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Ecology

Application of Up-to-Date Technologies for Monitoring the State of Surface Water in Populated Areas Affected by Hostilities

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(Presented by Academy Member Vladimer Tsitsishvili)

In the paper, an analysis of the influence various negative factors on the state of water bodies in places, where the population suffered as a result of hostilities has been carried out. Additionally, the consequences of ammunition explosions for the environment, given their massive nature have been noted. The aim of the paper is to develop modern organizational and technical methods for monitoring the state of water bodies in places of residence affected by hostilities. To achieve the aim in the paper, the possibility of using the previously developed author's approach has been investigated. This is based on a number of engineering techniques for the prevention of emergencies. These were associated with pollution of water bodies and soils. The approach was based on measuring the electrical conductivity and determining the identification coefficient of the studied water bodies. In the paper, the main stages of the methodology for monitoring the state of water bodies in places of residence at different times in the combat zone have been noted. It is proposed to use the parameters of undisturbed objects as basic characteristics. The presented approach is easy to use and expressively, and does not require expensive equipment. At the first stage, the application of this method for small settlements that do not have strong technical and economic capabilities was proposed. *© 2022 Bull. Georg. Natl. Acad. Sci.*

water body, settlement, monitoring, electrical conductivity, hostilities, pollution

The armed conflict with the Russian Federation and many days of hostilities in Ukraine have led to significant environmental degradation despite huge human losses and destruction of civilian infrastructure. This has an additional summing effect with previously recognized negative factors. Firstly, the existing “basic” conditions of the territory of Ukraine indicate the need for careful monitoring of the state of the environment. Significant anthropogenic impacts associated with the activities of industry, the agricultural and housing and communal sectors violate the environment in a significant way and cause concern for the entire world community.

For cities that are centers of anthropogenic activity, the situation can be complicated by the complex influence of the negative factors, such as transport, industry, surface runoff, household waste. These factors often have a cumulative effect on the elements of the environment and indicate the need for innovative approaches to the preservation of the natural component of cities.

Secondly, among other things, one can note the additional impact of medical waste generated during the COVID-19 pandemic, affecting the state of cluttered cities and the need for a logistical organization for handling this group of waste. There is significant plastic and microplastic pollution from personal protective equipment (masks, respirators, gloves, gowns, etc.) used during the COVID-19 pandemic. It should be noted that the chemical effects of these agents on living organisms, water bodies, and soils are poorly studied [1].

Under these conditions, the topical issue is the study of the state of water bodies in places of residence and the identification of its determining factors. In this case, different methods and approaches can be used. Thus, in [2], the authors propose a comprehensive multi-parameter assessment of the urban state rivers using online monitoring. For the study, 17 parameters were selected from 7 monitoring stations. At the same time, the water quality index was additionally calculated. In [3], the electrical conductivity parameter was used to determine the anthropogenic impacts of individual settlements in the Poltava region (Ukraine) on the state of the river flowing through them. The study of the composition and amount of phytoplankton was carried out in [4] using biomarkers and subsequent mathematical processing of the data obtained. The obtained correlation dependences indicate the influence of physicochemical parameters on the composition of phytoplankton in the Fenhe River (China).

The Water Quality Index is used to determine the water quality of Kashmir Valley springs due to its geographical location, regional hydrogeological conditions, anthropogenic activities and climate change [5]. The data indicate the potential use of sources to meet the demand of the population of the Kashmir Valley (India) in drinking water.

X-ray fluorescence method was used to study a number of drinking water sources in Kharkiv (Ukraine) [6]. The authors determine the content of heavy metals and draw attention to the need for more effective measures to ensure the quality of some sources. In [7], the authors use various mathematical methods of data processing and note that machine learning has obvious common advantages and is more suitable for predicting classified inversion of urban river water quality parameters.

Additional complicating factors in cities are emergencies, which can arise unsystematically and have additional negative consequences for the environment [8]. Moreover, both the elimination of these consequences [9] and the prediction of these occurrence and spread [10] is a separate difficult task.

Examples of emergencies related to changes in urban water quality include damage to reservoirs in 2019 at the Czajka treatment plant in Warsaw (Poland) and the subsequent leakage of pollutants into the Vistula River. Violations of the integrity of the septic tank in Baia Mare, Romania, in 2000 caused significant amounts of cyanides and heavy metals to enter the Sassar River and a number of other rivers, and industrial waste affected the plant's environmental performance.

The authors considered the impact of natural polutions and the risks involved in urban development [11]. The paper examines the relationship between floods, social factors and the growth of urban development in the Kathmandu Valley (Nepal). It points to the need for policy measures to reduce the risks of natural hazards. In turn, in [12] the authors note the use of Blue-Green

Infrastructure for Flood Management in the cities of Southeast Asia and the need for further research in this direction. In [13] notes that comprehensive technical and policy studies are needed that take into account the capacity of water systems and countries and the needs of the population in emergencies at different stages of development.

Different centralized response options are being developed for centralized urban water supply systems, based on monitoring the state of a number factors. Thus, the authors of [14] used a set of tools for modeling aqua transfer in a real-time system. In particular, the movement of water, its spatial distribution, changes in the concentration of toxic substances, etc. that can cause emergencies are monitored, and the risks of the latter are assessed.

At the same time, it is difficult to implement such tools for individual water bodies located within cities. Important for this are the economic feasibility and technical capabilities of monitoring systems.

In turn, the consequences of the impact of ammunition on the environment during hostilities should be attributed to the emergency situation, which causes additional significant negative impact on water bodies located in cities of permanent residence. At the same time, the organization of monitoring the condition of such water bodies and prevention of potential (pollution-related) emergencies is relevant. This is a separate difficult task.

Given the above, the aim of the paper is to develop organizational and technical methods for monitoring the state of water bodies within the territories with permanent residence of the population affected by hostilities.

As a basis in the paper it is proposed to use the method of prevention of emergencies related to pollution of water bodies.

Impact of Hostilities on the Environment

Many publications note that hostilities have a significant negative and prolonged impact on the environment and water bodies in particular.

The UNEP report notes that the fighting in Syria, Iraq and the Donbas (Ukraine) in significant human casualties and infrastructure damage, as well as the entry of pollutants into soil, air and water has been resulted.

As a result of damage to military equipment, explosions of shells and the presence of significant amounts of ammunition in fields and water for a long time, heavy metals, phosphorus and other dangerous compounds, including radioactive ones, are released into the environment .

It is noted that the fighting in Ukraine (2022), in particular, related to the shelling of cities led to the entry into the air of significant amounts of solid particles, flue gases from explosions of ammunition and fires. Sedimentation of these substances will lead to increased pollution of water bodies and soils in fairly large areas. At the same time, the selectivity of contaminants and their level of hazard above acceptable levels of risk remains a challenge.

In paper [15], the authors point to and suggest a significant deterioration in the quality of surface water in southern Iraq as a result of hostilities, a multiparameter study involving predictive models to determine their condition. The OSCE report on the environmental consequences of the fighting in Donbass (Ukraine) on significant environmental damage and the need for an urgent solution to the region's environmental problems indicates. The need for economic assessment of environmental damage due to hostilities in this area was also noted.

In general, there is currently a lack of scientific data on the impact of armed conflicts on and management of water resources and a lack of conceptual synergies in water management in hosilities conflicts noted by the authors [16].

Analysis of the Effects of Munitions Explosions on Environmental Pollution

The issue of assessing environmental pollution as a result of munitions explosions is complex. As noted above, in the context of hostilities in cities, quantifying the level of pollution or its individual components is a very difficult, almost impossible task, as well as ensuring environmental monitoring in general. Insufficient amount of factual material and the difficulty of obtaining scientifically sound data lead to certain assumptions.

For example, many researchers use data from previous explosions to assess environmental impacts. In particular, in [17] the authors analyze the factors influencing the frequency of emergencies in art warehouses and quantify the explosion of ammunition. The amount of mercury released into the environment during explosions of a certain type of ammunition was determined by calculation. At the same time, there are no further projected impacts on the population and its life activity as a result of such pollution.

air or water body. That requires additional research. The same authors note that as a result of an emergency situation at an ammunition depot in the village Novobohdanovka (Ukraine) released into the air: soot, dust, lead and their compounds, oxides of carbon, nitrogen and sulfur [18, 19]. The excess of these pollutants in the air was tens of thousands of times. The obtained values of risks indicate the danger of both long-term explosions for the population and the danger of being in a 5-kilometer zone from the source of explosions under initial conditions. Data on the content of heavy metals in Molochnaya River near the Novobogdanovka Village (Table) allowed the authors to calculate the risks of morbidity due to chemical contamination of drinking water [20]. The values of Mn, Cu, Zn, Cd, Pb, Cr, Ni, Fe measured in the river after ammunition explosions were used in the calculations. The obtained values of the risk and

Table. Data on the content of soluble forms of inorganic compounds in the surface waters of the Molochnaya River [18] due to an emergency situation at an ammunition dump in the Novobogdanovka Village

Parameter	Cu	Mn	Zn	Cd	Pb	Cr	Ni	Fe
Ion concentration in water, mg/l	95±0.9	0.414±0.004	0.97±0.1	0.021±0.001	0.62±0.4	0.239±0.002	1.06±0.06	11.6±0.3
Standart (MPC)	0.1	1.0	1.0	0.01	0.03	0.05	0.1	10.0

In [18-20], the authors a significant environmental impact of munitions explosions on the environment have been noted. At the same time, there is no united method of assessing the potential risk of life of the population living in the area adjacent to the emergency facility, as noted by the authors. As an important element in determining the environmental impact, authors propose an assessment of the risk of human morbidity due to chemical pollution of drinking water or air and an assessment of the potential risk to the population after an accident at an ammunition dump. The calculation of risks implies the availability of experimental data on the condition of atmospheric risk of carcinogenic effect for drinking water supply of the population indicated that the presence of compounds of copper, zinc, manganese and iron increases the total relative risk above the acceptable level of risk.

At the same time, it should be noted the targeting of studies, the high cost and duration of its determination.

Thus, existing approaches to assessing the impact of hostilities on environmental objects (water bodies within urban areas) require certain assumptions and long-term research. There is no united methodology today.

The Concept of Organizing Monitoring of the State of Waters in the Places of Residence of the Population Affected by the Hostilities

The author's approach proposed earlier in [21, 22] within the framework of methods for preventing emergencies associated with the ingress of pollutants into water and soil included:

- procedures for determining the electrical conductivity of the studied aqueous solutions (1):

$$æ = \frac{l}{SR}, \quad (1)$$

where æ is the electrical conductivity, [μS]; l is the distance between electrodes, [cm]; S is the area of electrodes, [cm^2]; R is the resistance of the solution, [Ohm] [23, 24];

- calculation of the identification coefficient (2):

$$K_{Id} = f_{Id}\, æ, \quad (2)$$

where K_{Id} is the identification coefficient [21, 23];

- comparison with the reference value and assessment hazards from individual production steps or hazards, followed by management decisions (Fig. 1).

The use of the electrical conductivity parameter made it possible to expressly estimate the total salt content [23] of an aqueous solution. The calculation of the identification coefficient determined the degree of hazardous. That approach is environmentally friendly and inexpensive to use.

According to the approach, it was proposed to use the prescribed values of the identification coefficient as the reference value of the identification coefficient. Displayed equations are centered and set on a separate line.

The movement in values for the studied environmental elements (water bodies) have been obtained for some time (for example, several seasons). Further determined values of these coefficients for the same objects were compared with them. The need to obtain several values of the identification coefficient during the year is a necessary component of the long-term process of timely identification of hazardous and prevention of an emergency. Because natural waters

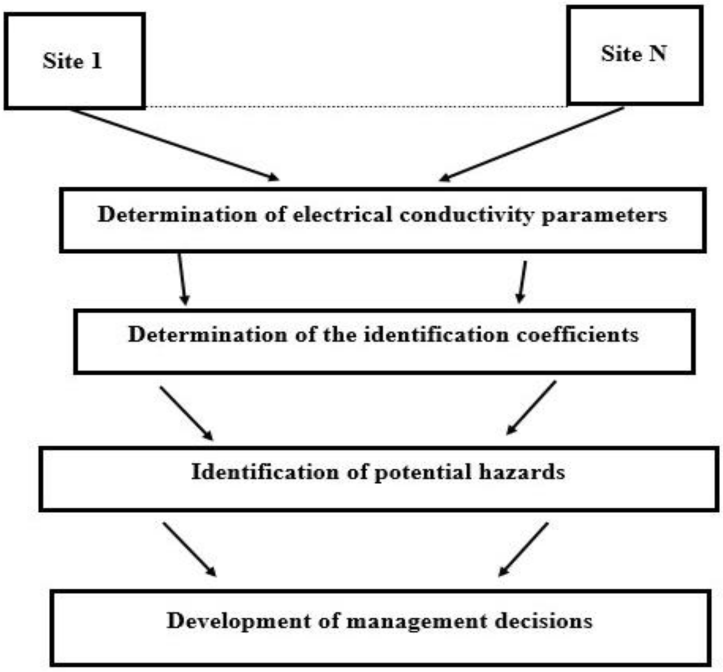

Fig. 1. Block diagram of the author's approach to the prevention of emergencies related to the ingress of pollutants into water or soil.

(especially surface waters) are vulnerable to environmental factors. By their nature, these have a long-term nature of manifestation and negative accumulation.

As noted above, explosions of ammunition entail significant pollution of the environment and water bodies. In this case, there is a multiple excess of pollutants over their maximum allowable concentration (MPC) in the environment (Table), which is identified by physical and physico-chemical methods of analysis. The analytical part in the conditions of monitoring the state of such objects should contribute a significant share to its economic and technical support.

In urban areas, as a result of hostilities, significant territories with infrastructure facilities are exposed to pollution. Ensuring monitoring of the state water bodies can act both as an independent element of the study of the state of the environment, and as an integral part of the prevention of emergency situations of a different nature.

Considering the foregoing, the following methodology for further research and monitoring of the state of water bodies in the places of residence of the population affected by the hostilities was proposed in the paper (Fig. 2).

The first stage should take into account the size of the water body, the depth of sampling, the impact of the territory, the degree of water pollution.

The second stage is a direct express study of the electrical conductivity of water samples. It can be carried out in the laboratory or on site.

At the third stage, the identification coefficient of the studied samples is calculated. This stage in the field conditions can be carried out too. It may include averaging the obtained values of the identification coefficient based on the statistical criteria of Grabs, Student, etc.

The fourth stage in terms of determining the state of water body or its individual components is decisive. It involves comparing the obtained coefficients for identifying water samples with data obtained before the begin of hostilities. In this case, possible seasonal fluctuations in the composition of water are no longer taken into account, since the influence of pollutants as a result of hostilities is predominant (Table). It is assumed that at this stage

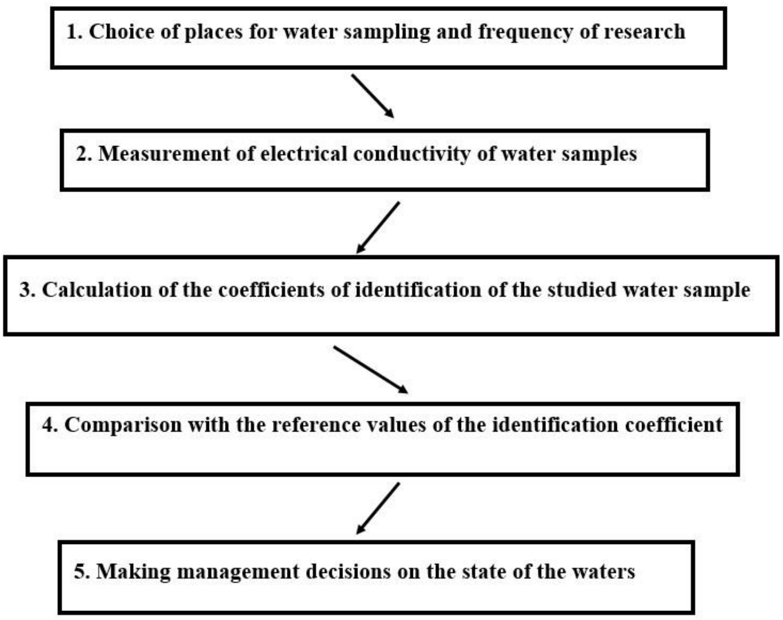

Fig. 2. Stages of monitoring of the state of water bodies in the places of residence of the population affected by hostilities.

the identification of the hazard (the pollutants themselves or their combination present in the water or what hazards change its state) is also carried out.

The last, fifth stage involves the adoption of the necessary management decisions both in terms of handling the water body and in terms of the primary reduction of the impact hazards on it. Its implementation allows targeted distribution of economic resources and the use of the necessary environmental technologies.

Obviously, each of these stages requires the solution of separate problems and the implementation of additional individual procedures for the studied water bodies.

The proposed methodology for monitoring the state of water bodies in places of residence population (affected as a result of hostilities) can be fully or partially automated, including using online technologies. That, according to the authors, is especially necessary for small settlements that do not have significant economic and technical capacities for instrumental long-term monitoring of the state of water bodies under these conditions. It is possible to integrate this algorithm for monitoring the state of water bodies into the civil protection system in terms of preventing emergency situations.

Conclusions

Thus, the state of the environment in cities today is a concern in many countries. Water bodies located in cities are the subject of extensive research, often using complex and costly approaches.

Additional negative impacts are experienced by water bodies in cities as a result of emergency situations. One of the types of these impacts is fighting, which has been established. An analysis of the impact of hostilities on the state of the environment showed significant negative direct and indirect consequences.

The lack of actual data on the study of ammunition explosions on the state of water bodies, as well as the complexity and high cost of known approaches for assessing their impact on the environment, was noted.

It was proposed to use approaches to prevent emergency situations in terms of monitoring the surface state of waters in places of residence of the population affected by hostilities. This made it possible to develop a methodology for monitoring the state of water bodies in places of residence of the population affected by hostilities. The methodology is based on obtaining electrical conductivity and identification coefficients of the studied water bodies, where the reference values are data before the begin hostilities, followed by the adoption of the necessary management decisions.

As advantages of this methodology, it should be noted that it is express, safe and informative, the possibility of independent and integrated application, including in an automated mode. Application in small settlements that do not have significant economic and technical capacities for long-term instrumental monitoring of the state of water bodies under these terms, it was proposed to use that methodology.

ეკოლოგია

უახლესი ტექნოლოგიების გამოყენება ზედაპირული წყლების მდგომარეობის მონიტორინგისთვის საომარი მოქმედებებით დაზარალებულ დასახლებულ ადგილებში

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(წარმოდგენილია აკადემიის წევრის ვ. ციციშვილის მიერ)

ნაშრომში წარმოდგენილია სხვადასხვა უარყოფითი ფაქტორების ზემოქმედების ანალიზი წყლის ობიექტების მდგომარეობაზე საბრძოლო მოქმედებების შედეგად დაზარალებულ მოსახლეობაში. გარდა ამისა, გამახვილებულია ყურადღება საბრძოლო მასალის აფეთქებების შედეგებზე გარემოსთან მიმართებაში. ნაშრომის მიზანია თანამედროვე ორგანიზაციული და ტექნიკური მეთოდების შემუშავება საომარი მოქმედებებით დაზარალებულ საცხოვრებელ ადგილებში წყლის ობიექტების მდგომარეობის კონტროლთან დაკავშირებით. აღნიშნული მიზნის მისაღწევად შესწავლილ იქნა ადრე შემუშავებული მეთოდის გამოყენების შესაძლებლობა, რაც ეფუძნება ზევრ საინჟინრო მეთოდს საგანგებო სიტუაციების პრევენციისთვის, წყლის ობიექტებისა და ნიადაგების დაბინძურებასთან დაკავშირებით. ეს მეთოდი ემყარებოდა ელექტრული გამტარობის გაზომვასა და შესწავლილი წყალსაცავების იდენტიფიკაციის კოეფიციენტის განსაზღვრას. ნაშრომში წარმოდგენილია საბრძოლო ზონაში, სხვადასხვა დროს, საცხოვრებელ ადგილებში წყალსაცავების მდგომარეობის მონიტორინგის მეთოდოლოგიის ძირითადი ეტაპები. ნავარაუდებია, ძირითადი მახასიათებლების სახით, გამოყენებულ იქნეს დაუზიანებელი ობიექტების პარამეტრები. წარმოდგენილი მეთოდი მარტივად გამოსაყენებელი და ექსპრესიულია და არ საჭიროებს ძვირადღირებულ აღჭურვილობას. პირველ ეტაპზე შემოთავაზებული იყო ამ მეთოდის გამოყენება მცირე დასახლებებისათვის, რომლებსაც არ გააჩნიათ ძლიერი ტექნიკური და ეკონომიკური შესაძლებლობები.

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