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Ecological and hydrochemical analysis of the rivers Drevlianskyi nature reserve (Ukraine)

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ABSTRACT

Problem statement. The quality of the surface water and ecological condition plays a big role in ecosystems, especially in the hydrochemical regime. The chemical composition and mineralization of river water are in a dynamic link and are formed under the influence of many external factors. Therefore, under the influence of the latter, there was a need to study the hydrochemical composition of the water reserve, which was an urgent issue of the work.

The purpose of the research: comprehensive ecological, hydro-chemical analysis of the state of the rivers of the «Drevlyanskyi» nature reserve for the optimization of environmental protection measures, monitoring, eco-safety and preservation of the biodiversity of hydrobionts.

Research methodology. Conducting research on water quality was based on classical, generally accepted methods: field research, literature review, laboratory research, analysis of the obtained results.

Results. According to research, it was established that within the nature reserve in the summer-autumn period, the water of the main Uzh River and its tributary is moderately fresh in terms of mineralization (0.1–0.6 g/dm^3), neutral in pH, and has a hydrocarbon-calcium chemical composition. Insignificant waterlogging of landscapes determines the low content of ammonium nitrogen and dissolved iron in river water. The Zvizdal and Osliv rivers are exception where *eutrophication* is observed which cauces high runoff of organic substances. It was also investigated that During the summer-autumn period of low water the water contained small amounts of microelements and heavy metals (with the exception of Fe, Mn) which don't exceed the established sanitary-hygienic maximum allowable concentrations. According to the classification proposed by O.O. Alekin all-natural waters are divided into three classes. According to the content of the main ions and the mineralization of the water, it was analyzed that the water bodies of the nature reserve belong to the *calcium hydrogen-carbonate*, class of type III. In the water bodies of the nature reserve Drevlianskyi there are water subtypes IIIa-IIIb. The last differ from each other by the presence of magnesium hydrogen carbonate $Mg(HCO_3)_2$ in IIIa and calcium sulfate $CaSO_4$ in IIIb.

Scientific novelty. For the first time, a comprehensive analysis of surface waters in radiation-contaminated territories was carried out under the conditions of complete bequest.

Practical significance and research perspectives. The practical value of the research materials lies in the further monitoring of hydroecosystems, the substantiation of environmental protection measures, and the results will be used in the annual "Chronicle of the Nature" program of the reserve for the Ministry of Environmental Protection and Natural Resources of Ukraine.

Keywords*: ecology; water ecosystems; hydrochemical regime; quality of water; nature reserve.*

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Formulation of the problem. Ukraine has significant and various water resources which over a long period were subjected to large-scale intensive exploitation which led to their negative man-made changes at the regional level and a significant decrease in their assimilation potential. Hence, we have a deep ecological crisis on its territory, in particular in water ecosystems, which is associated with excessive anthropogenic load. So, in 2019 the last water bodies were characterized by a large amount of wastewater which reached 5374 million m^3 [1–3]. In addition, fragmentation of the natural framework occurs in most regions which sometimes leads to the loss of the quality of the biota. The main "barrier" to the loss of zonal biodiversity (from organisms to communities) is the network of protected areas. The

last are unique reserves of pristine nature which allow scientists of various fields to carry out research and study the objects of inanimate and living nature as a whole for its preservation. In general, natural links of nature reserve areas (NRA) are a kind of ecological niche where a complex of plants, animals and microorganisms adapted to the conditions of existence of this area has already formed. They affect each other and the environment, besides they depend on rocks as a foundation and individual minerals that are part of the soil on which these compounds are found [4].

Analysis of recent research and publication. A number of scientific studies have been devoted to the assessment of the quality of surface water from various points of view. A significant contribution to the methodology of complex integral assessment of the ecological state of river basins was made by Romanenko V.D., Zhukinsky V.M., Yatsyk A.V. [5].

And since the beginning of the 2000-s in Ukraine, the history of hydrochemical research has been reformatted taking into account the requirements of the Water Framework Directive of the European Union. Yes, V.K. Khilchevskyi, V.I. Osadchim and S.M. Kuryl [6] used the latest results of research on the chemical composition of water for various water bodies on the territory of Ukraine, applied the hydrochemical characteristics of river basin regions in accordance with the modern hydrographic zoning of Ukraine, which takes into account the requirements of the Water Framework Directive of the European Union.

Based on the results of long-term research by Linnyk P.M. [7], the formation of organic matter in reservoirs at different stages of their formation was determined by the arrival of organic matter with river runoff, removal from bottom sediments, plant and animal remains, as well as by its production during the period of mass development of algae.

In addition, pollution of water resources and water evaluation are of interest to many scientists from other countries. Indian scientists, in particular Vinod Kumar, Anket Sharma, Renu Bhardwai, Ashwani Kumar Thukral [8] analyzed the water quality in the cities of Harike and Beas, which is somewhat higher during the pre-monsoon season, which is explained by the rapid degradation of organic matter in the Beas River during the summer season.

In the publications of authors from Eastern and Central European countries, the results of research on the physical and chemical analysis of water from rivers and ponds are given. Thus, in the work of Musliu M. [9], the content of some chemical compounds was monitored throughout the year at different times of the year. Hubacikova V. conducted similar studies in her article [10], where water samples were taken monthly throughout the year.

Selection of previously unsolved parts of the general problem. Therefore, the need to study the state of river waters under the influence of external and internal factors has become an extremely urgent issue. At the same time, it should be emphasized that the specified unidirectional changes in the physical and chemical composition of river waters occur against the background of periodic fluctuations in the water flow characteristic of each river.

The purpose of the resear. The purpose of the research is to find out the current ecological, physical and chemical state of the waters of the hydroecosystems of the Nature Reserve "Drevlyanskyi" with recommended further monitoring assessments, methodical, practical instructions of the directorate, the scientific department regarding the optimal development of hydrobionts, sustainable development of rivers and reservoirs.

Material and methods. Quite important is the study of the regularities of the connection between the degree of change in the mineral composition of river waters and water phases (spring flood and low-water periods). The transformation of the chemical composition should be evaluated in the following direction:

1) change in general quantitative characteristics (mineralization of water);

2) change at the qualitative level (contribution of each ion).

To assess changes in the ionic composition of V.K. Khilchevsky and S.M. Kurylo proposed a modernized classification of natural waters according to the chemical composition of O.O. Alekin where the transformation indicator is a change in classification features. Besides improvement doesn't affect the highest characteristic namely the class but concerns groups and types [11, 12].

The principles used to improve the classification of hydroecosystems of the reserve are as follows (Fig. 1).

First, for detail reflection changes chemical composition of water in group level by the predominant cation should add second cation when its content in recalculation for the amount of substance equivalent of more than 25% if the sums of equivalent anions and cations are taken as 100% (e.g., C^{CaMg}).

Second, for reflection quantitative changes class-forming anions in chemical composition of the natural water in all four types subtypes are distinguished according to the relative contribution of the class-forming anion.

This is illustrated by adding an alphanumeric subscript to the type symbol (Roman numeral). According to the contribution of the class-forming anion the first (I), the second (II) and the third (III) type of natural water are divided into three subtypes (a, b, c):

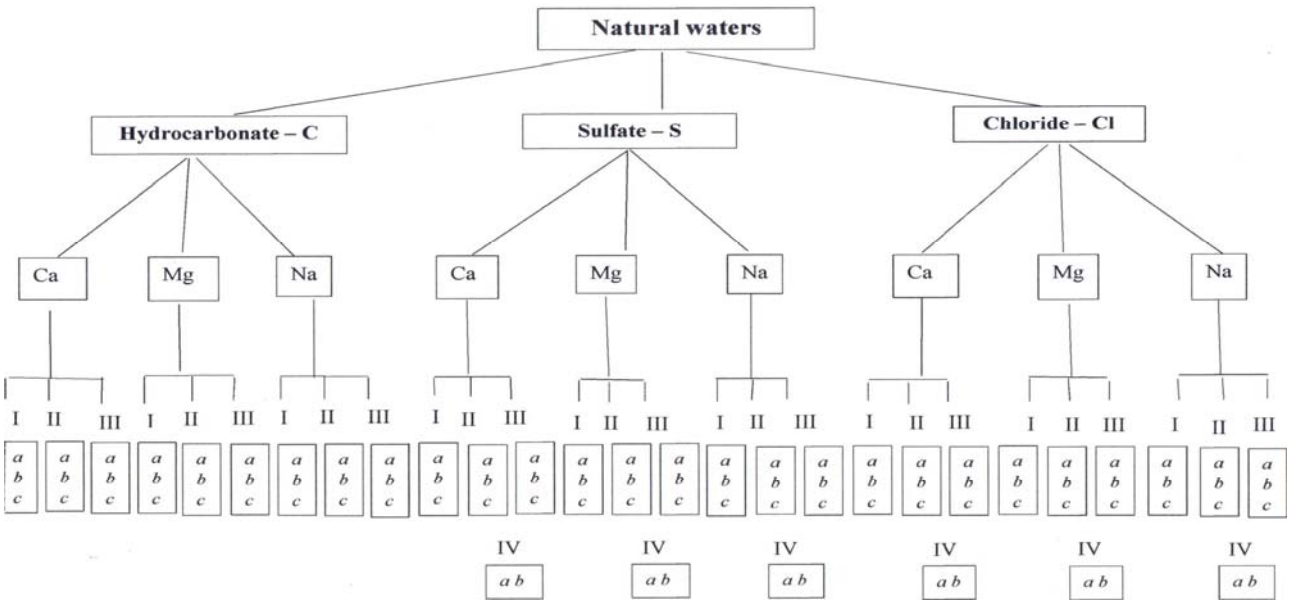

Fig. 1. Schematic representation of the modernized classification of natural waters by chemical composition by O.O. Alekin

I*a*, II*a*, III*a* is if the contents of the class-forming anion is more than 75% in terms of the amount of substance equivalent;

I*b*, II*b*, III*b* is if the contents of the class-forming anion is 50–75% in terms of the amount of substance equivalent;

I*c*, II*c*, III*c* is if the content of the class-forming anion is less than 50% in terms of the amount of substance equivalent. The fours type of natural waters is divided into two subtypes (a, b):

IV*a* if the contents of the class-forming anion are more than 75% in terms of the amount of substance equivalent;

IV*b* if the contents of the class-forming anion are less than 75% in terms of the amount of substance equivalent.

Such additions to the basic classification of O.O. Alekin allow to display chemical composition of natural waters at qualitatively new level.

The chemical composition of the surface waters of the "Drevlyanskyi" NR was analyzed in view of the peculiarities of the natural complex, which was formed under the influence of the landscape-forming factors of the physical and geographical region within the southern outskirts of the Polish lowland, which covers large areas of forests heavily contaminated with radionuclides.

In general terms, the territory of the reserve is characterized by a slightly undulating type of relief with insignificant amplitudes of fluctuations in relative heights, where extensive low-turf (often swampy) depressions alternate with small elevations with flat tops and gentle slopes, the steepness of which does not exceed 1–2°. That is, among other ecosystems on the territory of the NR, swamps are also protected.

The soils of the type of terrain prevailing in terms of area – sloping and undulating plains – are sod-medium podzolic sandy loams. The humus-eluvial horizon has a thickness of 12–15 cm and is characterized by the presence of 1.7–2.0% humus, the composition of which is dominated by fulvic acids.

The river network of the reserve is well developed. The largest river is the Uzh River (256 km long), and the Zherev River flows into it in the vicinity of Narodychi. The Zvizdal, Osliv, Loznytsia, Kamianka rivers should be singled out among the right tributaries of the Uzh River, and the Struchok River among the left tributaries. All watercourses are fed by rainwater, meltwater and underground water. In the spring-summer and summer-autumn periods, floods are observed on all the rivers of the reserve. A stable ice cover forms at the end of December – beginning of January and, depending on the weather conditions, lasts for 1.5–2 months [13, 14].

To assess the water quality of the Dreviyanskyi nature reserve 7 sources were selected, including the Uzh, Kamianka, Zherev, Osliv, Loznytsia, Zvizdal, and Bucha rivers (Fig. 2–3, Tab. 1).

To conduct a hydro-chemical analysis of surface water and obtain representative results of the analysis, water samples were taken in accordance with the requirements of the methodology. Sampling was carried out by the authors in seven streams with simultaneous measurement of water temperature, pH and electrical conductivity. The analysis of the selected water samples for the content of the main components of the chemical composition of water according to generally accepted methods was carried out at the laboratory on the Institute of Agroecology and Environmental Management of the National Academy of Agrarian Sciences Ukraine [15, 16].

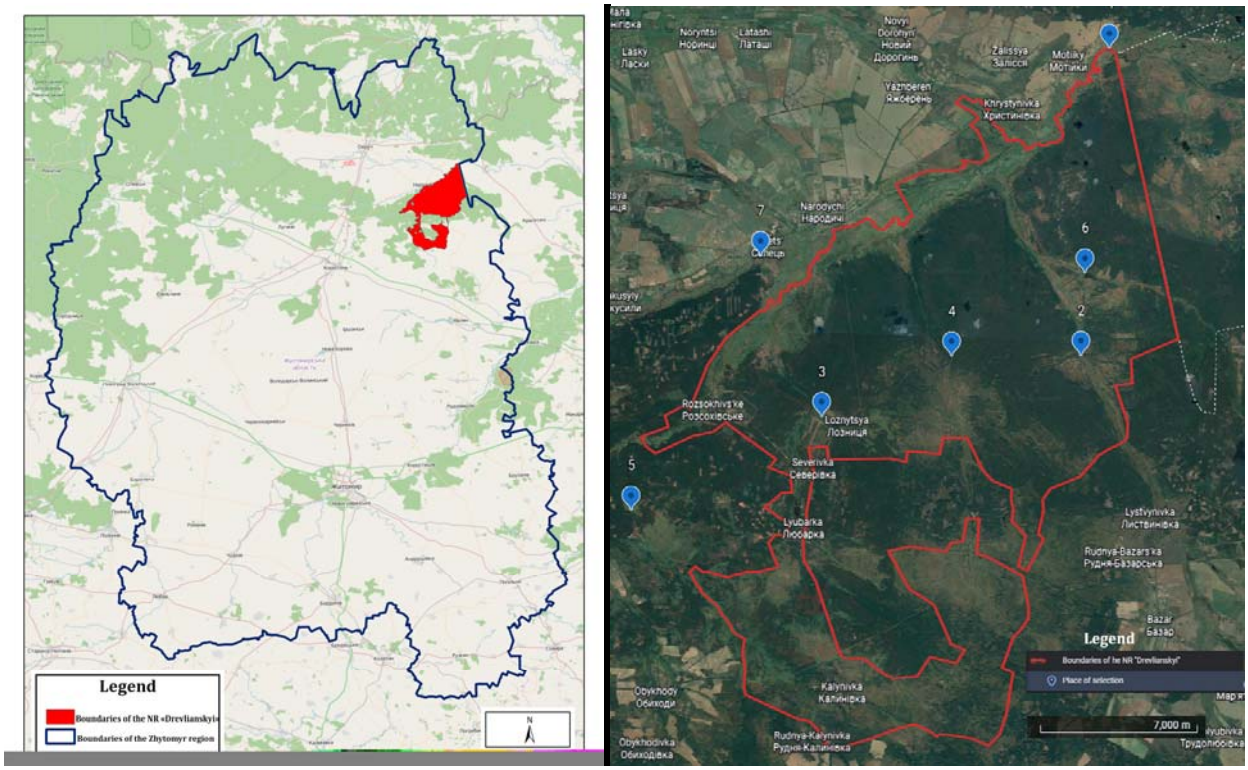

Fig. 2. Location Dreviyanskyi nature reserve

Water quality was assessed by the method of comparing the available indicators of water composition and properties with normative values.

The process of carrying out research on the state of water quality was based on the following methods: field research (sampling of water in vials, dishes; geobotanical descriptions; reconnaissance; general ecological assessment), collection and analysis of information, processing of literary sources (cameral), laboratory (physico-chemical analysis, redox potential, electrical conductivity, mineralization, acidity of water); generalization of the obtained results (determining cause-and-effect relationships, writing conclusions).

Presentation of the main research in material. The territory of the Drevlianskyi nature reserve (area is 30,872.84 hectares) is a natural laboratory with unique its possibilities of monitoring dynamic processes in the surface and underground components of the abiotic complex of hydroecosystems. Targeted monitoring of the abiotic complex has been conducted in the reserve since 2009.

Currently, the hydrochemical study of the rivers of the Drevlyanskyi Reserve is quite low. Also, information on the content of basic ions and biogenic substances in the water of small rivers appeared only recently. Therefore, the research of the authors on the assessment of quantitative and qualitative changes in the hydrochemical regime of the rivers of the Drevlyanskyi Reserve in the summer-autumn period is relevant.

The quality of water depends on its ion's composition. The composition of dissolved substances in surface waters is very diverse, as they interact with various geological rocks. However, it is possible to single out important hydrochemical indicators that evaluate water quality for various types of water use. For most natural waters the total salt content is determined by cations Ca^{2+}, Mg^{2+}, K^{+}, Na^{+} and anions HCO_3^{-}, SO_4^{2-}, Cl^{-}. Other ions are present in rather small amount but they can significantly affect the properties and quality of water [17]. However, it is impossible to assess the quality of river waters by all indicators for which maximum permissible concentrations (more than 900 substances) have been determined. That's why, the way out of this situation is to study the content of those substances that have the greatest importance in the formation of the ecological and chemical state of water bodies.

Having carried out comparative analysis of the chemical composition of water in the rivers of the Drevlianskyi nature reserve, it should be noted that the characteristic feature of this area is low water mineralization which doesn't exceed 600 mg/dm^3. In this region this is caused by a relatively large amount of precipitation, which causes significant washing of soils and rocks, and their poverty of mineral components. The composition of the main ions is relatively stable, calcium (28–64 mg/dm^3) and bicarbonate ion (201–260 mg/dm^3) dominate among them, shown in Fig. 4.

For comparison fig. 5 shows the average concentrations of secondary concentrations of anions and cations of salts of natural and anthropogenic origin

1

2

3

4

5

6

7

Fig. 3. Photos of sampling places: 1 – Uzh, 2 – Zvizdal, 3 – Loznytsia, 4 – Osliv, 5 – Kamianka, 6 – Bucha, 7 – Zherev (Author of the photo – Vasyl Konishchuk)

Table 1

Coordinates of rivers

№ place	River	Coordinates	
		X	Y
1	Uzh	51.266809	29.263087
2	Zvizdal	51.147689	29.244472
3	Loznytsia	51.124100	29.078671
4	Osliv	51.147529	29.161785
5	Kamianka	51.087788	28.953926
6	Bucha	51.179707	29.247085
7	Zherev	51.186484	29.039580

Source: GPS

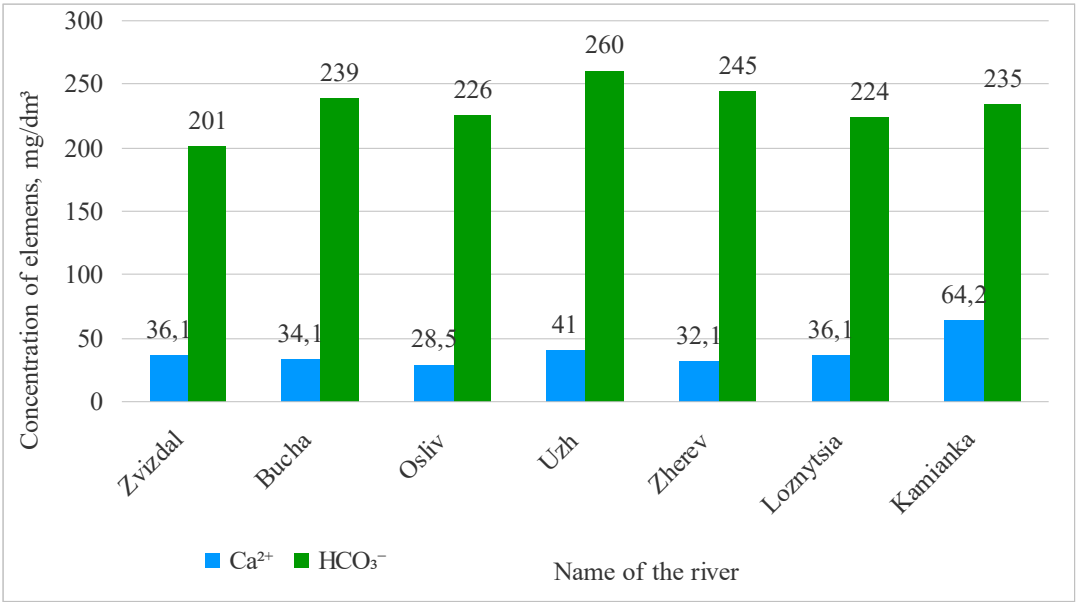

Fig. 4. Comparative analysis of the content of the main components of the cationic and anionic composition in the rivers of the Drevlianskyi nature reserve

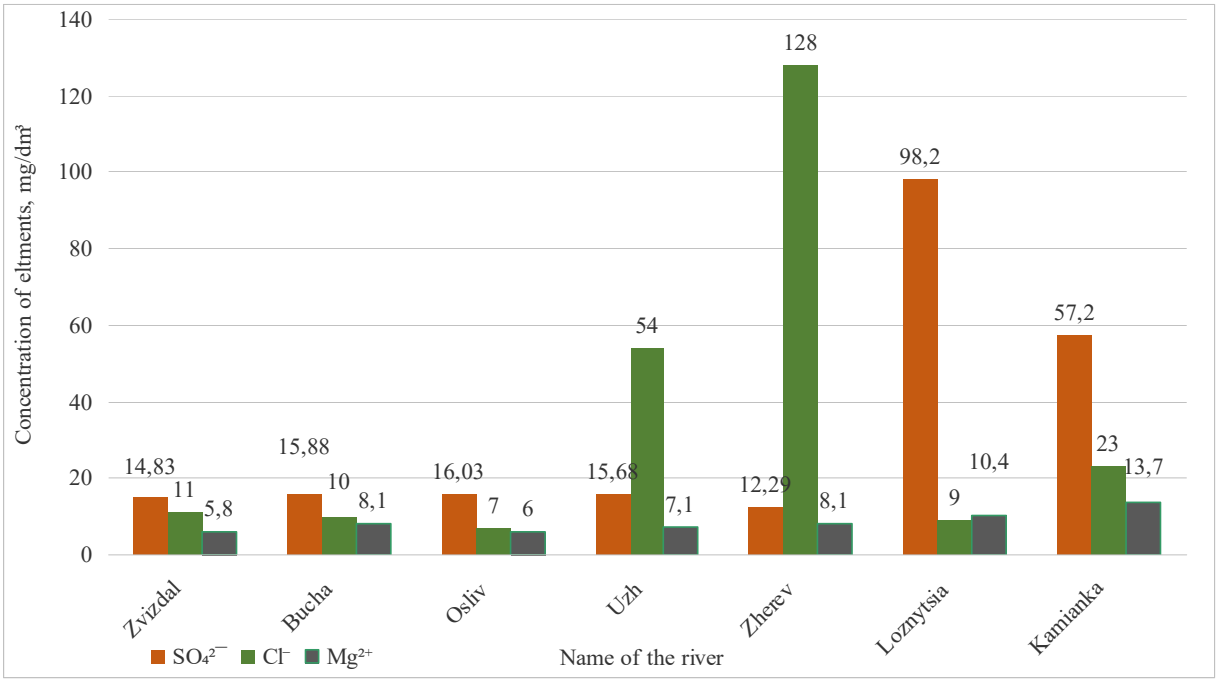

Fig. 5. Average concentrations of secondary concentrations of anions and cations of SO_4^{2-}, Cl^-, Mg^{2+} salts dissolved in water

dissolved in water: SO_4^{2-}, Cl^-, Mg^{2+}. The concentrations of chloride and sulfate ions change in a wider range, the maximum values of which are found in the water of the small Zherev and Loznytsia rivers. As for the content of potassium and sodium ions they are below the detection limit.

In the summer-autumn low water period due to consumption by phytoplankton, concentrations of mineral forms of phosphates and nitrogen are below the detection limit. In general, low content of ammonium nitrogen is inherent of most small rivers of this part of the reserve.

Only the Bucha and Loznytsia rivers are exceptions, whose water content of ammonium nitrogen exceeds 3.9 mg/dm^3.

The data presented obove shows that the concentration of the main ions as well as the amount of water mineralization is susceplible to the influence of natural and anthropogenic factors and depends on the location of the catchment area. It should be noted that the hydrochemical indicators of natural waters are quickly respond to anthropogenic interference in the natural environment and some components can serve as indicators of interference. These include chlorine and sulfate ions and nitrogen-containing compounds and water mineralization.

Among the studied biogenic substances in the water of the studied rivers the classic seasonal distribution of concentrations is characteristic of nitrates, the content of which is minimal during the growing season of plants. Often, during intensive photosynthesis NO_3^- isn't detected in the water at all as can be observed in the five studied rivers of the Drevlianskyi reserve (≤0.1 mg/dm^3).

The trace element composition of the reserve's river waters depends on the geological conditions of the territory. That's why watercourses differ in the content of microelements but on average the concentrations are not high, mostly they do not exceed the maximum permissible concentration values and the world average indicators for river waters. However, Fe, Cu, and Zn are exceptions.

The dynamics of organic matter, which is an active participant in weathering processes, is connected with the arrival of dissolved iron the concentration of which in the water of the Zherev River is small (0.09 mg/dm^3). Increased content of the iron which ash content of 10,7% is noted in Zvizdal, Loznytsia and Osliv rivers, which is one of the main components in the waters of Polissia peatlands. A significant amount of dissolved iron substances can fall into rivers with underground flows and also with former agricultural land flows. In addition, being a biologically active element, Fe affects the intensity of phytoplankton development and the qualitative composition of microflora in the reservoir, which requires further clarification and monitoring.

The vast majority of the rivers of Zhytomyr Polissia in one or another part flow within the boundaries of the Ukrainian crystalline shield where crystalline rocks, granites, gabbros and gabbronorites with relatively small reserves of microelements are overlain by poor sedimentary rocks of water-glacial origin of loamy sandy and sandy granulometric composition. That's why surface waters of the Drevlianskyi nature reserve during the summer-autumn low water contain small amount of microelements and heavy metals. Thus, the concentration of Cu^{2+} and Zn^{2+} are much lower than maximum permissible concentration (≤0,02 mg/dm^3), which makes their determination difficult. However, the microelements, even in low concentrations, have a negative effect on phytoplankton and zooplankton and accumulate in bottom sediments, adversely affecting benthic organisms.

Manganum unlike other elements, binds less in complexes. Its content in water determined by the intensity of consumption during photosynthesis, decomposition of algae and higher aquatic vegetation. The highest values are noted in the Zvizdal and Osliv rivers which drain in part of the watersheds of wetland landscapes with regenerative processes in the soil.

At the same time, the pH of water during the observation period in most rivers remains practically stable, except for waterlogged Zvizdal, Osliv and Loznytsia. Their characteristic feature is an acidic reaction (pH=5.4–6.9), to which swamp plants.

Besides, the activity of swamp microflora regulates the redox potential (Eh), the properties of which significantly affect the migration ability of elements. Thus, the regeneration process of metals with a variable degree of oxidation acquires special importance in weakly acidic swamp waters. Since this process is accompanied by the exchange of protons, that's why its course will directly depend on the protolytic properties of the environment.

Experimental studies on the recovery of ferrum (Fe^{3+}) and mangan (Mn) showed that the course of the process depends on the pH indicator and, as a rule, slows down with its increase (Tab. 2). Also shows that redox potential decreases with increasing pH. Thus, the maximum values of Eh (+800) are determined in acidic waters (pH<5), and the minimum values in highly alkaline waters (pH ≈ 12).

Now, there are many factors in the formation of the chemical composition of river waters. Thus, afforestation and plowing of the water catchment makes 34% of the contribution of all factors in the formation of water quality. It forms the water flow and regulates the income of chemical substances. In the autumn low water period (September-November) water flow is insignificant and on average it is 15%

Table 2

Hydrochemical composition of the water of the main watercourses of the Drevlyan Reserve

Indicator	The name of the river						
	Uzh	Zherev	Bucha	Zvizdal	Kamianka	Osliv	Loznytsia
pH	7.32	7.38	7.52	6.92	7.36	6.55	5.35
redox potential, mV	225	215	231	222	238	240	262
salinity, mg/dm³	215	299	118	130	233	112	173
conductivity, mS	423	616	237	260	465	225	333
mineralization, mg/dm³	286	399	158	174	312	150	230
Ca^{2+}, mg/dm^3	41.0	32.1	34.1	36.1	64.2	28.5	36.1
Mg^{2+}, mg/dm^3	7.1	8.1	8.1	5.8	13.7	6.0	10.4
SO_4^{2-}, mg/dm^3	15.68	12.29	15.88	14.83	57.2	16.03	98.2
Cl^-, mg/dm^3	54	128	10	11	23	7	9
HCO_3^-, mg/dm^3	260	245	239	201	235	226	224
Fe^{3+}, mg/dm^3	0.46	0.09	3.14	8.08	0.13	3.08	11.3

of the annual flow, but it can vary from year to year depending on the conditions of moistening. In addition, precipitation in the cold period is the main source of nourishment for the rivers of the region. In low-water years, the relative share of atmospheric nutrition reaches 50% of the volume of water flow, and in high-water years it increases to 85%. In general, the chemical composition of water in the catchment is affected by various [18, 19].

It should be noted, that such a global phenomenon as climate warming has been taking place for the past 50 years. During this period, the average air temperature increased by 2–3 ^{0}C in various regions of the planet, which led to a number of negative phenomena also in the Polissia zone, in particular Drevlianskyi Reserve. This definitely affects the increase of evaporation both from the surface of water bodies and from the soil of the adjacent areas of river floodplains. This is one of the factors of shallowing of rivers. At the same time, one shouldn't forget that there are other components of the natural environment (relief, soil and vegetation, geological structure, etc.) and also that human economic activity affects the regime of rivers and form their natural image. If, according to the figurative expression of scientists, water is the blood of the landscape, then rivers are the circulatory system of the landscape that transports matter and energy and transforms the landscape itself. However, the surface waters are more protected from surface factors and therefore are usually characterized by a stable chemical composition. Although in some regions, in particular, the nature reserve, due to natural factors or anthropogenic influence, these waters have a substandard composition.

According to the certification materials, there are currently no river basins in Ukraine with an undisturbed state of their water ecosystems. Some scientists, according to their research [20–22], state that all aquatic ecosystems are typical anthropogenic hydroecosystems. So, these are such transformed rivers, in which intra-watershed changes took place, which led to the violation of homeostasis, biogeochemical cycles, ecological capacity of the hydroecosystem and other transformations. Thus, researching the dependence of water mineralization on electrical conductivity in researched rivers of the Drevlianskyi nature reserve a graph was obtained, which is presented in fig. 6. It should be noted that the derived dependence between the value of electrical conductivity and mineralization, even in the summer flood and the winter low water, can be used for mutual control of the noted indicators during water analysis.

The analysis of the data of the rivers, which were characterized by different degrees of anthropogenic activity, indicates about close values of mineralization and ionic composition of water. This allows to make a conclusion about the predominant role of natural factors in forming the regime of the mentioned components in the surface waters of the region. In addition, the genetic composition of substances dissolved in surface waters to a large extent characterizes the hydro-chemical balance.

As is known, the hydro-chemical regime of rivers is formed under the influence of a number of complexes of physical and geographical, geological, hydrogeological, physical, biological and anthropogenic factors. They determine changes in time and space of concentrations of chemical components in water, its mineralization, hardness, gas composition and chemical type. These factors affect the external signs of the hydro-chemical regime. The internal factors of the hydro-chemical regime and their influence are determined by the structure of the chemical element [23, 24].

There is destruction (transformation) of organic compounds of dead hydrobionts, including plants from the *Fabaceae* family, dead mass of algae, sludge deposits, detritus, which causes an increase in the content of nitrogenous compounds.

There are different approaches to the systemati-

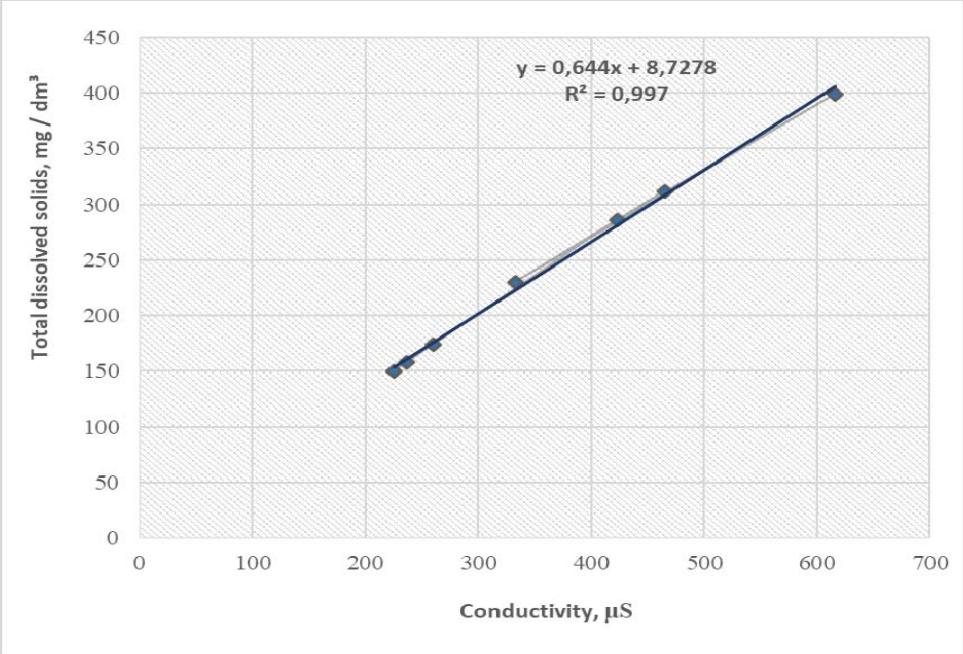

Fig. 6. Dependence of mineralization on electrical conductivity

zation of data on the chemical composition of natural waters. Thus, for a visual representation of the chemical composition of water in the rivers of the Drevlianskyi nature reserve, the *Kurlov formula* was used which is currently used to systematize data for fresh surface watercourses, as well as the general classification of O.O. Alekin (Tab. 1) [11]. At the same time, for a clearer perception of changes, the modernized classification of O.O. Alekin was applied, because the basic one doesn't fully show the dynamics of changes in the chemical composition of water (see Tab. 3).

Table 3

Averaged data on the chemical composition of river waters and examples of the use of Alekin's modernized classification

№	Place of sampling	Kurlov's formula, %-equivalent	Classification of O.O. Alekin		
			basic	modernized	
1	Zvizdal	$ж2{,}3M0{,}3\frac{HCO_3 83 SO_4 8 Cl 8}{Ca 78 Mg 20} pH 6{,}9$	C_{III}^{Ca}	C_{IIIa}^{CaMg}	hydrocarbonate class of the calcium-magnesium group of the third type of subtype a
2	Bucha	$ж2{,}4M0{,}3\frac{HCO_3 86 SO_4 7 Cl 6}{Ca 71 Mg 27} pH 7{,}5$	C_{III}^{Ca}	C_{IIIa}^{CaMg}	
3	Osliv	$ж1{,}9M0{,}3\frac{HCO_3 87 SO_4 7 Cl 4}{Ca 73 Mg 34} pH 6{,}5$	C_{III}^{Ca}	C_{IIIa}^{CaMg}	
4	Uzh	$ж2{,}7M0{,}4\frac{HCO_3 69 Cl 24 SO_4 5}{Ca 77 Mg 22} pH 7{,}3$	C_{III}^{Ca}	C_{IIIa}^{CaMg}	
5	Zherev	$ж2{,}3M0{,}4\frac{HCO_3 50 Cl 45 SO_4 3}{Ca 70 Mg 29} pH 7{,}3$	C_{III}^{Ca}	C_{IIIb}^{CaMg}	hydrocarbonate class of the calcium-magnesium group of the third type of subtype b
6	Loznytsia	$ж2{,}7M0{,}4\frac{HCO_3 61 SO_4 34 Cl 4}{Ca 67 Mg 31} pH 5{,}3$	C_{III}^{Ca}	C_{IIIb}^{CaMg}	
7	Kamianka	$ж4{,}3M0{,}4\frac{HCO_3 67 SO_4 20 Cl 11}{Ca 73 Mg 25} pH 7{,}3$	C_{III}^{Ca}	C_{IIIb}^{CaMg}	

Source: developed by authors, developed on the basis of methods (Alekin O.O.)

Evaluating a mineralization and chemical composition of water of the researched rivers of the nature reserve, it can be argued that the main feature of their chemical composition is belonging to moderately fresh, oligogenic, and soft waters.

According to the classification proposed by O.O. Alekin (see Fig. 1), all-natural waters are divided into three classes by predominant anion: hydro-

carbonate, sulfate, and chloride. According to the ionic composition, the water of the studied rivers is mainly of the hydro-carbonate class, the calcium-magnesium group, the third type. The difference between subtypes III*a* and III*b* is next:

except $MgSO_4$ from subtype IIIa waters magnesium hydrogen carbonate $Mg(HCO_3)_2$ can enter the soil that is a non-toxic salt for plants that can cause an alkaline reaction of soils;

subtype IIIb waters instead of magnesium bicarbonate contribute to the formation of gypsum ($CaSO_4 \times 2H_2O$) in the soil, which is an ameliorant of saline soils.

Discussion. Thus, after analyzing the influence of the main physical and geographical components on the hydrological regime of rivers, it can be concluded that the main factors are climate and relief, other components complement the hydrological, hydrochemical, hydrophysical state.

Therefore, the concentration of iron is subject to noticeable seasonal fluctuations. Autumn-spring mixing of water masses (homothermy) is accompanied by oxidation of Fe(II) into Fe(III) and precipitation of the latter in the form of $Fe(OH)_3$. Significant amounts of iron are observed in the right tributaries of the Uzh River (the Zvizdal and Loznytsia rivers).

With the exception of the Kamianka River, the Rozsokhivske tract (the basin of the Uzh River on the granite Ukrainian Crystalline Shield), all rivers are typical for Polissia with a slow flow, slight meandering with wide grassy-meadow floodplains.

Among the rare hydrogelophytes and phytosozophytes of hydroecosystems (especially rivers and marshes) in the Drevlyanskyi nature reserve, we noted the following species: *Juncus bulbosus* L., *Dactylorhiza incarnata* (L.) Soo, *Aldrovanda vesiculosa* L., *Drosera intermedia* Hayne, *Utricularia australis* R. Br., *Utricularia intermedia* Hayne et al. [25]. The ecological state of phytosozophytes depends on the quality and physical and chemical state of the water.

A rather intensive trend was revealed regarding the spread of invasive species in reservoirs and their floodplains: *Acer negundo* L., *Amorfa fruticosa* L., *Echinocystis lobata* (Michx.) Torr. et A. Gray, *Elodea canadensis* Michx., *E. nuttallii* (Planch.) St. John., *Fallopia sachalinensis* (F. Schmidt) Ronse Decr., *F. japonica* (Houtt.) Ronse Decr., *Galinsoga ciliata* (Rafin) Blake, *G. quadriradiata* Ruiz et Pav., *Heracleum mantegazzianum* Sommier et Levier, *H. sosnowskyi* Manden., *Impatiens glandulifera* Royle, *I. parviflora* DC., *Oenothera biennis* L., *O. depressa* Greene, *Padus serotina* (Ehrh.) Agardh., *Sarothamnus scoparius* (L.) Koch., *Solidago canadensis* L., *Zizania latifolia* (Griseb.) Turcz. ex Stapf., etc.

In co-authorship [26], based on the generally accepted EUNIS approaches, a hierarchical classification of rare settlements of the Drevlianskyi nature reserve was developed up to and including the 4th level (see below).

Therefore, having carried out an environmental assessment of the hydroecosystems of the Drevlianskyi nature reserve, we can conclude that they are quite valuable, little changed and have both national and international environmental significance.

With regard to practical recommendations and instructions for optimizing the ecological state of hydroecosystems, it is worth noting the expediency of background monitoring of surface water levels and their physical and chemical composition, as well as further assessment of the state of populations of rare species of biota, phytocenoses.

Since radiation pollution is specific to the reserve, in the future it is worth conducting appropriate measurements of the radiation background and the content of radionuclides in water, bottom sediments, and hydrobionts.

Invasive species should be removed from natural biotopes on the basis of scientifically based biotechnical measures.

Also important are the processes of regulating the surface flow of rivers and streams, spatially to raise the water level in order to reduce the fire hazard. Artificially created hydroecosystems (ponds, firefighting reservoirs), swamps, etc., require additional scientific research.

For the first time, a comprehensive hydrochemical analysis of the rivers of the "Drevlyanskyi" nature reserve was conducted according to current standards, NSU (ISO) (20 main indicators, characteristics were determined). The water quality of hydroecosystems has differences in the horological (territorial) aspect, in particular, it is clean in the rivers Zherev (quality class I), Bucha, Uzh, Kamianka (quality class II), moderately polluted in the rivers Zvizdal, Osliv (quality class III), polluted in the Loznytsia River (IV quality class). Nitrites in surface waters, in particular in the rivers of the "Drevlyanskyi" NR, are found in small amounts (≤ 0.003 mg/dm^3). Hydrolytic acidity (pH) varies from 5.35 to 7.52, that is, the water is relatively neutral and slightly acidic, alkalinity is not increased. The most active processes of eutrophication and saprobity are manifested in stagnant areas of hydroecosystems, in particular, this is characteristic of the Loznytsia River.

In the Kamianka and Loznytsia rivers, there are three times and twice as many hydrocarbonate ions as sulfates, respectively. One of the reasons for the formation of such a composition of river waters is the features of widespread regional soils and rocks with characteristic saline inclusions and a high content of soluble salts. The same factors cause a sharp difference in the chemical composition of water at the qualitative level.

Summarizing the consideration of intercomnec-

ted problems of rivers, we see that the latter require an urgent solution now and in the future. After all, the nature of the reserve is the most valuable wealth, the basis of the recreation, health and tourism industry, which is almost the only industry capable of providing decent conditions for the material life of the population.

Conclusions. The quality of surface waters plays a major role, especially their hydro-chemical regime. The conducted analysis showed that the features of the chemical composition of the surface waters of water bodies located on the territory of the Drevlianskyi nature reserve are determined by the complex of landscape and geochemical conditions of the Uzh River basin. In conditions of a positive moisture balance, the climatic component also plays a fundamental role in the formation of the chemical composition of waters.

The chemical composition of the water in all the rivers of the researched territory was characterized by fairly sustained uniformity. Water bodies are characterized by a low content of basic ions, correspondingly, by low mineralization (<600 mg/dm^3), which is confirmed by field observations. However, there was no significant difference in the concentrations of the main ions and their sum in the studied objects, which indicates common factors in the formation of the chemical composition of the rivers of the nature reserve. During the summer-autumn low water, the water contained small amounts of microelements and heavy metals (except for Fe and Mn) that didn't exceed the established sanitary and hygienic maximum permissible concentration.

Having analyzed the results of the research, it can be stated that the water bodies throughout the territory of the reserve were characterized by clearly defined belonging to the hydro-carbonate class of III type. Water subtypes III*a* and III*b* differ from each other in the presence of magnesium bicarbonate $Mg(HCO_3)_2$ in III*a* and calcium sulfate $CaSO_4$ in III*b*.

Therefore, the problem of eliminating contradictions between society and nature and the need to stop the process of destruction of the biosphere remain open. Thus, it is necessary to state the tense ecological situation in the country and to take many steps with the attraction of funds and new approaches to correct the situation. Also, Ukraine should develop the social sphere on a democratic basis in combination with massive investments in environmental science and education, in order to implement its strategies for stabilizing and improving the state of the environment, especially water ecosystems. However, it should be emphasized that under the current conditions, it is impossible to solve this problem in a short period of time, since it is necessary to improve production and raise the level of consciousness of people. Because, the protection and preservation of water is the responsibility of each of us.

Thus, for the first time, a comprehensive hydrochemical analysis of the rivers of the Drevlianskyi nature reserve was carried out in accordance with the current standards of the State Standards of Ukraine (ISO) (20 main indicators and characteristics were determined). The water quality of hydroecosystems has differences in the chorological (territorial) aspect, in particular, it is clean in the rivers Zherev (I quality class), Bucha, Uzh, Kamianka (II quality class), moderately polluted in the Zvizdal, Osliv rivers (III quality class), polluted in the Loznytsia River (IV quality class). Nitrites in the surface waters of the rivers of the Drevlianskyi nature reserve are detected in small amounts (≤0.003 mg/dm^3). Hydrolytic acidity (pH) varies from 5.35 to 7.52, thus, the water is relatively neutral and slightly acidic, alkalinity is not increased. The most active processes of eutrophication and saprobic are manifested in stagnant areas of hydro-ecosystems, in particular, this is characteristic of the Loznytsia River.

For most of the surface water sources, there is a significant dependence between the composition of the water and the effect of hydrometeorological conditions and biological processes. A feature of all surface water bodies is seasonal fluctuations in the composition of water, which can be particularly clearly traced by changes in such indicators of its quality as turbidity, color, alkalinity, hardness, temperature, etc.

Prospective studies of the physico-chemical and ecological state of the waters of the "Drevlyanskyi" nature reserve include further background monitoring, seasonal analysis of the dynamics of changes in indicators, establishing regularities in space and time. It is worth noting that additional studies may relate to the influence of the physical and chemical state of water on the population of rare, endangered species of hydrobionts of the reserve.

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Екологічний та гідрохімічний аналіз річок природного заповідника «Древлянський» (Україна)

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Якість поверхневих вод відіграє велику роль, особливо їх гідрохімічний режим. Хімічний склад і мінералізація річкових вод знаходяться у динамічному зв'язку і формуються під впливом багатьох зовнішніх чинників. Тому під впливом останніх постала необхідність у дослідженні гідрохімічного складу водойм заповідника, що було актуальним питанням роботи. Мета – комплексний екологічний, гідрохімічний аналіз стану річок природного заповідника «Древлянський» для оптимізації природоохоронних заходів, моніторингу, екобезпеки та збереження біорізноманіття гідробіонтів. Виконання досліджень стану якості води базувалося на класичних, загальноприйнятих методах: польові дослідження, літературний огляд, лабораторні, аналіз отриманих результатів. Згідно із дослідженнями було встановлено, що у межах природного заповідника у літньо-осінній, період вода основної річки Уж та її приток за величиною мінералізації є помірно прісною (0,1–0,6 г/дм^3), за величиною pH – нейтральною, хімічного складу – гідрокарбонатно-кальцієвою. Низька заболоченість ландшафтів обумовлює вкрай низький вміст у воді річок амонійного азоту та розчиненого заліза. Виняток становлять річки Звіздаль та Ослів, у течії яких спостерігається невелика заболоченість, що спричинює підвищений стік органічних речовин. Також було досліджено, що у період літньо-осінньої межені вода містила невеликі (за винятком Fe і Mn) кількості мікроелементів й важких металів, які не перевищують встановлених санітарно-гігієнічних ГДК. Відповідно до класифікації, запропонованої О.О. Алекіним, всі природні води діляться на три класи. За вмістом головних йонів і мінералізацією води, було проаналізовано, що водні об'єкти заповідника належать до гідрокарбонатно-кальцієвого класу III типу. У водних об'єктах ПЗ «Древлянський» зустрічаються підтипи вод IIIа–IIIб. Останні відрізняються один від одного, зокрема наявністю гідрокарбонату магнію ($Mg(HCO_3)_2$) у IIIа та сульфату кальцію ($CaSO_4$) у IIIб. Вперше проведено комплексний аналіз поверхневих вод радіаційно забруднених територій в умовах повного заповідання. Практична цінність матеріалів досліджень полягає у подальшому моніторингу гідроекосистем, обґрунтуванні природоохоронних заходів, а результати будуть використані в щорічній програмі «*Літопис природи*» заповідника для Міністерства захисту довкілля та природних ресурсів України.

Ключові слова*: екологія; водні екосистеми; гідрохімічний режим; якість води; заповідник.*

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