2. *Mingchen Z*. Result of radiotherapy in nasopharyngeal cancer. A retrospective comparison of split-course and continuous-course treatment schedules // Acta oncol. – 1989. – Vol. 28, №1. – P. 77–80.

3. *Алиев Б. М., Чуприк-Малиновская Т. П., Кошалиев Э. Ш.* и др. Поздние повреждения нормальных тканей при различных вариантах консервативного лечения рака носоглотки и полости рта // Диагностика и лечение поздних местных лучевых повреждений. – Обнинск, 1988. – С. 16–17.

4. Алгоритмы диагностики и лечения злокачественных новообразований: клинический протокол / Министерство здравоохранения Республики Беларусь. – Минск: Профессиональные издания, 2019. – 616 с.

5. *Шарашова Е. Е., Холматова К. К., Горбатова М. А., Гржибовский А. М.* Применение регрессии Кокса в здравоохранении с использованием пакета статистических программ SPSS // Наука и Здравоохранение. 2017. № 6. С. 5–27.

МЕТОДЫ ОЦЕНКИ ЭКОЛОГИЧЕСКОЙ ЕМКОСТИ ПРИРОДНЫХ И УРБАНИЗИРОВАННЫХ ВОДНЫХ СИСТЕМ

METHODS FOR ASSESSING THE ECOLOGICAL CAPACITY OF NATURAL AND URBANIZED WATER SYSTEMS

Е. П. Живицкая[1], Е. К. Власенко[1,2], В. А. Стельмах[1], А. Г. Сыса[1]

E. P. Zhyvitskaya[1], E. K. Vlasenko[1,2], V. A. Stelmakh[1], A. G. Sysa[1]

[1]Белорусский государственный университет, МГЭИ им. А.Д. Сахарова БГУ
г. Минск, Республика Беларусь
[2]Государственное предприятие «Научно-практический центр ЛОТИОС»
г. Минск, Республика Беларусь
alena.zhyvitskaya@gmail.com

[1]Belarusian State University, ISEI BSU, Minsk, Republic of Belarus
[2]State enterprise «Scientific and practical center LOTIOS», Minsk, Republic of Belarus

Антропогенное загрязнение и эвтрофирование водных экосистем являются глобальными проблемами. Особенно остро стоит проблема снижения качества и без того ограниченного запаса пресных вод. Эти проблемы вызвали проведение широкого круга исследований в области мониторинга водных экосистем, который позволяет оценить экологическое состояние водоема. Функционирование водных экосистем в значительной мере определяется антропогенным и естественным поступлением биогенных элементов из окружающей среды, поэтому для определения экологически обоснованных норм антропогенного поступления биогенных элементов в экосистему водоема необходимо выявить особенности структуры фито- и зоопланктона, макрофитов, а также определить концентрацию химических элементов, содержащихся в воде.

Anthropogenic pollution and eutrophication of aquatic ecosystems are global problems. Especially important is the problem of reducing the quality of the already limited supply of fresh water. These problems have led to a wide range of studies in the field of monitoring of water ecosystems, which allows us to assess the ecological state of the reservoir. The functioning of aquatic ecosystems is largely determined by the anthropogenic and natural input of biogenic elements from the environment, so to determine the environmentally sound norms of anthropogenic input of biogenic elements into the ecosystem of the reservoir, it is necessary to identify the features of the structure of phyto- and zooplankton, macrophytes, as well as to determine the concentration of chemical elements contained in the water.

Ключевые слова: качество воды, загрязнение, организмы-индикаторы, фитопланктон, зоопланктон, эвтрофирование, биоиндикация.

Key words: water quality, pollution, indicator organisms, phytoplankton, zooplankton, eutrophication, bioindication.

https://doi.org/10.46646/SAKH-2021-1-252-255

In the context of the global anthropogenic impact on water sourses, there is a growing need to study natural and anthropogenic factors in the development of the ecosystems. In this case, the perspective of studying river ecosystems (as accumulating elements of the landscape) is determined by the fact that their change serves as an indicator of the anthropogenic impact on the territory.

The low predictability of the anthropogenic experience of observing the nonlinearity of system processes in determining the degree of violation of natural limnogenesis requires the study of various parts of the ecosystem. At the same time, it is important to take into account the ambiguity of the deviations of the latter, which is related to the variety of characteristics of reservoirs, their interaction with catchments, and the influence of the landscape and climate. Along with the description of changes in the structural and functional characteristics of the community, it is necessary to establish regulatory mechanisms to identify the stability of the ecosystem and forecast their development [1].

Without adequate knowledge of the functioning of hydrobionts, it is impossible to solve the main task of hydroecology, namely, to learn how to manage aquatic ecosystems. No wonder that bioindictional research within the framework of hydroecological monitoring should be systematic and one of the priority areas of water ecology.

The observed rise in the field of studying the ecological state of reservoirs and water bioindication methods using bottom communities is largely due to the need to solve practical problems related to the protection and conservation of ecological systems of continental reservoirs and is significantly suspended by the success of the development of an effective theory of the functioning of ecological systems [2]. Hence, the implementation of the theoretical prerequisites for functioning in the study of flow hydroecosystems is interfered due to the lack of reliable witnesses on the ecology of individual species and groups of animals that can prove a significant influence on the functional characteristics of supra-organizational systems [3]. The necessary accumulation of information, its analysis and synthesis, in processes that bring the structural and functional features of biocenoses and their bioindication qualities into line with each other. The search for and use of informative components in the assessment of the ecological state of watercourses is part of the actual task.

Environmental studies of surface platoons in recent decades are experiencing a flourishing time: hydroecological knowledge is rapidly accumulating, new directions are being created. One of the important tasks in highly industrial areas is to determine the critical levels of anthropogenic pressure on watercourses. In the absence of constant monitoring of the hydroecological state of water and watercourses, women will become reliably pregnant due to the possibilities of environmental research in terms of assessing the interaction between the intensity of anthropogenic load and the response of the aquatic ecosystem.

Ecological studies of freshwater communities are often more descriptive than descriptive in the studies related to the problems of polluting rivers, which is caused by their diversity and dynamic system. In order to obtain adequate data when studying watercourses, it is necessary to obtain the available drivers and violations in a predictable manner. Such a forecast should be based on a deep understanding of the natural environment, the dynamics of the biota, and the response of organisms to external travel.

The need for rapid forecasting of ecocrisis situations and previous information about environmental hazards requires the improvement of monitoring studies involving methods of complex mathematical processing of the results of many observations. In this regard, the autocology of hydrobionts should be considered as a common area of interest of zoology and hydrobiology, and autocological research should be aimed at obtaining data that can understand the places and roles of individual species and groups of animals in aquatic ecological systems [4].

Bioindication is an actively developing field of scientific research in modern ecology. In a large case, the purpose of using various indicators and indices is to assess the ecological state of water bodies; they are also used to obtain solutions for ensuring the development of territories, regions, and ecosystems of various scales. The study of the composition of living organisms of the reservoir allows you to quickly establish its sanitary condition, determine the degree and nature of the embrace and the ways of its spread in the water, as well as to give a quantitative characteristic of the past processes of natural self-purification.

Different kinds of living animals show by what the environment is polluted. The indicator can be phyto- and zooplankton, benthos, macrophytes, fish, etc. Scientific data obtained shows that the increased content of various toxicants in the water leads to massive violations of embryonic and larval development, the appearance of numerous deformities. In young fish, tumors and disorders of individual organs (liver, brain, gill apparatus, etc.) develop randomly. In addition, there may be water areas with unfavorable conditions for hydrobionts in the same reservoir.

As long-term practice shows, toxicological experiments on the test object Tetrahymena pyriformis are mandatory for the hygienic assessment of water systems. The primary toxicological assessment of aquatic systems occurs in a population of Tetrahymena pyriformis in the stationary growth phase. The effect of toxic action is learned from the "life-death" reaction.

Tetrahymena is a unicellular, non-pathogenic, free-living, eukaryotic cell, ubiquitously present in all aquatic and moist terrestrial environments. In the natural environment, it feeds on bacteria. It links prokaryote to eukaryotes in the food chain and plays a major role in the aquatic environment by controlling the harmful bacterial population. It also affects the virus's population by grazing on free phage particles or phage infected host bacteria.Their abundance may represent a healthy aquatic environment.

Their behaviour in the natural environment can suggest us about the cumulative effect of different toxicants and also provide quantitative information on the quality of soil and water. This aspect has enabled toxicologists to utilize Tetrahymena as a test system for studies of contaminants and health risk assessment. Moreover, Tetrahymena is unicellular organism; it acts as a single eukaryotic cell and the whole organism at the same time. Various other reports previously stated the importance of Tetrahymena in ecological, biological, and toxicological studies.

Several studies have been available on the physiology and biochemistry of Tetrahymena [5]. They are comparable to the higher group of animals and show various similarities specially, with respect to receptors and secondary messenger receptors. In toxicity testing, the use of the number of animals could be replaced with the use of Tetrahymena. It can growin different media and is easily available for experimental manipulation.

While conducting acute (3-6 hours) and subacute (24 hours) experiments, the main parameters of toxicity are determined based on the calculation of % lethality:

LD_{16} - the dose that causes the death of 16% of individuals;

LD_{50} - the dose that causes the death of 50% of individuals;

LD_{84} - the dose that causes the death of 84% of individuals;

K_{kum} is the cumulative coefficient as a particular compound of the average lethal dose obtained in the subacute experiment and the average lethal dose obtained in the acute experiment.

The total duration of the experiment is 2 days.

In the chronic experiment, water systems that have passed a primary toxicological assessment are studied. The study of the toxicity of aquatic systems in a chronic experiment occurs throughout the life cycle of the population of Tetrahymena pyriformis.

Based on the results of the calculation of the population in the lag phase, logarithmic phase, the phase of expected growth and stationary standing, indicators are calculated that characterize the patterns of population growth:

- instantaneous growth rate,
- generation time,
- number of generations;
- calculate ED_{16}, ED_{50}, ED_{84}, K_{kum}.

Based on the obtained data, the No Observed Adverse Effect Level (NOAEL) is determined and the LD50/NOAEL indicator is calculated. The duration of the chronic experiment is 96 hours.

The study of the toxicity of aquatic systems in a prolonged experiment takes place in a sevenfold reseeding of the population of Tetrahymena pyriformis, cultivated in a medium containing the toxic compound, into the freshly prepared medium with the same toxicant at the same concentrations.

In the prolonged experiment the same indicators are studied as in the chronic one. Additionally, an indicator is calculated that characterizes the reserve of adaptive capabilities of the population-labor. The duration of the extended experiment is 384 hours.

The total duration of studies on toxicological and hygienic assessment of aquatic ecosystems in acute, subacute and chronic experiments on Tetrahymena pyriformis is 1 month. The total duration of studies on the current-sycological-hygienic assessment of industrial waste in acute, subacute, chronic and prolonged experiments on Tetrahymena pyriformis is 2-3 months.

The classification of aquatic ecotoxicants to the toxicity class for Tetrahymena pyriformis is carried out according to the indicator, the value of which corresponds to the highest class according to the "Classification of valuable items by the degree of toxicity and hazard based on the results of studying their toxic properties on Tetrahymena pyriformis (Table 1).

Table 1 – Classification of valuable assets according to the degree of toxicity and hazard based on the results of the study of their toxic properties on Tetrahymena pyriformis

Indicator	Classes by decreasing degree of toxicity and hazard			
	1	2	3	4
LD_{50}, mg/ml	lower 0,1	0,1 – 1,0	1,1 – 20	higher 20
$Kkum_{ac,}$ $Kkum_{chr.}$	lower 0,1	0,10 – 0,30	0,31 – 0,50	higher 0,50
LD_{50}/ NOAEL	lower 10^{6}	10^{-6} – 10^{5}	10^{5} – 10^{4}	higher 10^{4}
NOAEL, mg/ml	lower 10^{-6}	10^{-6} – 10^{-4}	10^{-4} – 10^{-1}	higher 10^{-1}

The high correlation of the toxicity indicators of valuables obtained in experiments on Tetrahymena pyriformis and white rats allows us to precipitate a toxicological classification of valuables according to the toxicity and danger indicators obtained in experiments on Tetrahymena pyriformis.

To rank the results obtained by toxicity classes GOST 12.1.007-76 «Hazard chemicals. Classification and general safety requirements» is used.

During the investigation, the average lethal doses in mg/kg of body weight of white rats with intraventricular administration for drugs of four hazard classes were compared with the average lethal doses for the same drugs obtained in experiments on Tetrahymena pyriformis (in mg/ml of culture). The results of the study of cumulative properties of chemical properties on white rats and Tetrahymena pyriformis are also presented (Table 2).

While comparing the obtained results of assigning the hazard class of aquatic ecotoxicants, carried out by different methods, differences in certain hazard classes for the studied subjects were established. It is shown that when using the experimental method, the studied water systems are referred to a higher hazard class.

This is due to the fact that the calculation method is individual, since the determination of the hazard class occurs on the individual components of its components, and the experimental method appears complex, loading the mutual embedding of components. The following, related way is confirmed by the hazard class obtained by calculation, using the method of bioassay.

Table 2 – Classification of toxic chemicals according to the degree of toxicity and hazard based on the results of the study of their toxic properties on Tetrahymena pyriformis

Waste	Calculation method	According to the results of the study of acute toxicity with a single intravenous administration to white rats	On the Tetrahymena pyriformis test object
Waste from washing machines containing oils	V class	IV class	III class
Bottom sediment waste	V class	IV class	III class
Extract of dry sediment (subjected to thermal or other drying)	V class	IV class	III class

Thus, it is confirmed that the degree of toxicity of water systems is influenced by factors that are not loaded when calculating the method for determining the hazard class, for example, the mutual embedding of components of water systems on top of each other. Therefore, the preference for establishing the hazard class remains for experimental methods, and for a more reliable establishment of the hazard class of polluting water systems, we cannot assess their ecotoxicity.

REFERENCES

1. *Tyurin VG, Dolgov VA, Lopata FF, Kochish OI*. Role of environmental factors in obtaining safe product of animal husbandry / Food safety and sustainable development of the agro-industrial complex materials of the International scientific-practical conference. 2015;534–537.

2. *Dolgov VA, Lavina SA, Kozak SS, Nikitchenko DV*. Biotesting food, feed and environmental objects / Bulletin of RUDN. Series Agronomy and Livestock. 2014;3:69–78.

3. Guidelines for the use of ciliates of Tetrahymena pyriformis as a test culture in the device "Biotester2". Moscow: Veterinary Department of the Ministry of Agriculture of the Russian Federation. 2000;13-7-2:2157.

4. Automated method for determining the toxicity of animal products, feed and environmental objects (guidelines). Moscow, RAAS, 2006.

5. *Maurya R*. Importance of protozoa Tetrahymena in toxicological studies: A review / Maurya R, Pandeya AK // Science of The Total Environment. 2020;741(1):140058

РЕГУЛЯТОРНЫЕ, АНТИОКСИДАНТНЫЕ И ГЕПАТОПРОТЕКТОРНЫЕ ЭФФЕКТЫ РАСТИТЕЛЬНЫХ ПОЛИФЕНОЛОВ И ИХ НАНОСТРУКТУРИРОВАННЫХ КОМПЛЕКСОВ

REGULATORY, ANTIOXIDATIVE AND HEPATOPROTECTIVE EFFECTS OF PLANT POLYPHENOLS AND THEIR NANOSTRUCTURED COMPLEXES

И. Б. Заводник, Е. А. Лапшина, Т. В. Ильич, А. Г. Вейко, Т. А. Коваленя, В. У. Буко

I. B. Zavodnik, E. A. Lapshina, T. V. Ilyich, A. G. Veiko, T. A. Kovalenia, V. U. Buko

Гродненский государственный университет имени Янки Купалы,
Гродно, Беларусь, zavodnik_il@mail.ru
Yanka Kupala State University of Grodno, Grodno, Republic of Belarus

Флавоноиды, вторичные метаболиты растений, обладают широким спектром биологической и фармакологической активности. В нашем эксперименте флавоноиды и их комплексы с циклодекстринами в концентрации 10-100 мкМ дозозависимо предотвращали перекисное окисление липидов мембран эритроцитов и митохондрий, ингибировали окисление восстановленного глутатиона, модулировали проапоптотический процесс формирования пор высокой проницаемости в митохондриях, что определяется липофильностью полифенола и его структурой. Генерирование карт распределения электронной плотности в молекуле кверцетина и семихинон-радикала кверцетина показывает, что активные электронные орбитали кверцетина и его семихинон-радикала делокализованы по фенольным кольцам, что в случае радикала, обеспечивает его стабилизацию. Комплекс кверцетин-гидроксипропил-β-циклодекстрин оказался более эффективным антиоксидантом.

Flavonoids, secondary plant metabolites, demonstrate a wide range of biological and pharmacological activities. In our experiment, flavonoids and their complexes with cyclodextrins (10-100 μM) dose-dependently prevented lipid peroxidation of erythrocyte and mitochondrial membranes, inhibited oxidation of reduced glutathione, and modulated the proapoptotic process of the mitochondrial permeability transition pores formation, that depends on flavonoid lipophilicity and structures. Generation of maps of the electron density distribution in the quercetin molecule and