been determined. Each task also has one or two indicators to be used to measure progress.

Table **1. Structure of tasks and indicators of their implementation for SDG 6 "Clean Water and Sanitation" in accordance with the resolution of the UN General Assembly resolution on sustainable development in 2015**
(Source: United Nations. Goal 6)

TasksSDG 6			**Implementation indicators**	
№	**Task title**	**Year of implementation**	**№**	**Indicator title**
6.1	Safe and affordable drinking water	2030	6.1.1	The share of the population that uses safe drinking water
6.2	Termination of open defecation and provision of access to sanitation and hygiene	2030	6.2.1	The share of the population that uses: a) safe sanitation services; b) hand washes with soap and water
6.3	Improving water quality, wastewater treatment and safe reuse Improving water efficiency, providing fresh water supplies, and significantly reducing the number of people suffering from water shortages	2030	6.3.1	The share of domestic and industrial wastewater that is safely treated
			6.3.2	The proportion of water bodies with good water quality
6.4	Introduce integrated water resources management at all levels, including through cross-border cooperation Protection and restoration of water-related ecosystems	2030	6.4.1	Changes in water efficiency over time
			6.4.2	Water stress level: freshwater intake as a share of available freshwater resources
6.5	Expanding support to developing countries in the field of water supply and sanitation (desalination, recycling and reuse technologies)	2030	6.5.1	Degree in integrated water resources management
			6.5.2	Part of the territory of the transboundary basin with the current mechanism of water cooperation
6.6	Safe and affordable drinking water	2020	6.6.1	The length of water-related ecosystems changes over time
6.6a	Termination of open defecation and provision of access to sanitation and hygiene	2030	6.6a.1	The amount of official development assistance related to water supply and sanitation, which is part of the cost plan, is coordinated by the government
6.6b	Improving water quality, wastewater treatment and safe reuse	-	6.6b.1	Support and strengthen the participation of local communities in improving water and sanitation management

There are a total of 11 indicators *(United Nations. Goal 6)*. The main sources of data on SDG 6 targets and indicators come from a body called the Integrated Monitoring Initiative for SDG 6, coordinated by UN-Water. Each government must decide how to include them in national planning processes, policies and strategies based on national realities, opportunities, levels of development and priorities *(United Nations, 2018)*.

The paper *(Fritz et al., 2019)* considers a plan for the inclusion of citizen science data for sustainable development. The paper was prepared by citizen science representatives, academic scientists working in the field of citizen science, and the United Nations Environment Program (UNEP) to evaluate a practical approach to using citizen science's capacity to assess the implementation of the SDG's objectives. Involving citizens can have important benefits, especially when collecting data.

Thus, the participation of citizen science can be significant in the context of SDG 6.3.2 "Identification of the share of water bodies with good water quality" (Table 1), as these studies are related to the monitoring of water bodies at the community level.

FreshWater Watch program. FreshWater Watch is a global CS project launched by the international environmental non-profit organization Earthwatch *(Earthwatch, 2021)* to study water quality and ecosystem degradation in freshwater bodies. Earthwatch is developing a citizen science model to raise funds and recruit individuals, students, faculty and corporate fellows to participate in critical field research to understand nature's response to accelerating global change. Earthwatch is headquartered in Boston, USA, with regional offices in Oxford, England, Melbourne, Australia, Tokyo, Japan and Hong Kong, China.

The FreshWater Watch program is based on the continuous monitoring of freshwater bodies, which began in 2012 *(FreshWater Watch, 2021)*. She works with local groups and scientists who have scientific questions about their specific surface water bodies. Thus, using global approaches, it is possible to answer local questions about water quality and the state of ecosystems *(Hadj-Hammou et al., 2017; Loiselle et al., 2017)*. The project works both globally and locally.

Global level – citizen scientists in different countries who participate in the program, work on common methods and register a common set of parameters that are loaded into the same database. Therefore, the results can be compared globally. Local-level – the ability to conduct small-scale research with high density. At the same time, local communities often use the results of CS research to address specific local hydroecological issues *(Hadj-Hammou et al., 2017)*.

As of 2020, more than 23000 field samples were registered under the program, and water quality was monitored in more than 2500 water bodies on five continents (Figure 2).

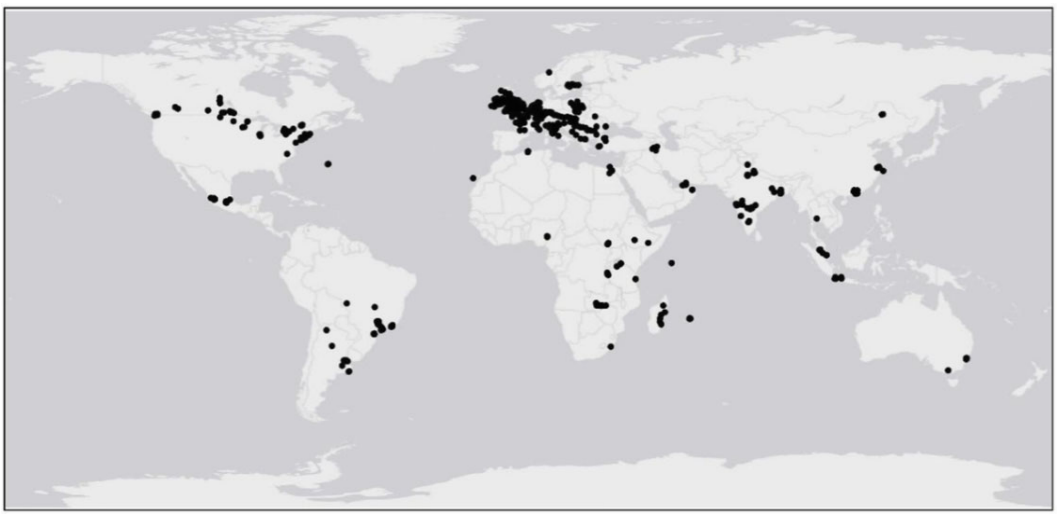

Fig. 2. Map of surface water sampling by representatives of citizen science under the program FWW "Earthwatch FreshWater Watch", which covers all continents – 2012–2019
(Source: Hegarty et. al., 2020)

Although the FreshWater Watch program does not measure all the parameters needed to achieve SDG 6.3.2, citizens do measure the phosphorus content of phosphates (PO_4^{3-}) and nitrogen in the form of nitrates (NO_3^-) at all points. And other parameters are measured within specific local projects. Many of them are concentrated in urban freshwater bodies, which are particularly vulnerable to anthropogenic impact.

The state of affairs with citizen science in Ukraine. As noted above, in the Ukrainian scientific periodicals issues of citizen science are not considered at all. There are no publications that would indicate the use of data obtained from participation in real citizen science projects.

But among the Ukrainian electronic resources, we managed to find information platforms that position their commitment to citizen science. In particular, "Earth Day Ukraine". As stated on the main page, this all-Ukrainian platform is "created to unite the media, business, NGOs, volunteers, activists and bring the eco-consciousness of Ukrainians into an active state" *(Earth Day Ukraine, 2021)*; UkrBIN – National Biodiversity Information Network is a public project for the identification and collection of observations of living organisms *(Ukrainian Biodiversity Information Network, 2021)*.

On Facebook (FB), there are groups of biological, hydrological and geological orientationin Ukraine, which have their sites on FB (Table 2).

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***Table* 2. Availability of separate information sites or groups on Facebook (FB) in the Ukrainian Internet space as of 2022, which position their commitment to citizen science**

(Source: Created by the authors)

Site, group – title in English (original title in Ukrainian)	Purpose of activity	Year of foundation	Number of participants, thousand
Information platforms			
Earth Day Ukraine	uniting the media, business, and public organizations and bringing the eco-consciousness into an active state	–	–
UkrBIN	identification and collection of observations of living organisms	–	–
Groups in FB biological orientation			
Mushrooms of Ukraine (Гриби України)	association of the mycological community	2016	98.0
Flora of Ukraine (Рослинний світ України)	exchange of information on wild flora and natural vegetation	2017	28.9
Birds of Ukraine (Птахи України)	exchange of ornithological information	2014	24.3
Insects of Ukraine (Комахи України)	exchange of information about insects	2017	15.3
Ukrainian Botanical Group	exchange of information about the flora of Ukraine and the world	2012	12.3
Birdwatching Ukraine	bird watching in the wild	2014	5.0
Groups in FB hydrological orientation			
Save the Dniester from hydroelectric power plants (Врятуй Дністер від ГЕС)	preservation of the Dniester ecosystem	2015	6.0
The Dnieper unites! (Дніпро єднає!)	exchange of information on water resources of the Dnieper	2018	0.68
SOS Rivers! (Річки SOS!)	preservation of Ukrainian river systems	2016	0.49
Water movement in the Kyiv region (Водний рух Київщини)	preservation of Lybedi and others. small rivers of Kiev	2015	0.31
Ukrainian river network (Українська річкова мережа)	improving the condition of rivers in Ukraine	2015	0.19
Group in FB geological orientation			
Minerals of Ukraine (Мінерали України)	exchange of information on minerals and deposits	2021	0.85

The most numerous are groups of biological orientation: "Mushrooms of Ukraine" – unites the mycological community of the country (about 98 thousand participants); "Flora of Ukraine" (about 28 thousand participants) – dedicated to wild flora and natural vegetation of Ukraine; "Birds of Ukraine" (about 24 thousand participants) – ornithological community for the exchange of information about birds; "Ukrainian Botanical Group" (about 12 thousand participants) – definition and discussion of the flora of Ukraine and the world; "Birdwatching Ukraine" (about 5 thousand participants) – discussion and observation of birds in the wild (amateur ornithology); "Flora of Ukraine" (about 4 thousand participants) – popularization of knowledge about the diversity of plants in the country.

In Ukraine, the issue of water resources and water conflicts is relevant (*Khilchevsky, 2021; Khilchevsky, Mezentsev, 2021*). But there are much fewer groups of hydrological orientation in FB than biological ones. Among them, the group " Save the Dniester from hydroelectric power plants" (6 thousand people) stands out for the number of participants. Among others – "The Dnieper unites!", "SOS Rivers!" and others.

The geological orientation is represented by the group "Minerals of Ukraine".

Conclusions:

1) Citizen science is of growing interest to society since the beginning of the 21st century, which is associated with the development of digital technologies, and the possibility of connecting to the Internet. This movement is most active in Western Europe, the United States, Canada, Australia, and in the last decade in China.

2) Analysis of completed projects shows that citizen science has the greatest impact on research in biology, ecology and environmental issues and is used mainly for data collection and classification.

3) The accuracy of the data obtained by citizen science representatives depends on the proper organization of research and requires constant monitoring and cooperation with professional scientists.

4) It is important to involve representatives of citizen science in solving the challenges facing SDG 6 "Clean Water and Sanitation", one of the 17 global goals adopted at the UN Summit on Sustainable Development for the period 2015–2030. Participation in citizen science can be significant in the context of SDG 6.3.2 "Identification of the proportion of water bodies with good water quality", as these studies are related to the monitoring of water bodies at the community level.

5) The Global FreshWater Watch program, launched in 2012, is based on continuous monitoring of freshwater bodies. The global level is provided by common methods and registration of a common set of parameters that are loaded into a single international database. Local-level – work with local groups and scientists who have scientific questions about specific surface water bodies.

6) In countries where citizen science is developing, there are three aspects as a motivation to participate in it: a) the desire to increase the individual scientific and educational level and awareness of society; b) filling gaps in state monitoring and identifying local problems; c) the use of scientific knowledge to inform politicians and decision-makers and to ensure that actions are appropriate at different scales.

7) In Ukraine, the situation with citizen science is radically different from that described above. Citizen science as it exists in the world is absent in Ukraine. This is due to the

general economic condition of the country, the constant reduction of scientific institutions, declining interest in science, and moral and ethical aspects (from the scepticism of professional Ukrainian scientists about the activities of citizen science to the unwillingness of the general public to spend time working in citizen science projects).

8) Ukraine's integration into the structure of the European Union will contribute to the emergence of new opportunities for further development of citizen society, including participation in citizen science projects.

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ГРОМАДЯНСЬКА НАУКА І МОНІТОРИНГ ДОВКІЛЛЯ: СВІТОВІ ТЕНДЕНЦІЇ, СИТУАЦІЯ В УКРАЇНІ

Метою дослідження є характеристика основних тенденцій у розвитку громадянської науки (ГН), яка викликає зростаючий інтерес з боку суспільства з початку XXI ст., що пов'язано з розвитком цифрових технологій, можливістю підключення до інтернету. Згідно з Оксфордським словником, "громадянська наука – це збір і аналіз даних, що належать до світу природи, представниками широкого кола громадськості, як правило, у рамках спільного проєкту із професійними вченими". Цей рух має значну активність у країнах Західної Європи, США, Австралії, останнє десятиліття – у Китаї. Аналіз виконаних проєктів показує, що найбільше громадянська наука впливає на дослідження в галузі біології, екології, вирішення проблем довкілля і застосовується в основному для збору та класифікації даних. Точність даних, отриманих представниками ГН, залежить від організації досліджень і вимагає постійного контролю та співпраці із професійними вченими. Мотивація, якою послуговуються громадяни, беручи участь у наукових дослідженнях, може також вплинути на результати проєктів ГН. Можна виділити три загальні аспекти як мотивацію до участі в ГН: а) підвищення індивідуального науково-освітнього рівня й бажання розширити обізнаність суспільства; б) заповнення прогалин у державному моніторингу та виявлення місцевих проблем; в) використання наукових знань для інформування політиків та осіб, що приймають рішення, а також забезпечення відповідності дій у різних масштабах.

Вагомим напрямом досліджень громадянської науки є моніторинг якості води у водних об'єктах, про що свідчить понад 800 праць, опублікованих протягом 2010–2020 рр. у періодичних виданнях, що індексуються Web of Science. Актуальним є залучення представників ГН до вирішення завдань, які стоять перед Ціллю сталого розвитку 6 (ЦСР 6) "Чиста вода та належна санітарія", однією із 17-ти глобальних цілей, які були прийняті на Саміті ООН зі сталого розвитку (2015) на період до 2030 р. Участь громадянської науки може бути значною у контексті ЦСР 6.3.2 "Виявлення частки водних об'єктів із хорошою якістю води", оскільки ці дослідження пов'язані з моніторингом водних об'єктів на рівні громад. Програма "Fresh Water Watch", розпочата 2012 р., базується на безперервному моніторингу прісноводних водних об'єктів. Програма має як глобальний, так і локальний рівень. Глобальний рівень – представники ГН у різних країнах, які беруть участь у програмі, працюють за уніфікованими методиками і реєструють загальний набір параметрів, що завантажується до єдиної бази даних. Локальний рівень – робота з місцевими групами та вченими, у яких є наукові питання щодо конкретних водних об'єктів. Отже, використовуючи глобальні підходи, можна відповісти на місцеві питання стосовно якості води та стану екосистем.

В Україні ситуація з ГН кардинально відрізняється від описаної вище. Громадянська наука в такому вигляді, як у країнах Західної Європи, Північної Америки, Австралії та Східної Азії, в Україні відсутня. Пов'язано це як із загальним економічним становищем країни, постійним скороченням наукових установ, зменшенням інтересу громадян до науки, так і з морально-етичними аспектами (від скепсису професійних українських учених щодо діяльності представників ГН до неготовності широких верств громадян витрачати свій час на роботу у проєктах ГН). Але на фейсбці (ФБ) усе ж є групи біологічної, гідрологічної та геологічної спрямованості в Україні, які мають свої сайти у ФБ і проводять певну роботу. Інтеграція України до структур Європейського Союзу сприятиме появі нових можливостей для подальшого розвитку громадянського суспільства, у тому числі участі у проєктах громадянської науки.

Ключові слова: громадянська наука, достовірність інформації, довкілля, екологічна політика, цілі сталого розвитку, вода і санітарія, ситуація в Україні.