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CONTENS / ЗМІСТ

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ASSESSMENT OF THE URBAN ENVIRONMENT QUALITY IN KYIV

Abstract. Green plantings, which are a part of the modern city, are an important element creating an environment providing favorable microclimatic and sanitary conditions for human living. Plants of the city streets, which tend to grow near the roadway, play an important role. Stability of development as the ability of an organism to pass all stages of ontogenesis is a sensitive indicator of the natural population's state and allows estimating the total amount of anthropogenic load. The easiest and most widely used method for assessing the stability of development is the determination of the fluctuation asymmetry magnitude of the biliary morphological features. It represents a deviation from bilateral symmetry due to imperfection of ontogenetic processes and manifests itself in insignificant differences between the parts (within the norm of the organism's reaction). The resulting integrated assessment of the environmental quality is the answer to the reaction of a living organism to adverse effects within the period of individual development.

Keywords: silver birch (*Betula pendula Roth.*), development stability parameter, fluctuating asymmetry, environmental monitoring, bioindication

INTRODUCTION

Due to the increase of anthropogenic impact on the environment, environmental monitoring, which includes the sites optimal by their number and location, parameters and frequency of environmental observations enabling public authorities to make appropriate decisions at all levels of departmental and national environmental protection activities, becomes especially relevant [5].

The main sources of pollution in the city are industrial enterprises and road transport, resulting in the significant reduction of tree plants resistance to abiogenic stressors, which leads to anatomical and morphological fluctuations in their vegetative and generative organs. To assess the stability of the living organisms development, the criteria for fluctuation asymmetry (FA) are used, which show slight non-directional differences between the right and left sides of the body, which are laid down during ontogenesis. In a satisfactory state of the environment, their level is minimal, but when the negative effect increases, an asymmetry is manifested [15]. The FA parameter allows to record even minor deviations of the parameters in the environment, but the main condition for the use of the object is the bilateral symmetry of his body, which parameters will be applied to the study [1].

Thus, the level of fluctuation asymmetry for the morphological structures can be used as a non-specific stress indicator reflecting the deformation of interactions between the organism and the environment [20]. In FA, the differences between the parts are not strictly genetically determined. This asymmetry (as opposed to directed asymmetry and antisymmetry) does not have an independent adaptive value. It is an indicator for the minor symmetry violations that is allowed by natural selection, and reflects the development stability. Estimation of the FA value is a valid way for formalizing the degree of deviation of the of individuals and even populations from the norm. Monitoring such manifestations of destabilization can provide information not only about negative biotic or abiotic factors, but also about the presence of anthropogenic pressure [17].

The purpose of the study is the quality assessment of the urban environment of Kyiv using the bioindication method. To achieve the goal, the following tasks were set: 1) to identify the morphological features of woody plants in the urban environment and to study the influence of anthropogenic factors on the formation of morphological structures of tree plants by

determining the FA indexes lamina in different parts of the city; 2) assess the state of plants by the magnitude of the integral of the development stability indicator; 3) determine the dependence of the FA level of a plant in relation to the source of pollution.

Analysis of recent research and publications. There are many works in the field of environmental monitoring in the scientific literature. The Regulation "On State Monitoring of the Environment" states that state monitoring of the environment is a system for monitoring, collecting, processing, transmitting, storing and analyzing information on the environment situation, forecasting its changes and developing scientifically substantiated recommendations for the development of management decisions [3, 7]. Sufficient work of foreign scientists is aimed at solving issues regarding the definition of areas and fields of monitoring, evaluation indicators, methods and means of conducting it [4, 8, 9, 12, 13]. Some authors suggest the use of grassy annuals [3, 16] and perennial [6, 18] plants as bioindication objects, but most of them believe that use of woody plants to characterize sufficiently large areas is the most effective [17, 10, 14, 19, 21].

MATERIALS AND METHODS

The silver birch (*Betula pendula Roth.*), which is often used for greening the cities, was selected as an object of the study to determine the degree of the development stability [11]. This is one of the fastest growing tree species. Under favorable conditions, this species reaches 25-30 m in height and up to 80 cm in diameter. Very light-loving, its crown is open, transmits a lot of light. The root system is highly developed, but penetrates deeply into the soil. It is elatively short-lived, lives up to 120 years, rarely to more adulthood.

The collection of material was carried out in accordance with the methodology for assessing the status of organisms in terms of disruption of the development stability [2]. The material of the studies was laminas *B. pendula*, collected after the growth of leaves (at the end of August 2017). Each sample consisted of 100 laminas (10 leaves of one tree), taken from the bottom of the tree crown, at the level of the raised arm, with the maximum number of available branches, evenly around the tree. When collecting leaves, its size and functional state (collected leaflets of medium size) was taken into account.

The collection of material on the Kyiv territory was held in 4 districts with different anthropogenic load: the zone of intensive traffic flow (Prospekt Peremohy) near the PJSC "Borschagivsky Chemical and Pharmaceutical Plant", near the Kyiv TV Tower and within the territory of the "Nyvky" park. The leaves were collected from trees located 10-20 m from the objects of influence. The location of test sites (TS) is presented in Fig. 1.

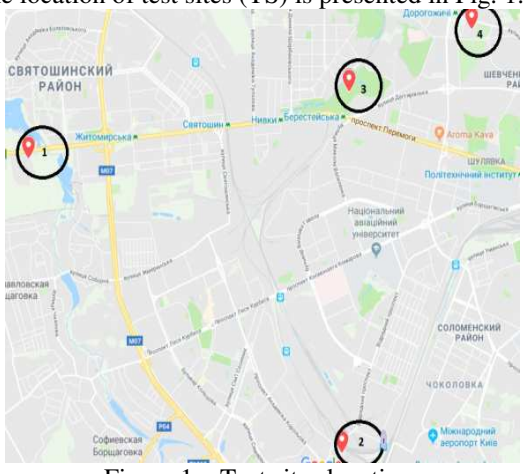

Figure 1 – Test sites location:
TS1 - road (Prospekt Peremohy); TS2 - PJSC "Borshchagivsky Chemical and Pharmaceutical Plant"; TS3 - Park "Nyvky"; TS4 - Kyiv TV Tower.

In order to estimate the FA values according to existing methods [2], 5 bilateral signs were investigated: 1 - the width of the left and right halves of the leaf; 2 - distance from the base to the end of the vein of the second order, the second from the basis of the leaf; 3 - the distance between the bases of the first and second veins of the second order; 4 - the distance between the ends of the first and second veins of the second order; 5 - the angle between the main vein and the second one from the base of the leaf with the second-order vein.

For measurements of the left and right halves of the lamina, a meter compass, a ruler and a protractor were used. The calculation of the integral index was carried out according to the methodology of V.M. Zakharova [2]: 1) for each lamina, the relative values of the asymmetry for each sign were calculated (the difference between the measurements on the left (L) and the right (R) was divided by the sum of these measurements: (L-R) / (L + R); 2) the asymmetry index for each leaf was calculated (the relative values of asymmetry was added for each sign and divided by the number of features); 3) the integral index of development stability was calculate - the value of the average relative difference between the parts on the sign (the arithmetic mean of all values of the asymmetry (for each of ten trees)was calculated).

To assess the degree of detected deviations from the norm, a class scale was used to characterize the level of pollution for the territory based on the FA index [2] (Table 1).

Table 1. Estimation scale for the body deviations from the conditional norm by the value of the integral stability index [2]

Class	Value of the FA indicator	Characteristic
I	<0.040	Conditional norm
II	0.040 − 0.044	Plants are weakly influenced by adverse factors
III	0.045 − 0.049	Contaminated areas
IV	0.050 − 0.054	Very polluted areas
V	>0.054	Extremely unfavorable conditions, plants are in a very depressed state

The values of the integral index of asymmetry corresponding to the first gade are usually observed in plant samples for favorable growth conditions, for example, in natural reserves. The fifth class is critical (such asymmetric data are observed in extremely unfavorable conditions when the plant is in a very depressed state).

The statistical processing of the material was carried out using the standard MS Excel program package.

RESULTS AND DISCUSSION

One of the requirements for the features that were defined by the FA is the low level of variability for the indicators. It was found during the studying the variability for the signs of the *B. pendula* lamina that all the features are characterized by low values of the coefficient of variation (Tables 2-5).

Despite the fact that there are metro stations "Beresteyskaya" (in the eastern part of the park) and "Nyvky" (in the western part) near the "Nyvky" park, and the railroad passes, the magnitude of the fluctuation asymmetry in this area was 0.036 in 2017, which is conditional norm of the the environmental state (atmospheric air). The resulting indicators are most likely due to the fact that the "Nyvky" park is one of those few parks in Kiev, which still preserves centuries-old trees in its territory, and its area is 60 hectares (the western part is 15 hectares, and the eastern part is 45 ha).

Table 2. Integral index of fluctuation asymmetry in the sample ("Nyvky" park)

	Indicator No.					Value of asymmetry
No.	1	2	3	4	5	
1	0.050	0.047	0.043	0.111	0.008	0.052
2	0.054	0.10	0.037	0.043	0.009	0.045
3	0.05	0.022	0.13	0.024	0.012	0.048
4	0.022	0.011	0.071	0.043	0.011	0.032
5	0.04	0.026	0.025	0.090	0.019	0.04
6	0.027	0.024	0.071	0.047	0.028	0.04
7	0	0.012	0.025	0.037	0.034	0.022
8	0.013	0.012	0.023	0.090	0.016	0.031
9	0.013	0.024	0	0.034	0.018	0.018
10	0.027	0.051	0.076	0	0.016	0.027
Value of asymmetry in the sample						X=0.036

Table 3. Integral index of fluctuation asymmetry in the sample (Kyiv TV Tower)

	Indicator No.					Value of asymmetry
No.	1	2	3	4	5	
1	0.024	0.020	0.026	0.062	0.009	0.028
2	0.023	0.011	0.05	0.083	0.037	0.041
3	0	0.012	0.027	0	0.018	0.011
4	0.058	0.013	0	0.125	0.045	0.048
5	0.014	0	0	0.071	0.048	0.027
6	0.012	0.022	0.111	0.1	0.042	0.057
7	0.023	0.020	0.068	0.083	0.018	0.042
8	0.014	0.011	0.029	0.083	0.008	0.029
9	0.076	0.020	0.096	0.037	0.018	0.05
10	0	0.027	0.062	0.096	0.024	0.042
Value of asymmetry in the sample						X=0.038

Table 4. Integral index of fluctuation asymmetry in the sample (PJSC Borshchagivsky Chemical and Pharmaceutical Plant)

	Indicator No.					Value of asymmetry
No.	1	2	3	4	5	
1	0.013	0.010	0.027	0.083	0.030	0.033
2	0.031	0.038	0.028	0.047	0.009	0.031
3	0.043	0.030	0.037	0.043	0.009	0.032
4	0.014	0.04	0.071	0.066	0.015	0.041
5	0.016	0.029	0	0.090	0.057	0.038
6	0.030	0.033	0.034	0.043	0.016	0.031
7	0.013	0.012	0	0.047	0.027	0.02
8	0.071	0.012	0.090	0.052	0.019	0.049
9	0	0.054	0.14	0.043	0.008	0.049
10	0	0.048	0.032	0.047	0.015	0.028
Value of asymmetry in the sample						X=0.035

The value of the fluctuation asymmetry on the territory of the Kyiv television tower is 0.038. This indicator characterizes the conditional norm of the environmental state (atmospheric air). Probably, the the location of the Kyiv TV tower far from motorways and other objects of the industrial complex can reduce the negative impact on plant organisms in the process of ontogenesis.

According to the results of calculating the asymmetry value in the sample at the PSC "Borshchagivsky Chemical and Pharmaceutical Plant", which occupies one of the leading places in terms of production and sales of finished pharmaceuticals among Ukrainian pharmaceutical companies, it is determined that the territory is characterized by favorable conditions for the development of plants. This is due to the fact that the company began a new stage in development with a change in leadership. The plant management made a decision regarding the technical re-equipment and the establishment of a quality system meeting the world's standards for the production of medicines – GMP (Good Manufacturing Practice) requirements. At the enterprise, a certification audit was conducted to meet the GMP rules for the production, control, storage and transportation of sterile antibiotics injections and antibiotics in capsules, the quality control laboratory (Audit – Certipharm, France). In 2003, the certification inspections were carried out on the production of sterile antibiotic powders in vials and capsules of antibiotics for compliance with GMP requirements of the EU, PIC / S recommendations, taking into account GMP VISA. In 2004, the company introduced one of the most advanced automated production and resource management systems MFG / PRO. The integrated pharmaceutical quality system (IPQS), which combines the requirements of GMP, GDP, GSP, G (Q) CPL, ISO 9001, ISO 14001, ISO 17025, ISO 50001, OHSAS 18001, SA 8000, was introduced at the enterprise. Such cardinal changes at PJSC "Borshchagivsky Chemical and Pharmaceutical Plant" were marked and in 2006 by the Diploma from the Ministry of Environmental Protection of Ukraine and the medal "People's Choice" for environmentally friendly production.

Table 5. Integral index of fluctuation asymmetry in the sample (motorway, Prospekt Peremohy)

	Indicator No.					**Value of asymmetry**
No.	1	2	3	4	5	
1	0.036	0.019	0.024	0.083	0.019	0.036
2	0.098	0.073	0.037	0.176	0.023	0.081
3	0.085	0.020	0.04	0.071	0.015	0.046
4	0.083	0.032	0.069	0.2	0.034	0.084
5	0	0.011	0.024	0.090	0.008	0.027
6	0.012	0.011	0	0.111	0.021	0.031
7	0.098	0.021	0.030	0.043	0	0.038
8	0.060	0.022	0.076	0.1	0.017	0.055
9	0.118	0.031	0.071	0.04	0.046	0.061
10	0.093	0.027	0.047	0.037	0.042	0.049
Value of asymmetry in the sample						X=0.051

One of the highest indicators of asymmetry is observed at a research area near the motorway on Prospekt Peremohy. A large number of motor transport of various categories, constant traffic jams, and lack of automotive bypassings led to the assignment the highest IV point for this site, according to our research, with an index of 0.051. The emissions of road transport contain more than 200 chemical compounds, including dangerous to human health, such as carbon monoxide and nitrogen oxides, various hydrocarbons. Gasoline engines, in

addition, produce products that include metals, chlorine, bromine, and diesel egines produce a significant amount of soot and other particles of ultra microscopic size. All these components are released into the environment and negatively affect both plant organisms and human health.

CONCLUSIONS

The article provides a background monitoring for the city of Kyiv. For this purpose, four model platforms were selected in different parts of the city. In order to assess the quality of the urban environment, the silver birch was used. During the formation of the lamina at these trees, the inhibition of growth processes and deformation of the leaf occurs due to the accumulation of toxic substances. Therefore, the signs of lamina of *B. pendula* are the main object for the characterization of the development stability and the environmental quality.

According to the results of the work, the state of the environmental quality (atmospheric air) was evaluated using the fluctuation asymmetry index for the lamina of *B. pendula*. The calculation of the class for the quality of the urban environment based on the FA showed that trees in park zones and territories with the location of enterprises, concerned about their image in the field of environmental protection, were formed in conditions with minimal impact on individual development, in contrast to the trees in Kyiv, which area of growth are motorways significantly violating the state of atmospheric air, thus forming a critical IV class of environmental situation.

REFERENCES

1. Захаров В.М., 1987. Асимметрия животных. М.: Наука, 215.
2. Захаров В.М., 2000. Здоровье среды: практика оценки. Центр экологической политики, 318.
3. Малишева Н.Р., 2008. Державний моніторинг довкілля. Екологічне право України. Академічний курс: Підручник. К.: ТОВ «Видавництво «Юридична думка», 195 - 200.
4. Родіонов О.В., 2006.Екологізація і ділова репутація підприємства: монографія. Луганськ: Вид-во СНУ ім. В. Даля, 168.
5. Скакальський О., 2015. Екологічний моніторинг у системі природоохоронної діяльності регіональноївлади Державне управління та місцеве самоврядування. 4(27), 152-162.
6. Тихонова И.О., 2012. Экологический мониторинг водных объектов: Учебное пособие. М.: Форум, НИЦ ИНФРА-М, 152.
7. Шарафутдинов Г.С., 2012. Экологический мониторинг техносферы: Учебное пособие. СПб.: Лань, 368.
8. Broun L., 2002. Eco-Economy. New York: W. W. Norton&Company, 334.
9. Callens T., Galbusera P., Matthysen E., Durand EY., Githiru M., 2011 Genetic signature of population fragmentation varies with mobility in seven bird species of a fragmented Kenyan cloud forest. Mol Ecol 20, 1829–1844.
10. Cowart N., Graham J., 1999. Within- and among-individual variation in fluctuating asymmetry of leaves in the fig (*Ficus carica L.*). Int J Plant Sci., 160, 116–121.
11. Franiel I., 2008. Fluctuating asymmetry of Betula pendula Roth. leaves – an index of environment quality. Biodiv. Res. Conserv., v. 9-10, 7-10.
12. Jenkins B.R., 2003. Benchmarking for best practice environmental management. Environmental monitoring and assessment, № 85, 115-134.
13. Loehle C. 2004. Challenges of ecological complexity. Ecological complexity, 1, 3-6.

14. Nivova D. J., Dushkova P. I., Kovacheva G. V., 1983. Anatomical, Morphological studies of *Platanus acerifolia* at various degrees of air pollution. Ekologiya (Sofia)., 6, 35–47.
15. Palmer A., 2004. Symmetry breaking and the evolution of development. Science., v. 306 (5697), 828-833.
16. Sakai K., Shimamoto Y., 1965. Developmental instability in leaves and flowers of Nicotiana tabacum. Genetics., 51, 801–813.
17. Shadrina E., Vol'pert Y., 2015. Evaluation of Environmental Conditions in Two Cities of East Siberia. Using Bio-indication Methods (Fluctuating Asymmetry Value and Mutagenic Activity of Soils). International Journal of Biology, v. 7, 1; 20-32.
18. Sherry R., Lord E., 1996. Developmental stability in leaves of Clarkia tembloriensis (Onagracea) as related to population outcrossing rates and heterozygosity. Evolution, 50, 80–91.
19. Van Dongen S., Molenberghs G., Matthysen E., 1999. The statistical analysis of fluctuating asymmetry: REML estimation of a mixed regression model. J Evol Biol 12, 94–102.
20. Velickovi M., 2010. Developmental stability in Tilia cordata leaves. Period biol, v. 112, 3, 273-281.
21. Wilsey B.J., Haukoja E., Koricheva J., Sulkinoja M., 1998. Leaf fluctuating asymmetry increases with hibridization and elevation tree – line birches. Ecology, v. 79 (6), 2092-2099.

АНОТАЦІЯ

ОЦІНКА ЯКОСТІ УРБОСЕРЕДОВИЩА м. КИЄВА

У статті проведено фоновий моніторинг м. Києва. Для оцінки якості урбосередовища використовувалась деревна рослина береза повисла (Betula pendula). Під час формування листової пластинки цих дерев, по мірі накопичення токсичних речовин, відбувається гальмування ростових процесів і деформація листка. Тому, ознаки листової пластинки B. pendula являються основним об'єктом для характеристики стабільності розвитку і якісного стану навколишнього середовища. Листові пластинки B. pendula були відібрані після зупинки росту листя (в кінці серпня 2017 р.). Кожна вибірка складалася зі 100 листових пластинок (по 10 листків з одного дерева), які були взяті з нижньої частини крони дерева, на рівні піднятої руки, з максимальної кількості доступних гілок, рівномірно навколо дерева. При зборі листя враховували його розмір і функціональний стан (збирали розвинені листові пластинки середніх розмірів).

Для досліджень використано методику оцінки якості середовища за флуктуаційною асиметрією B. pendula. Проведено вивчення морфологічних показників об'єкта дослідження на пробних майданчиках (ПМ) різних районів м. Києва: ПМ1 – автомобільна дорога (проспект Перемоги); ПМ2 – ПАТ НВЦ «Борщагівський хіміко-фармацевтичний завод»; ПМ3 – Парк «Нивки»; ПМ4 – Київська телевежа.

За результатами дослідження визначено, що незважаючи на те, що поряд з парком «Нивки» розташовуються станції метро: «Берестейська» (у східній частині парку) і «Нивки» (у західній частині) та проходить полотно залізниці, у 2017 р. величина флуктуаційної асиметрії в цьому районі склала 0,036 – умовна норма стану середовища (атмосферного повітря). Отримані показники, скоріш за все пов'язані з тим, що парк «Нивки» – це один з тих небагатьох парків Києва, який ще зберіг на своїй території багатовікові дерева, а площа його становить 60 га (західна частина – 15 га, а східна – 45 га).

Встановлено, що величина асиметрії у вибірці біля ПАТ НВЦ «Борщагівский ХФЗ», який займає одне з провідних місць за обсягами виробництва і реалізації готових лікарських засобів серед українських фармацевтичних підприємств характеризується достатньо сприятливими умовами для розвитку рослин. Це пов'язано з тим, що у підприємства зі зміною керівництва розпочався новий етап у розвитку – технічне переоснащення підприємства й створенні системи якості, яка відповідає світовим стандартам виробництва лікарських засобів.

За даними досліджень, на території Київської телевежі величина флуктуаційної асиметрії складає 0,038. Показник характеризує умовну норму стану середовища (атмосферного повітря). Ймовірно, віддаленість району розташування Київської телевежі від автотранспортних магістралей та інших об'єктів промислового комплексу зменшує вплив на рослинні організми в процесі онтогенезу.

Одним знайбільш високих показників величини асиметрії характеризується район досліжень біля автомобільної магістралі на проспекті Перемоги. Велика кількість автомобільного транспорту різних категорій, постіні затори, відсутність автомобільних розв'язок призвело до присвоєння цьому району за даними наших досліджень найвищого IV балу з показником 0,051.

Таким чином, проведено оцінку стану якості середовища (атмосферного повітря) з використанням показника флуктуаційної асиметрії листової пластинки B. pendula. Розрахунок бальних оцінок якості урбосередовища за показниками ФА показав, що дерева в районах паркових зон та територій з розташуванням підприємств, які турбуються про свій імідж в сфері охорони навколишнього середовища сформувались в умовах, які мінімально впливають на індивідуальний розвиток, на відміну від дерев м. Києва, районом зростання яких є автотранспортні магістралі, що істотно порушують стан атмосферного повітря, тим самим формують критичний IV клас стану середовища.

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FORMATION OF SOIL PROPERTIES ON THE SLOPE DEPENDING ON THE LOCATION IN THE RELIEF ON THE EXAMPLE OF CERGOWA IN THE BESKID NISKI

Abstract. In low mountains with a small vertical diversity of climatic conditions, the lithological properties of the substrate rocks and the characteristics of the rock decay (parent rock) take on a relatively greater significance in shaping the soil process. The mountain climate in the Low Beskids region is diversified. Above 600 m above sea level, there is a moderately cold floor with an average annual air temperature below 6.0 °C with an annual rainfall of more than 1150 mm and a vegetation period of 195-200 days. At lower altitudes, it is warmer and there is less rainfall.

Within the geomorphological cross-section of the examined slope, 4 soil profiles were unveiled. Among the humus substances of the upper part of the slope, humins and humic acids dominate, while in the lower part, fulvic acids. The pH of soil in the upper part of the slope is slightly acidic (pH>6.5), while in the lower part – intensively used for agriculture, there is a strong top acidity (pH<4.5). Degree of saturation of the soil sorption complex on the slope with alkaline cations usually exceeds 70%, and only in soils intensively used for agriculture in the lower part of the slope, it is about 60%.

Key words: humus substances, KSG cation structure, agricultural usefulness of soils

INTRODUCTION

The Low Beskids, within which Cergowa lies, belongs to the medium-high mountains in terms of altitude, the long and relatively mild slopes of which are usually used for agricultural purposes. Only in some top parts of the slopes, there are small patches of initial rocky soils and small soilless surfaces. The soil cover on the slopes shows little typological diversity and a clear link to the lithology of the ground rocks and the orography of the terrain (l3,16). The lithology and tectonics of rocks in connection with the relief modify the condition of soil material and hydrological conditions consisting in the lateral movement of water (horizontal transport of soluble components and suspensions) as well as spatial differentiation of the moisture in the profile. Local diversity of these factors in different parts of the slope determines the quality of habitat and the way it is used (6). Also, intensive human economic activity exerted an influence on the soil cover by means of cleaning the slopes and creating a plough-humic level (12). The agricultural usefulness of modern soils in this region is diverse and refers to habitat factors, quality of soil material, terrain sculpture and exposition that shape the local microclimate (3,12).

The aim of the research was to determine the relationship between soil properties and their location in terrain, as well as their agricultural suitability within the transect on the northern slope of Cergowa.

METHODS

Characterization of soils within the northern transect of concave Cergowa slope was carried out on the basis of the field work and laboratory tests carried out at the Department of Soil Science, Environmental Chemistry and Hydrology, Faculty of Biology and Agriculture at the University of Rzeszów. Their physical properties, location in relief and morphological structure are presented in paper (5). The article mainly focuses on the presentation of sorption properties of soils and their abundance in nutrients. In soil samples, active acidity (according to

the method used in the Department of Soil Science, Environmental Chemistry and Hydrology, UR), exchange acidity applying Dajkuhara method and hydrolytic acidity according to Kappen (4) as well as pH in water and 1mol(+)KCl·dcm-1 using the potentiometric method, were determined. Contents of exchangeable forms of calcium, magnesium, potassium and sodium extracted with ammonium acetate were determined and the sum of exchange bases was calculated. The content of total nitrogen was determined by the Kjeldahl method, whereas the level of available phosphorus and potassium forms was determined by the Egner-Riehm method and magnesium by the Schachtschabel method

RESULTS AND DISCUSSION

Soil processes are inseparably connected with the occurrence of water, that is the environment of chemical reactions and essential for biological life. Renewing its resources in the soil (as the difference of precipitation and the surface runoff) also allows the transport of components in accordance with the flow of ground waters. On the slopes, the flow of the ground waters is conditioned by the tectonics and lithology of the ground rocks, which complicates the distribution of humidity in the profiles referring to the position in different parts of the slope. According to studies by Nana et al. (10), the highest water flow velocity occurs at about 15% of the skeletal fractions content. In addition, the intensity of subsurface water flow depends on the slope inclination, and above all, on the soil moisture before rainfall (1).

The Cergowa peak range is overgrown with a complex of fertile humid habitats of Carpathian beech forest and mountain pine (Dentario glandulosae-Fagetum) with fir elm and sycamore, and a small undergrowth. This ecosystem is under the clear influence of locally emerging surface water abundant in nutrients. Soils in the upper part of the slope (profiles 1 and 2) are fed with water from direct rainfall and water flowing down from the rocky ridge part of the slope. These waters usually have pH above 5.6, which is considered as the natural degree of acidification of rainwater (17), and the results of performed analyzes show a low active and exchangeable acidity in the whole profile of these soils (Table 1), which allows to classify them in terms of pH to slightly acidic.

Table 1. Acidity and soil reaction in the northern slope of Cergowa

Profile No. and elevation	Genetic horizon	Depth [cm]	Acidity			pH	
			Hcz*	Hw**	Hh***	1MKCl	H2O
			cmol(+)·kg-1 soil				
1 551 m.a.s.l.	A	0-24	0,05	0,01	4,4	5,63	5,97
	ABbr	24-30	0,07	0,01	3,6	5,53	6,17
	Bbr/C	30-57	0,09	0,01	3,4	5,69	6,34
	C1(g)	57-79	0,13	0,01	3,2	5,57	6,56
	C2g	79-100	0,17	0,01	2,8	5,45	6,74
2 505 m.a.s.l.	A	0-13	0,05	0,01	4,0	5,76	6,08
	ABbr	13-33	0,06	0,01	3,2	5,68	6,43
	Bbr/C	33-49	0,10	0,01	2,8	5,69	6,83
	Bh/C(g)	49-82	0,12	0,01	3,6	5,78	6,81
	C(g)	82-100	0,13	0,01	2,8	5,80	6,63
3 436 m.a.s.l.	Ap	0-13	0,05	0,27	9,2	3,83	4,71
	ABr	13-31	0,05	0,27	6,4	3,83	4,97
	Bbr/C(g)	31-44	0,03	0,02	4,8	4,32	5,39
	C1(g)	44-67	0,05	0,01	4,9	5,48	6,30
	C2g	67-100	0,08	0,01	6,0	5,98	6,89

4 400 m.a.s.l.	Ap	0-18	0,05	0,17	8,3	3,83	4,76
	ABbr	18-51	0,05	0,06	4,4	4,26	5,22
	Bbr/C	51-58	0,05	0,03	4,8	4,27	5,25
	Bhbr/C(g)	58-69	0,05	0,03	7,2	4,13	5,35
	Cg	69-100	0,04	0,01	4,0	6,33	6,83

*Hcz – active acidity
**Hw – exchangeable acidity
***Hh – hydrolytic acidity

In the levels of solum as well as the parent rock of these soils, there is a large variation in the grain size (fraction of <0.002 mm is in the range of 18 to 48%) and organic carbon content, which does not translate into the dynamics of hydrogen ions. About 20% of hydrogen cations strongly bonded in the sorption complex, with hydrolytic acidity of 3-4 cmol(+)·kg-1 of the soil, indicates good soil buffering in this part of the slope.

Soils in the highest positions on the slope (with a large inclination of the surface) usually have the highest bulk density, hence low water retention and relatively large surface runoff (14). Movement of water involves the transport of organic black and dark gray colloidal humid substances. In soils of the Western Bieszczady Mountains, in habitats with beechwood, but at much higher heights, Drewnik (2) found that at a high rate of changes resulting from the degradation of ectohumus, the products are dominated by the fulvic acid fraction, which should be associated with extremely low soil pH and vegetation type. In our own research, dark gray and black colloidal substances are visible in the form of surface runoff and groundwater runoff in the soil profiles. These hardly soluble humic substances with a high carbon content do not show higher chemical and physicochemical activity, including sorption abilities. In profile 2, their accumulation allows separating the morphologically distinct level of enrichment of Bh/C with the content of carbon in humus substances at the level of 1.42%, lying at a depth of 49-82 cm. The content of total nitrogen determined in this profile determines the increased trophicity of the habitat, and the relation C/N = 12.9 resulting from the nature of humic substances transformation confirms the high proportion of humines in humic substances (Table 2).

Table 2. Selected sorption properties of soils and C/N ratio in soil profiles of the northern Cergowa slope

Profile No.	Genetic horizon	SEB*	CEC**	BS ***	N	C/N
		cmol(+)·kg-1 soil		(%)	(%)	
1	A	13,4	17,7	75,7	0,17	13,4
	ABbr	14,0	17,6	79,5	0,12	12,2
	Bbr/C	13,3	16,7	79,6	0,07	10,3
	C1(g)	13,1	16,3	80,4	0,02	-
	C2g	12,8	15,6	82,0	0,02	-
2	A	15,6	19,6	79,6	0,17	13,9
	ABbr	12,2	15,4	79,2	0,10	12,3
	Bbr/C	13,6	16,4	82,9	0,08	11,4
	Bh/C(g)	13,4	17,0	78,8	0,11	12,9
	C(g)	14,8	17,6	84,1	0,08	-
3	Ap	13,0	22,2	58,5	0,12	12,5
	ABbr	14,0	20,4	68,6	0,04	12,2
	Bbr/C(g)	18,4	23,2	79,3	0,03	10,3

	C1(g)	17,2	22,1	77,8	-	-
	C2g	15,6	21,6	72,2	-	-
4	Ap	12,6	20,9	60,3	0,13	10,8
	ABbr	11,2	15,6	71,8	0,04	9,0
	Bbr/C	12,6	17,4	72,4	0,05	8,4
	Bhbr/C(g)	14,4	21,6	66,7	0,19	9,3
	Cg	13,0	17,0	76,5	-	-

*SEB – Sum of exchangeable bases
**CEC – Cation exchange capacity
***BS = S/T·100%

Significant enrichment of Bh/C level of this soil in carbon of humus substances is undoubtedly related to the increase in the content of skeleton fractions, that at a depth of 49-82 cm constitute about 30% of the soil material volume, against their absence in level A.

The profile distribution of humus in soils of the slope is shaped, according to Smith et al. (15), by erosion processes. They shape a mosaic of organic carbon distribution and its transformation throughout the landscape. The profile distribution of organic carbon in the upper part of the slope is, according to Novara et al. (11), quite stable and refers to the intensity of erosion.

In the basement of the soil, in the upper part of the slope, at a depth of about 50 cm, there is periodically excessive waterlogging favoring hydromorphism processes, which are marked by marble-like gleying. Soils of the upper part of the slope are characterized by very good sorption properties (Table 3).

Table 3. Structure of the sorption complex of soils on the northern slope of Cergowa

Profile No.	Genetic horizon	Ca	Mg	K	Na
		%			
1	A	72,7	16,5	8,6	2,2
	ABbr	71,3	16,3	9,6	2,8
	Bbr/C	65,4	21,8	11,3	1,5
	C1(g)	71,9	17,3	10,1	0,7
	C2g	64,8	22,3	12,1	0,8
2	A	69,6	20,0	7,8	2,6
	ABbr	59,8	26,2	10,7	3,3
	Bbr/C	67,6	22,4	9,2	0,7
	Bh/C(g)	68,3	21,2	9,8	0,7
	C(g)	68,9	19,9	9,9	1,3
3	Ap	69,6	15,8	8,5	6,1
	ABbr	71,1	15,1	7,4	6,4
	Bbr/C(g)	80,9	10,7	6,8	1,6
	C1(g)	79,1	11,8	8,0	1,1
	C2g	76,5	11,8	10,4	1,3
4	Ap	72,7	14,8	7,0	5,5
	ABbr	66,3	17,3	8,3	8,1
	Bbr/C	74,8	14,4	9,3	1,5
	Bhbr/C(g)	79,9	10,5	8,9	0,7
	Cg	71,8	16,5	10,9	0,8

They show quite large sorption capacity, from 15.4 to 19.6 cmol(+)·kg-1 of soil in individual genetic profiles, not related to the fraction of □<0.002 and carbon content of humus substances. Profile differentiation according to Kacprzak (8) is a manifestation of lithologic-pedogenic discontinuity phenomena commonly occurring on the Carpathian slopes.

In the structure of the sorption complex, proportion of sodium cations was from 0.7 to 3.3%, potassium from 7.8 to 12.1%, magnesium from 16.3 to 26.2% and calcium from 59.8 to 72.7%, in individual soil levels. The abundance of slope soils in nutrients important from the agricultural point of view was little differentiated. In the upper part of the slope, there was a deep deficiency of available phosphorus in soils. Its content was usually below 5mg P_2O_5.100g-1 soil. The content of available magnesium was very high – above 14 mg Mg.100g-1 soil, whereas content of available potassium was not very varied within the profiles and belonged to the middle-abundant class (table 4).

According to research by Li et al. (9), organic matter in the soils of upper part of the slope limits the risk of surface runoff and loss of nutrients (nitrogen and phosphorus). Due to the location and long distance to farm buildings, a large part of these soils is currently a post-agricultural area or is planted with trees nowadays. The utility value of soils in the upper part of the slope, despite the relatively good quality of soil material, is low. These soils belong to the IV class of bonitation due to the climatic conditions associated with elevation above sea level, slope and the northern exposition (13.16).

In the lower part of the slope (less than 450 m above sea level) with a smaller slope of about 7°, the soil has been intensively used as arable land for many years. The reaction of these soils (profiles 3 and 4) in surface levels is very acidic (Table 1), which is undoubtedly associated with the intensive removal of alkaline cations with the yield of cultivated plants and, on the other hand, with the abandonment of their rational fertilization, including liming. Concentration of free hydrogen ions strongly bound to the sorption complex in the level of Ap is 9.2 and 8.3 cmol(+)·kg-1 of the soil, with relatively small concentration of hydrogen ions weakly bound to the sorption complex, 0.27 and 0.17 cmol(+)·kg-1 soil, respectively. Concentration of hydrogen ions is related to the saturation of the sorption complex of these soils with basic cations. In the level Ap, it is about 60%, while in lower levels, it increases to 70-80%. The sorption capacity of soils in the lower part of the slope is clearly higher compared to soils in the upper part of the slope (Table 2) and is usually above 20 cmol(+)·kg-1 of the soil. Yellow color of the soil in the dry state suggests dominance of humic substances by fulvic acids in these soils. Determined C/N ratio in the level Ap is above 10, while in levels below, less than 10, which confirms the high proportion of fulvic acids in humic substances. In the level of Bhbr/C (g) of the soil (in profile 4), at a depth of 58-69 cm, relatively high content of soil nitrogen was found – 0.19% N with a C/N ratio = 9.3

The high nitrogen content indicates the high trophicity (fertility) of the habitat, and the northern exposition additionally favors the nitrification process of nitrogen (7), which increases its dynamics in the profile. Shi et al (14) draws attention to the variability of the soil properties on the slope. According to these authors, variation coefficient in soil physical properties is about 37% in the 15-25 cm layer, while in the 15-85 cm layer, only 12%. However, variability of chemical properties is much greater.

The structure of basic cations in the sorption complex of the soils in the lower part of the slope did not differ much from those in the upper part (Table 3). The proportion of sodium cations ranged from 0.7 to 8.1%, with a high share only in surface levels, which indicates their anthropogenic nature. Proportion of potassium ranged from 6.8 to 10.9% in individual genetic profiles and was associated with a top impoverishment. The proportion of soluble forms of magnesium and calcium ranged from 10.5 to 17.3% and from 66.3 to 80.9%, respectively, without any dependence on genetic levels.

Table 4. The content of bioavailable forms of nutrients in the soils of the northern Cergowa transect

Profile No.	Genetic horizon	Content of available forms		
		P_2O_5	K_2O	Mg
		mg ·100g-1soil		
1	A	4,05	14,9	16,8
	ABbr	3,08	13,2	16,6
	Bbr/C	3,30	13,1	15,9
	C1(g)	3,83	14,9	16,8
	C2g	4,43	15,4	17,6
2	A	4,09	13,8	17,9
	ABbr	4,35	11,7	18,5
	Bbr/C	3,90	8,5	14,5
	Bh/C(g)	15,98	13,9	16,6
	C(g)	12,55	15,3	14,3
3	Ap	4,35	15,6	15,6
	ABbr	3,53	16,4	24,6
	Bbr/C(g)	4,01	15,0	23,8
	C1(g)	3,08	15,8	19,3
	C2g	6,56	16,5	20,0
4	Ap	3,75	8,9	12,5
	ABbr	3,04	8,8	18,8
	Bbr/C	3,72	12,4	26,7
	Bhbr/C(g)	4,24	16,3	28,0
	Cg	8,80	11,0	29,0

Soil abundance in digestible forms of nutrients at the bottom of the slope did not differ much from soils in the upper part of the slope. They were severely depleted from the available forms of phosphorus and showed strong variation within individual profiles, which is consistent with results achieved by Shi et al. (14), who found that in the case of available phosphorus, the profile variability coefficient reaches 95%. Abundance in available potassium in profile 3 was average, while in profile 4 – low. Content of available magnesium allowed to count soils at the bottom of the slope to a high-abundant class. The utility value of soils from the lower gentle part of the slope is medium, and similar to soils in lowland areas, which makes it possible to include them in the third class of bonitation.

CONCLUSIONS

1. Among humus substances, humins and humic acids dominate in the upper part of the northern slope, while in the lower part, fulvic acids predominate.

2. The soil reaction in the upper part of the slope is slightly acidic (pH>6.5), while in the lower part – intensively used for agriculture, there is a strong top acidification (pH<4.5).

3. Degree of the sorption complex saturation of soils on the slope with basic cations usually exceeds 70%, only in soils intensively used for agriculture in the lower part of the slope, it is about 60%.

4. Quite large proportion of sodium cations (5.5-8.1%) in the soil sorption complex from the humus level in the lower part of the slope is of anthropogenic nature.

5. Regardless of the location in the relief, the content of available phosphorus in soils is critically small, while magnesium and potassium – satisfactory

LITERATURE

1. Ban Y., Liqin Q., Tingwu L., Yuan G. 2017. Effect of stone content on water flow velocity over Loess slope: non-frozen soil. Journal of hydrology. 549, 525-533.
2. Drewnik M. 2006. Właściwości stropowych poziomów próchniczych gleb polskiej części Karpat. Rocz. Bieszcz. 14, 221-235.
3. Gąsior J., Jakobieńczuk W.F., Oliwa B. 2003. Kształtowanie się właściwości gleb górskich Karpat pod trwałymi użytkami zielonymi. Zesz. Nauk. AR Kraków. 399, 71-79.
4. Gąsior J., Kaniuczak J., Hajduk E.,Właśniewski S., Nazarkiewicz M., Bilek M. 2013. Metody badań fizycznych właściwości gleb cz. I i II. Wyd. UR Rzeszów. 55.
5. Gąsior J., Właśniewski S., Hamor A., Bartman M. 2017. Procesy glebowe na północnym stoku Cergowej jako wskaźniki geomorfologicznych procesów stokowych w Beskidzie Niskim. Acta Carpathica. 25/26, 13-22.
6. Hacisalihoglu S. 2007. Determination of soil erosion in a steep hill slope with different land-use types: a case study in Mertesdorf (Ruwertal/Germany). Journal of Environmental Biology. 28 (2 Suppl), 433-438.
7. Hishi T., Urakawa R., Shibata H. 2017. Effects of soil origin and current microclimate conditions on nitrogen mineralization in forest soil on different slope aspects in Hokkaido, Japan. Ecological Research. 32 (5), 725-733.
8. Kacprzak A. 2003. Pokrywy stokowe jako utwory macierzyste gleb Bieszczadów Zachodnich. Rocz. Gleb. LIV, (3), 97-110.
9. Li Z., Chi-ming G.,Fang Ch., Guo-shi Z., Li W., Mohamed I., Run-hua Z., Run-qin Z., Yi L. 2017. The benefic effect induced by biochar on soil erosion and nutrient loss of slopping land under natural rainfall conditions in central China. Agricultural water management. 185, 145-150.
10. Nana Z., Fuliang Y., Chuanzhe L., Lu Z., Jia L., Wenbin M., Hao W. 2015. Soil Moisture Dynamics and Effects on Runoff Generation at Small Hillslope Scale. Journal of Hydrologic Engineering. 20 (7), 1-13.
11. Novara A., Pisciotta A., Minacapilli M., Maltese A., Capodici F., Cerdà A., Gristina L. 2017. The impact of soil erosion on soil fertility and vine vigor. A multidisciplinary approach based on field, laboratory and remote sensing approaches. The Science Of The Total Environment. 622/623, 474-480.
12. Partyka A. 1972. Rolnicza przydatność gleb obszaru Bieszczadów (cz. I i II), Wyd. IUNG Puławy 54,72.
13. Partyka A. 2001. Procesy glebowe na stokach na przykładzie miejscowości Terka w Bieszczadach Zachodnich. Zesz. Nauk. AR w Krakowie. 375, 15-26.
14. Shi D., Jiang G., Jiang P., Lou Y., Ding W., Jin H. 2017. Effects of soil erosion factors on cultivated-layer quality of slope farmland in Purple Hilly Area. Transactions of the Chinese Society of Agricultural Engineering. 33,(13). 270-279.
15. Smith S.V., Bullock S.H., Hinojosa-Corona A., Franco-Vizcaíno E., Escoto-Rodríguez M., Kretzschmar T.G., Farfán L.M., Salazar-Ceseña J.M. 2007. Soil erosion and significance for carbon fluxes in a mountainous Mediterranean-climate watershed. Ecological Society of America. 17, (5) 79-87.

16. Uziak S. 1969. Wpływ rzeźby terenu na typologiczne zróżnicowanie pokrywy glebowej w Karpatach Fliszowych. Rocz. Gleb. 20, 81-96.
17. WIOŚ Rzeszów. 2014. Raport o stanie środowiska w województwie podkarpackim w roku 2013. Biblioteka Monitoringu Środowiska, 153.

STRESZCZENIE

KSZTAŁTOWANIE SIĘ WŁAŚCIWOŚCI GLEB NA STOKU W ZALEŻNOŚCI OD POŁOŻENIA W RZEŹBIE TERENU NA PRZYKŁADZIE CERGOWEJ W BESKIDZIE NISKIM

W Beskidzie Niskim należącym do gór niskich, o niewielkim pionowym zróżnicowaniu warunków klimatycznych, właściwości gleb zależą przede wszystkim od skał podłoża i powiązanymi z nimi zbiorowiskami roślinności. Dużą rolę odgrywa również ukształtowanie terenu i miąższość zwietrzeliny oraz sposób jego użytkowanie. Czynniki te decydują o „mozaikowatej strukturze pokrywy glebowej" w obrębie stoków. Kształtowanie się właściwości gleb istotnych z rolniczego punktu widzenia na północnym stoku Cergowej przedstawiono na podstawie prac terenowych i wyników analiz laboratoryjnych gleb z czterech profili glebowych odsłoniętych wzdłuż transektu na wysokości od 551 do 400m n. p. m.

Pasmo szczytowe Cergowej porośnięte jest kompleksem żyznych wilgotnych siedlisk buczyny karpackiej i jaworzyny górskiej (Dentario glandulosae-Fagetum) z jodłą wiązem górskim i jaworem oraz nielicznym podszytem. Ekosystem ten jest pod wyraźnym wpływem wydostających się lokalnie na powierzchnie wód śródpokrywowych zasobnych w składniki pokarmowe. W części podszczytowej (profile 1 i 2) obecnie teren nie stanowi gruntu ornego, jest trwałym użytkiem zielonym lokalnie terenem porolnym. W dolnej części (profile 3 i 4) powierzchnia stoku jest intensywnie użytkowana rolniczo.

Wody opadowe o niewielkim naturalnym stopniu zakwaszenia (pH >5,6), w górnej części stoku (o większym nachyleniu) słabo infiltrują, a w większości spływają powierzchniowo i podpowierzchniowo. Skutkiem tego gleby nie ulegają większemu zakwaszeniu, natomiast substancje humusowe w szybkim tempie ulegają dekompozycji, a produkty ich przemian w formie kwasów huminowych są przemieszczane z poziomym przepływem roztworu glebowego i deponowane w niższych położeniach. W ten sposób migrują również inne rozpuszczalne składniki, tym bardziej, że w spągu profili procesy glejowe ułatwiają rozpuszczanie połączeń.

W dolnej części stoku (poniżej 450m n.p.m.) o mniejszym nachyleniu gleby od wielu lat są intensywnie użytkowane rolniczo jako grunty orne, a ich odczyn (profile 3 i 4) w poziomach powierzchniowych jest bardzo kwaśny. Wiąże się to niewątpliwie z intensywnym wyprowadzaniem kationów zasadowych z plonem uprawianych roślin, a z drugiej strony z zaniechaniem racjonalnego nawożenia, w tym wapnowania. Towarzyszy temu redukcja wysycenia kompleksu sorpcyjnego kationami zasadowymi od około 60%. Stosunkowo duża zawartość azotu w glebie profilu 4 wskazuje na dużą troficzność (żyzność) siedliska, a północna wystawa dodatkowo sprzyja procesowi nitryfikacji azotu, co zwiększa jego dynamikę w profilu.

Bez względu na położenie w rzeźbie terenu zawartość przyswajalnych form fosforu w glebach jest krytycznie mała, natomiast magnezu i potasu zadowalająca. Dość duży udział kationów sodu (5,5 – 8,1%) w obsadzie kompleksu sorpcyjnego gleb z poziomu próchnicznego w dolnej części stoku ma charakter antropogeniczny.

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ENVIRONMENTAL DISTRIBUTION OF IODINE AND ITS PRACTICAL APPLICATIONS

Abstract. Iodine, belonging to the halogen group of chemical elements, is one of the least abundant nonmetallic elements in Earth's composition. Iodine is very unevenly distributed throughout the planet with varying concentrations in different environmental compartments. Most terrestrial environments are characterized by a low content of iodine, while the major part of global iodine is in the marine environment. Iodine is an essential micronutrient for humans and animals and an industrially important element. For industrial purposes, the main sources of iodine are deposits of Chilean caliche, containing iodine admixtures in the form of calcium iodate, and subterranean brines associated with oil and gas deposits. Iodine, along with its chemical compounds, has multiple applications in various industry sectors, medicine and agriculture.

Key words: iodine, micronutrient, iodine biogeochemistry, iodine reserves, caliche, subterranean brine, iodine applications, biocides, iodine-containing additives, fertilizers.

INTRODUCTION

Iodine, discovered in 1811 by Bernard Courtois, is the least abundant of the halogen elements in Earth's composition. Iodine is a naturally occurring constituent of the earth's crust; however, its natural distribution is uneven and varies greatly in different environmental compartments. Iodine levels have been shown to be low in most terrestrial environments (igneous rocks, continental waters, soils, land vegetation), whereas the marine environment, sedimentary rocks rich in organic material, and subterranean brines are characterized by higher iodine concentrations [14, 15]. The element can accumulate in many taxonomic groups of biota, especially in marine organisms (algae, invertebrates) capable of effectively concentrating iodine from the surrounding milieu. In humans and other vertebrates, iodine accumulates in the thyroid gland, where it is involved in the synthesis of thyroid hormones [3, 4, 28, 41], potent regulators of metabolic and physiological processes [2, 4, 6, 7].

Iodine is largely a cyclic element and moves through the biotic and abiotic compartments of Earth, thereby participating in global environmental processes. Iodine cycles involve its chemical speciation in the atmosphere, hydrosphere and soils, as well as at the air-water-sediment interfaces [8]. The mobility and reactivity of iodine species is affected by changes in environmental conditions (physicochemical factors, as well as biological activity). At present, the natural cycle and geochemical behaviour of iodine are of particular interest in relation to environmental chemistry, radioecology, nutrition and human health. Iodine deficiency in humans caused by inadequate iodine intake is a significant public health problem worldwide [18, 41, 50]. This problem is quite acute in Ukraine, especially in endemic areas such as the Carpathian region in the west of Ukraine [3, 4].

Being a natural component of the environment, iodine is an industrially important element and has many practical applications in various industries, medicine, agriculture, etc. [3, 4, 19, 23]. The aim of the article was to analyze the chemical properties of iodine, its environmental distribution, industrial use and other practical applications of this element.

1. CHEMICAL PROPERTIES OF IODINE AND ITS COMPOUNDS

The chemical element iodine (I) with an atomic number of 53 and an atomic mass of 126.9 belongs to halogens that are in group 17 of the periodic table. Elemental iodine is a dark-gray to purple-black, lustrous solid with a rhombic crystalline structure, which easily sublimes bypassing the liquid form. Chemically, iodine exhibits a relatively high reactivity compared to other non-metals, although it is almost the least reactive among halogens. Iodine exists in the environment in the form of compounds rather than as a pure element, and shows oxidation states: –1, 0, +1, +3, +5 and +7 (valence I, III, V and VII) [27]. Although only slightly soluble in water, iodine dissolves easily in chloroform, hexane, and other organic solvents due to its lack of polarity.

Iodine forms environmentally important and industrially useful compounds with hydrogen, metals, other halogens and oxygen. In particular, iodine can form different oxides, such as radical iodine oxide (IO), iodine dioxide (IO_2), diiodine tetroxide (I_2O_4), diiodine pentoxide (I_2O_5) and tetraiodine nonoxide (I_4O_9). Many of them have been detected in the atmosphere and are considered to be particularly important in the marine boundary layer [24].

Iodine can react with many metals, preferably in the presence of water, and directly reacts with other halogens with the formation of interhalogen compounds (such as ICl, IBr_3, IF_5, etc.). Interhalogens are more reactive than elemental iodine and can be readily hydrolyzed with formation of halogen acid and oxy-halogen acid [39].

By interacting with reducing agents, iodine forms a gaseous hydrogen iodide (HI), which is readily soluble in water. Aqueous solution of HI is known as a hydroiodic acid (the second strongest hydrohalic acid after hydroastatic acid). Hydroiodic acid reacts with metals, oxides and salts of the other weak, non-oxidizing acids, causing the formation of iodides. Most iodides, such as KI, NaI, CaI_2, MgI_2, ZnI_2, BaI_2, are highly soluble in water, whereas Ag, Hg, Pb, Bi, Sn salts are insoluble [17]. Cuprous iodide (CuI) is poorly soluble in water (0.00042 g/L at 25°C), but it dissolves in the presence of NaI or KI to form the linear anion $[CuI_2]^-$. Dilution of such solutions with water reprecipitates CuI (this dissolution-precipitation process is employed to purify CuI) [26]. Iodide anion demonstrates strong reducing properties and can be oxidized in the presence of oxygen, halogen molecules or other oxidizers to molecular iodine (I_2). Iodide interaction with iodine molecules in aqueous milieu leads to the formation of polyiodides (that is, polyhalogen anions composed entirely of iodine atoms). The most common and simplest member is the triiodide ion, I_3^- [43].

Oxyacids of iodine are hypoiodous acid (HIO), iodous acid (HIO_2), iodic acid (HIO_3), and periodic acid, which can exist in two forms: orthoperiodic acid (H_5IO_6) and metaperiodic acid (HIO_4). Hypoiodous acid is a weak acid ($K_a = 2.3 \times 10^{-11}$), which exists only in weak aqueous solutions. It is extremely unstable and rapidly decomposes by disproportionation with the release of iodic acid and elemental iodine: $5HOI \rightarrow HIO_3 + 2I_2 + 2H_2O$. The salts of hypoiodous acid (hypoiodites) are also unstable, existing only in solutions.

Iodic acid is one of the most stable oxyacids of the halogens in its pure state. It is a medium-strong acid (pK_a=0.804), which is strongly oxidizing in acidic solution. When iodic acid acts as an oxidizer, the product of the reaction is either iodine, or iodide anion. The salts of iodic acid (iodates) exhibit strong oxidizing properties. When interacting with iodides in an acidic medium, iodates release elemental iodine. Most iodates are insoluble in water (except Na, K, NH_4, Mg salts) [17].

A portion of iodine is present in natural and industrial environments in the form of organic compounds that contain one or more carbon-iodine bonds. In humans and vertebrate animals, organic iodine compounds are represented by thyroglobulin, iodinated amino acids (3-monoiodotyrosine and 3,5-diiodotyrosine), iodine-containing hormones (thyroxine and triiodothyronine) and intermediates of their metabolism [4]. A variety of natural organic compounds of iodine have been found in marine invertebrates.

Organic iodine compounds (including those containing iodine at higher oxidation states) are widely produced by organic synthesis in the chemical industry and have found extensive application in various sectors of economic activity. Industrially significant organoiodine compounds, often used as disinfectants or pesticides, are iodoform (CHI_3), methylene iodide (CH_2I_2), methyl iodide (CH_3I), and others [33].

2. ISOTOPES OF IODINE

Most of the iodine in nature is represented by the only stable isotope ^{127}I. In addition, iodine has 42 recognized radioactive isotopes and isomers at atomic number 108–141 that include one long-lived radioactive isotope ^{129}I (half-life of 15.7 million years) and a number of short-lived radioactive isotopes [5]. The radioisotopes ^{131}I and ^{129}I are of particular environmental concern [25]. The long-lived isotope ^{129}I is the only naturally occurring radioactive isotope of iodine and an important by-product of nuclear fission. This radioisotope is produced in nature by cosmic-ray-induced spallation of xenon in the atmosphere and by spontaneous fission of uranium in the geosphere [42]. Artificial ^{129}I originates mainly from the fission of ^{235}U and ^{239}Pu induced by thermal neutrons with a fission yield of 0.9% from ^{235}U and 1.6% from ^{239}Pu. Anthropogenic ^{129}I has been released into the environment as a result of nuclear weapons testing, nuclear accidents (such as the Chernobyl disaster in 1986) and from spent nuclear fuel reprocessing plants. Nuclear weapon tests, which began around 1945 and peaked in 1963, added tens of kilograms of ^{129}I to the atmosphere [37]. Unlike most radionuclides produced during atmospheric bomb testing, which have returned to near pre-nuclear levels, the amount of ^{129}I in the environmental compartments has continued to increase due to subsequent emissions from nuclear fuel reprocessing plants [37]. At present, nuclear fuel reprocessing facilities are the major source (>90%) of ^{129}I released to the environment [5].

It has been recognized that ^{129}I is an important contributor in risk assessment because of its tendency to concentrate in biota components and in the human thyroid gland, a long half-life, and high mobility in the environments. Artificial ^{129}I enters the environmental cycle of iodine and changes the natural iodine isotopic ratio. Its concentration is used as an environmental tracer and as an indicator of the long-term human impact on the environment [40]. At present time, as a result of anthropogenic activities, the $^{129}I/^{127}I$ ratios in environmental compartments have being reached to values of 10^{-10} to 10^{-4} (compared with 10^{-12} in the pre-nuclear era) [20].

The short-lived ^{131}I isotope (with a half-life of 8.02 days) is one of the most important radioactive iodine isotopes because of its high specific activity of 4.59×10^3 TBq (terabecquerel) per gram. Radioisotope ^{131}I is a hazardous fission product, representing a major risk of short-term contamination in the event of nuclear accident or other incidents involving the release of radioactive materials. During thermal fission of ^{235}U, the ^{131}I and ^{129}I isotopes are produced with an isotopic ratio of $^{131}I/^{129}I = 3.82$ [11]. According to experts, ^{131}I isotope was responsible for 46% of the radioactivity dispersed after the reactor explosion in the Chernobyl disaster. The ^{131}I inventory in the reactor core at Chernobyl was estimated to be 3.2 EBq (exabecquerel) and the total ^{131}I released during the course of the accident was about 1.76 EBq [45]. In conditions of accidental release of ^{131}I into the environment, this radioisotope can accumulate in large quantities in the human thyroid, especially in people with iodine deficiency, which leads to radiation damage to thyroid follicular epithelial cells and thyroid dysfunction. Exposure to high doses of ^{131}I during and after the Chernobyl accident is considered the leading cause of thyroid cancer in populations living in the surrounding areas [45]. In the past, a huge amount of ^{131}I has been released into the environment during nuclear weapons testing. From 1945 until 1998, over 2000 nuclear tests were carried out all over the world. In particular, from 1951 to 1992, more than 900 nuclear tests were conducted at the Nevada Test Site, releasing about 5.55 EBq of ^{131}I [38], and more than 700 tests were conducted in the former USSR between 1949 and 1990 [35].

Despite the ecological risk of radioactive iodine isotopes in the case of their release in the above-mentioned situations, several radioisotopes of this element are used in medicine, scientific research, etc. In particular, due to the short half-life of ^{131}I, this radioisotope along with ^{123}I (with a 13-hour half-life) is used in diagnostic scintigraphic imaging, in the therapy of hyperactive thyroid gland and for post-surgical ablation of thyroid remnant in patients with thyroid cancer [1].

3. BIOGEOCHEMICAL BEHAVIOUR OF IODINE

Iodine is a trace element of the earth's crust (concentration of around 0.3 to 0.5 mg/kg) and is generally regarded as a hydrophile, atmophile and biophile element [14, 15]. In contrast to the lithophile nature of other halogens, iodine is more chalcophile than lithophile in character, as indicated by the high levels of iodine found in some ore minerals and sulfide-containing carbonatites [13]. Iodine is a volatile element that is transported through the atmosphere in gaseous form (such as I_2, alkyl iodides) and can therefore be classified as an atmophile; it is highly concentrated in the in marine and oceanic waters and, consequently, is classified as hydrophile element [13]. Iodine is also considered a biophile because of its marked association with organic matter [16]. Bioconcentration of iodine in living organisms from the surroundings is one of the features of iodine behaviour in the natural environment, with the global cycle of this element being closely associated with its biogenic transformation. Iodine is present in the environmental compartments in multiple oxidation states and in a variety of its chemical species, both inorganic and organic. Chemical speciation of iodine in nature is highly sensitive to changes in the surrounding environment and depends on pH, redox potential, organic matter content, temperature, sunlight intensity and microbial activity [14, 15].

Major part of the world's iodine reserve is found in the waters and bottom sediments of the seas and oceans, and the remainder is in continental rocks and soils. It is considered that most iodine in the soils and freshwater systems is derived from the World Ocean, the dominating source of iodine in its global environmental cycle [15]. The enrichment of terrestrial environments with iodine occurs via the volatilization of this element from the marine environment to the atmosphere and its subsequent transfer to the land surface by dry and wet deposition [15]. The oceans contain about 70% of the Earth's surface inventory of natural iodine. Oceanic iodine is commonly trapped by sediments and various groups of biota, with a special role being played by brown algae. Representatives of the genus *Laminaria* (Phaeophyceae) are the most potent iodine bio-accumulators among all living systems [29].

Concentration of iodine in terrestrial vegetation is usually low, but it can be significantly increased in crops and vegetables by using iodine-containing fertilizers. Although iodine is not considered an essential micronutrient for land plants, this element has been found to stimulate some metabolic processes and plant growth. In particular, the use of iodine-containing plant growth stimulants (such as "Vermyiodis") provides increased productivity and the formation of biologically active secondary metabolites in medicinal plants (*Calendula officinalis* L., *Matricaria recutita* L.) [31, 32].

4. WORLD RESERVES AND USES OF IODINE

World iodine reserves are estimated at about 7.5 million tonnes of crude element (Table 1) [46]. Iodine naturally occurs in several minerals (e.g. iodargyrite, marshite, lautarite, dietzeite, bellingerit, salesite etc.), but most of these minerals are rare and not concentrated in the form of deposits [22]. Lautarite $[Ca(IO_3)_2]$ and dietzeite $[Ca_2(IO_3)_2(CrO_4)\bullet H_2O]$ are the two crystalline forms in which iodine naturally occurs in caliche ore used for industrial extraction of this element. Chilean caliche mined in the Atacama Desert of northern Chile and west of the Andes Mountains provides significant part of the world's reserves of iodine (Table 1). The chemical

form of iodine in caliche is calcium iodate: $(CaIO_3)_2$; iodine content of the ore is of around 400 mg/kg. Other potent reserves of iodine are subsurface brines associated with oil and gas deposits. In deep brines, this element often occurs as sodium iodide with an iodine concentration ranging to 150 mg/L and above. Iodine is extracted industrially from brines associated with gas wells in Japan, USA, Turkmenistan, Azerbaijan, and Indonesia. By far the largest producer of iodine from brine is Japan, where iodine-rich water is co-produced with natural gas. Concentration of iodine in Japanese subterranean brines ranges up to 150–160 mg/L. The main producing area is the Southern Kanto gas field on the east-central coast of Honshu, which accounts for about 80% of Japan's iodine output [23].

Table 1. Iodine estimated reserves per region and iodine production in 2017 [34, 46]

Origin	Region	Reserves (× 1000 metric tonnes)	Production in 2017 (metric tonnes)
Underground brines	Japan	5 000	10 600
	USA	250	NA
	Azerbaijan	170	200
	Russia	120	NA
	Indonesia	100	15
	Turkmenistan	70	500
Caliche ore	Chile	1 800	20 000
Seaweed	China	4	NA
World total (rounded)		7 514	NA

NA: Data not available.

In addition to the above-mentioned sources, the world's largest reserve of iodine is contained in seawater; however, direct extraction of iodine from this source is economically unfeasible because of its low concentration (on average 45–60 μg/L) [19]. Potential large resource of iodine is marine algae, capable of accumulating this element up to 30 000 times compared to seawater [29]. Some species of seaweed, especially the brown algae of the genus *Laminaria*, contain significant amounts of iodine in the form of sodium and potassium iodides. Before the development of iodine extraction from caliche ore, the marine algae were an important source of this element, and the production of iodine from seaweed was a major economic activity in the coastal regions of Europe (in parts of Brittany, Normandy, Ireland and Scotland) [29]. However, seaweed-based iodine production is not economic at present. Today, approximately 2% of the total iodine consumption comes from this source (iodine is being obtained as a by-product in the processing of sodium alginate). The seaweed-based production of iodine is concentrated mainly in China (in Shandong, on the northern coast of Jiangsu, and in a part of Zhejiang).

At present, iodine and its chemical compounds have many practical applications in a variety of economy sectors. The element is being widely used in various industries, medicine, agriculture and other areas of human activity (Fig. 1) [4, 41, 47].

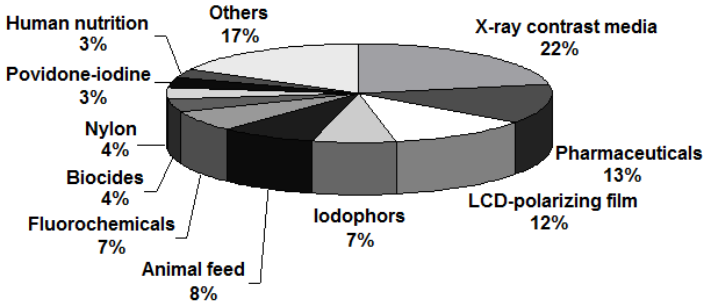

Figure 1. Global demand for iodine according to its application (adapted from: [19])

A significant part of the globally produced iodine is used in industrial catalysis. In particular, hydroiodic acid is used as a co-catalyst for the production of acetic acid by the Monsanto and Cativa processes [21]. Organic derivatives of polyvalent iodine (known as hypervalent iodine compounds) have attracted considerable interest as versatile and environmentally benign reagents for organic synthesis [49]. Iodine is also important constituent for the synthesis of the X-ray contrast agents because of its high mass X-ray absorption coefficient [1.94 cm^2/g at 100 keV] and its chemical versatility [9]. Currently, iodinated contrast agents such as iohexol, a nonionic monomer (Omnipaque™) and iodixanol, a nonionic dimer (Visipaque™) are widely used in X-ray diagnostic procedures such as angiography, urography and computed tomography.

The important application of iodine is its use in the production of liquid crystal displays (LCDs), which are indispensable in modern visual devices such as television screens and smart phone touch screens. Iodine and its compounds are used in the polymer industry, in the production of dyes, photographic reagents, pharmaceuticals and food additives [23].

Iodine is widely used as a disinfectant and antiseptic, often in a solution of alcohol and water containing potassium iodide (tincture of iodine, and Lugol's iodine), and in the form of iodophors (iodine complexed with a solubilizing agent, such as a surfactant or povidone) [12]. In particular, an effective and widely used antiseptic, povidone-iodine (known under the trade names: Betadine, Wokadine, Pyodine, etc.) contains from 9 to 12% of iodine. An important antiarrhythmic medication amiodarone (Fig. 2) contains approximately 37% iodine by weight.

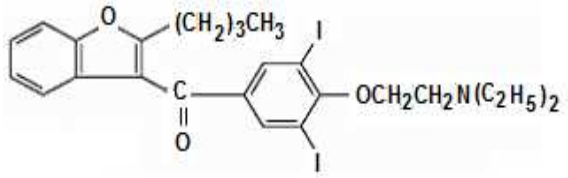

Figure 2. Iodine-containing antiarrhythmic medication amiodarone

Iodine has been introduced into metallurgical processes for the production of several transition metals in a high state of purity, such as titanium, zirconium, thorium, cobalt, and chromium [36]. Iodine has the potential to be used in hydrometallurgy as one of the alternative reagents for extracting gold from gold ores, as well as for the recovery of precious metals (gold, silver, palladium) from secondary sources, such as waste generated by the electrical and electronic devices [30, 48]. This element can be used for the recovery of mercury from fluorescent lamp waste [44].

Iodine and its compounds have various applications in the food industry: for the fortification of table salt, bread, and dairy products and for the production of food additives (e.g., dough conditioning and maturing agents, as well as a cherry-pink colouring agent, erythrosine). Iodine is the most effective agent for water purification. In agriculture, this element is used for the production of fertilizers and agricultural chemicals (e.g., herbicides and fungicides); iodine supplements are widely used in the farm animal feeding [3, 4, 41, 47].

Iodine in the form of silver iodide has long been used to induce weather modification, namely for the cloud seeding process [10]. This widely practiced rainmaking method involves injecting clouds with particles of silver iodide, "seeds" around which ice particles can form. The ice crystals fall toward the ground and melt to become water droplets. Potassium iodide is also used for this purpose.

It is noteworthy that there are no comparable substitutes for iodine in many of its principal applications, such as human and animal nutrition, catalytic, pharmaceutical and photographic uses [46]. Other halogens, namely bromine and chlorine could substitute for iodine in biocides and dyes; however they are usually considered less suitable than iodine. Antibiotics and boron may also be used as biocides instead of iodine.

In view of the wide range of applications of iodine and its compounds, the global demand for this element is constantly growing and currently exceeds 33 thousand metric tons per year [23]. Chile and Japan are the world's largest producers of iodine (Table 1), with iodine production in Japan accounting for about 30% of total iodine production in the world. In 2017, the production of iodine in Chile amounted to around 20 000 metric tonnes, and Japan produced 10 600 tonnes of iodine [34]. According to available data, in 2017 a significant amount of iodine was also produced in Turkmenistan, Azerbaijan and other countries (Table 1).

CONCLUSIONS

The chemical element iodine, discovered by Bernard Courtois in 1811, is a highly reactive nonmetal belonging to the halogen group. Iodine shows oxidation states from –1 to +7 and forms a variety of chemical compounds (both inorganic and organic). Most of the iodine in nature is represented by the only stable isotope ^{127}I. Iodine has 42 recognized radioactive isotopes, two of which (^{129}I and ^{131}I) are of particular environmental concern.

Iodine is generally regarded as a hydrophile, atmophile and biophile element. Its concentrations in the terrestrial environment are generally low and highly variable, while most of the global stock of iodine is found in oceanic water and sediments. Iodine is a largely cyclic element and moves through the biotic and abiotic compartments of Earth along a cyclic path known as the biogeochemical cycle. Enrichment of terrestrial environments with iodine occurs due to volatilization of this element from the marine environment to the atmosphere and its subsequent transfer to the land surface by dry and wet deposition.

For industrial purposes, the main sources of iodine are its mineral deposits, both Chilean caliche ore and underground brines. Iodine is also obtained as a by-product in the processing of sodium alginate from seaweed.

Iodine and its compounds have found various industrial applications. Iodine is used as a catalyst in the production of various chemicals, mainly acetic acid; it is an important constituent of radiocontrast media, surfactants, iodophors, biocides and pharmaceuticals. One of the important applications of iodine is its use in the production of liquid crystal displays (LCD), which have become an indispensable part of most electronic devices. Iodine and its compounds are also used in the production of photographic reagents and dyes. Iodine has important applications in the healthcare industry: as a disinfectant, in the manufacture of medicines, and in water purification. Iodine compounds are used as fertilizers in agriculture; this element is an important component of food additives used in human diets and animal nutrition.

REFERENCES

1. Abdulrezzak U., Tutus A., Isik I., Kurt Y., Kula M., 2017. Quantitative comparison of low dose and standard dose radioiodine therapy effectiveness in patients with low risk differentiated thyroid cancer.Q. J. Nucl. Med. Mol. Imaging, v. 61(3), 314-322.
2. Antonyak H.L., 1999. [The effect of thyroxine and insulin on the hemopoiesis in animals during neonatal development]. Tsitologiia, v. 41(6), 512-515.
3. Antonyak H., Pershyn O., Panas N., Lupak O., Hoivanovych N., Savytska O., Zhylishchych Y., 2018. Iodine in the diet and human health. In: Ecology and human health. Krynski A., Tebug G.K., Voloshanska S. (eds.). Czestochowa: Educator, 35-52.
4. Antonyak H.L., Vlizlo V.V., 2013. Biochemical and geochemical role of iodine. Lviv, 390 p. [Biokhimichna ta heokhimichna rol′ yodu. L′viv, 2013].
5. Atwood D.A., 2010. Radionuclides in the environment. Chichester: John Wiley & Sons, 560 p.
6. Babich N.O., Antonyak H.L., Tymochko M.F., 2000. [Effect of thyroxine on the activity of some enzymes of energy metabolism in bone marrow myeloid cells and blood neutrophils from piglets]. Voprosy meditsinskoĭ khimii, v. 46(2), 162-167.

7. Babych N., Antonyak H., Sklyarov A.Ya., 2000. The influence of thyroxine on intensity of energy metabolism in bone marrow myeloid cells and neutrophilic polymorphonuclear leukocytes of neonatal pig. Endocrine regulations, v. 34(2), 73-81.
8. Cox E.M., Arai Y., 2014. Environmental chemistry and toxicology of iodine. Advances in Agronomy, v. 128, 47-96.
9. De La Vega J.C., Häfeli U.O., 2015. Utilization of nanoparticles as X-ray contrast agents for diagnostic imaging applications. Contrast Media Mol. Imaging, v. 10(2), 81-95.
10. Dennis A.S. (ed.), 1980. Generation and Application of Silver Iodide Crystals and Other Seeding Agents. International Geophysics. Volume 24. Weather Modification by Cloud Seeding, 96-134.
11. England T.R., Rider B.F., 1994. ENDF-349 evaluation and compilation of fission product yields. Rep. LAUR-94-3106.
12. Fleischer W., Reimer K., 1997. Povidone-iodine in antisepsis – State of the art. Dermatology, v. 195 (Suppl 2), 3-9.
13. Fuge R., 1988. Sources of halogens in the environment, influences on human and animal health. Environ. Geochem. Health, v. 10(2), 51-61.
14. Fuge R., Johnson C.C., 1986. The geochemistry of iodine – a review. Environ. Geochem. Health, v. 8(2), 31-54.
15. Fuge R., Johnson C.C., 2015. Iodine and human health, the role of environmental geochemistry and diet, a review. Appl. Geochem., v. 63, 282-302.
16. Goldschmidt V.M., 1954. Geochemistry. Muir A. (ed.). Oxford, Clarendon Press, 730 p.
17. Heimerzheim C.J., 1941. Solubility generalizations. J. Chem. Educ., v. 18(8), 377.
18. Hetzel B.S., 2005. Towards the global elimination of brain damage due to iodine deficiency – the role of the International Council for Control of Iodine Deficiency Disorders. Int. J. Epidemiol., v. 34(4), 762-764.
19. Hora K., 2016. Iodine production and industrial applications. IDD Newsletter, N 8.
20. Hou X., Hansen V., Aldahan A., Possnert G., Lind O.C., Lujaniene G., 2009. A review on speciation of iodine-129 in the environmental and biological samples. Anal. Chim. Acta, v. 632(2), 181-196.
21. Jones J. H. The Cativa^{TM} Process for the Manufacture of Acetic Acid. Platinum Metals Rev. – 2000. – 44, N 3. – P. 94-105.
22. Kabata-Pendias A., Szteke B., 2015. Trace elements in abiotic and biotic environments. Chapter 21: Iodine (I, 53). CRC Press, 145-152.
23. Kaiho T., 2014. Iodine chemistry and applications. John Wiley & Sons, Inc, Hoboken, N.J., 656 p.
24. Kaltsoyannis N., Plane J.M.C., 2008. Quantum chemical calculations on a selection of iodine-containing species (IO, OIO, INO_3, $(IO)_2$, I_2O_3, I_2O_4 and I_2O_5) of importance in the atmosphere. Phys. Chem. Chem. Phys., v. 10(13), 1723-1733.
25. Kaplan D.I., Denham M.E., Zhang S., Yeager C., Xu C., Schwehr K.A., Li H.P., Ho Y.F., Wellman D., Santschi P.H., 2014. Radioiodine biogeochemistry and prevalence in groundwater. Crit. Rev. Environ. Scie. Technol., v. 44(20), 2287-2335.
26. Kauffman G.B., Fang L.Y., Viswanathan N., Townsend G., 1984. Purification of copper (I) iodide. In: Inorganic Syntheses. Holt S.L. (ed.). John Wiley & Sons, Inc., Hoboken, NJ, USA, v. 22, 101-103.
27. Kendrick M.A., 2016. Halogens. In: Encyclopedia of geochemistry. White W.M. (ed.), Springer International Publ. AG, 1-5.
28. Kopp P., 2005. Thyroid hormone synthesis: thyroid iodine metabolism. In: Werner and Ingbar's the thyroid: a fundamental and clinical text. Braverman L., Utiger R. (eds.). 9th ed. N.Y.: Lippincott Williams Wilkins, 52-76.
29. Küpper F.C., 2015. Iodine in seaweed: two centuries of research. In: Springer Handbook of Marine Biotechnology. Kim S.K. (ed.) Springer, Berlin, Heidelberg, 591-596.

30. Lucheva B., Iliev P., Kolev D., 2017. Recovery of gold from electronic waste by iodine-iodide leaching. J. Chem. Technol. Metallurgy, v. 52(2), 326-332.
31. Lupak O.M., Kovalchuk H.Ya., Antonyak H.L., 2017. Potentiometric determination of the antioxidant activity of plant extracts of *Calendula officinalis* L. under the action of growth bio-stimulants. ScienceRise: Biological Science, v. 6(9), 10-13.
32. Lupak O., Kovalchuk H., Antonyak H., 2018. Comparative analysis of integrated antioxidant activity of inflorescences of *Calendula officinalis* L. plants grown in the conditions of Precarpathian area and the effect of growth biostimulants. Biological Resources and Nature Management [Bioresursy i pryrodokorystuvannya], v. 10(1-2).
33. Lyday P.A., 2005. Iodine and iodine compounds. In: Ullmann's Encyclopedia of Industrial Chemistry, Weinheim: Wiley-VCH.
34. Major countries in iodine mine production from 2012 to 2017 (in metric tons). https://www.statista.com/statistics/264945/major-countries-in-iodine-production/
35. Mikhailov V.N., 1996. USSR nuclear weapons tests and peaceful nuclear explosions: 1949 through 1990; The Ministry of the Russian Federation for Atomic Energy, and Ministry of Defense of the Russian Federation.
36. Moore J.J., Boyce E.A., Brooks M.J., 1981. Chemical Metallurgy. Butterworths, 400 p.
37. Moran J.E., 2002. Sources of iodine and iodine-129 in rivers. Water Resources Research, v. 38(8), 1149.
38. NCI (National Cancer Institute), 1997. Estimated Exposures and Thyroid Doses Received by the American People From ^{131}I in Fallout Following Nevada Atmospheric Nuclear Bomb Tests. NIH Publication No. 97-4264. Washington, DC.
39. Saxena P.B., 2007. Chemistry of interhalogen compounds. Discovery Publishing House, 307 p.
40. Schwehr K.A., Santschi P.H., Moran J.E., 2005. ^{129}Iodine: new hydrologic tracer for aquifer recharge conditions influenced by river flow rate and evapotranspiration. Appl. Geochem., v. 20, 1461-1472.
41. Solohub L.I., Antonyak G.L., Antonyak T.O., Stefanyshyn O.M., Gufriy A.D., 2005. Iodine in organism of animals and humans (biochemical aspects). The Animal Biology, v. 7(1-2), 31-50. [Yod v orhanizmi tvaryn i lyudyny (biokhimichni aspekty). Biolohiya Tvaryn]
42. Suzuki T., Kitamura T., Kabuto S., Togawa O., Amano H., 2006. High sensitivity measurement of iodine-129/iodine-127 ratio by accelerator mass spectrometry. J. Nuclear Sci. Technol., v. 43(11), 1431-1435.
43. Svensson P.H., Kloo L., 2003. Synthesis, Structure, and Bonding in Polyiodide and Metal Iodide−Iodine Systems. Chem. Rev., v. 103(5), 1649-1684.
44. Tunsu C., Ekberg C., Foreman M., Retegan T., 2015. Investigations regarding the wet decontamination of fluorescent lamp waste using iodine in potassium iodide solutions. Waste Manag., v. 36, 289-296.
45. UNSCEAR, 2000. Report to the General Assembly: Sources and effects of ionizing radiation. Vol. 2, Annex J. Unated Nations, N.Y., 453-551.
46. USGS Mineral Commodity Summary Iodine statistics and information, 2016. http://minerals.usgs.gov/minerals/pubs/commodity/iodine/
47. Vlizlo V.V., Solohub L.I., Janovich V.G., Antonyak H.L., Yanovych D., 2006. The biochemical bases of mineral feeding standardization in cattle. 2. Trace elements. The Animal Biology, v. 8(1-2), 41-62. [Biokhimichni osnovy normuvannya mineral′noho zhyvlennya velykoyi rohatoyi khudoby. Mikroelementy. Biolohiya Tvaryn].
48. Xiu FR., Qi Y., Zhang F.S., 2015. Leaching of Au, Ag, and Pd from waste printed circuit boards of mobile phone by iodide lixiviant after supercritical water pre-treatment. Waste Manag., v. 41, 134-141.
49. Yusubov M.S., Zhdankin V.V., 2015. Iodine catalysis: A green alternative to transition metals in organic chemistry and technology. Resource-Efficient Technologies, v. 1(1), 49-67.

50. Zimmermann M.B., Boelaert K., 2015. Iodine deficiency and thyroid disorders. Lancet Diabetes Endocrinol., v. 3, 286-295.

АНОТАЦІЯ

РОЗПОВСЮДЖЕННЯ ЙОДУ В НАВКОЛИШНЬОМУ СЕРЕДОВИЩІ ТА ЙОГО ПРАКТИЧНЕ ЗАСТОСУВАННЯ

Йод, галоген 17-ї групи періодичної таблиці, є мікроелементом земної кори та одним з незамінних компонентів харчування людини. Йод – реакційно активний елемент, який утворює різноманітні неорганічні та органічні сполуки, виявляючи ступінь окиснення від –1 до +7. Основна частка йоду у природі представлена одним стабільним ізотопом ^{127}I. Окрім того, йод має 42 радіоактивні ізотопи, два з яких (^{129}I та ^{131}I) особливо важливі в екологічному аспекті. Радіоізотоп ^{129}I з періодом напіврозпаду 15,7 млн. років – єдиний природний радіоактивний ізотоп йоду та побічний продукт ядерного поділу. Антропогенний ^{129}I надходить у навколишнє середовище в результаті випробувань ядерної зброї, ядерних аварій (таких, як Чорнобильська катастрофа 1986 року) та від переробки відпрацьованого ядерного палива. Його концентрацію використовують як екологічний маркер та показник довготривалого антропогенного впливу на навколишнє середовище. Радіоізотоп ^{131}I (з періодом напіврозпаду 8,02 дні) – небезпечний радіонуклід, який створює значний ризик короткочасного забруднення в разі ядерної аварії або інших випадків, пов'язаних з викидом радіоактивних речовин.

Основна частина глобального резерву йоду знаходиться у водах та донних осадах Світового океану. Першорядну роль у збагаченні наземного середовища йодом відіграє випаровування цього елемента з поверхні морів і океанів в атмосферу з подальшим перенесенням на сушу шляхом сухого і вологого осадження. Концентрація йоду в наземних рослинах зазвичай низька, проте може значно збільшуватись у сільськогосподарських культурах внаслідок використання йодовмісних добрив під час вирощування. Морські організми (водорості, безхребетні тварини) здатні ефективно концентрувати цей елемент з водного середовища і трансформувати його неорганічні сполуки в органічні. Важлива роль в акумуляції йоду належить бурим водоростям, особливо представникам роду *Laminaria* (Phaeophyceae), які є найпотужнішими з усіх живих систем біоакумуляторами цього елемента.

Для промислового видобутку йоду використовують поклади чилійської селітри, яка містить домішки кальцію йодату, та підземні розсоли, які супроводжують родовища нафти і газу. Йод також отримують як побічний продукт виробництва альгінату натрію з водоростей. Найбільші природні запаси йоду є в Чилі та Японії; ці країни є світовими лідерами промислового виробництва та експорту йоду.

Йод та його сполуки мають широке застосування в різних промислових галузях, медицині та сільському господарстві. Йод використовують як каталізатор у хімічній промисловості, зокрема, під час виробництва оцтової кислоти. Цей елемент має важливе значення для синтезу радіоконтрастних та поверхнево-активних речовин, фармацевтичних препаратів, а також для виробництва рідкокристалічних дисплеїв, лазерів, акумуляторів. Йод використовують у виробництві барвників та реагентів для фотографії; цей елемент є важливою складовою біоцидів та антисептиків. Йод має широке застосування в галузі охорони здоров'я: як дезінфікуючий засіб, як компонент лікарських препаратів, а також у процесі очищення води. Сполуки йоду використовують як добрива в сільському господарстві, для йодування кухонної солі та збагачення цим елементом харчових продуктів. Йод є важливим компонентом мікроелементних добавок, які використовують у харчуванні людини і тварин.

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INTEGRATION OF SUSTAINABLE DEVELOPMENT PRINCIPLES IN THE DECENTRALIZATION PROCESS IN UKRAINE

Abstract. The principles of sustainable development and ecosystem approach as an ideological background for the development of local self-government in terms of decentralization are considered.

It is shown that the reform of the administrative system in Ukraine, aimed at decentralization, creates favorable conditions for the implementation and integration of the sustainable development principles at the basic local level of society organization.

The article analyzes the requirements of international documents on the sustainable development for local communities, which emphasize the local self-government. The normative and legal bases of the national legislation of Ukraine regulating the integration of sustainable development and local self-governance are presented.

The essence of the ecosystem approach as the strategy of integrated management for the environment in local communities is determined.

The method of social mobilization and the process of "activity from below" are described. Their role for decentralization, formation of centers of civil society, integration of the sustainable development principles is characterized.

Keywords: sustainable development, Agenda 21, local community, environment, social mobilization.

INTRODUCTION

The liberation of countries from dictatorships and the transition to a democratic form of government is always a painful social process, especially in local communities. People who are not yet formed the community are often not ready to assume full responsibility in their local areas of residence, and the blame for the lack of reforms is translated into central authorities. The processes of social mobilization at the local level and the activity of communities "from below" in the post-dictatorial regimes are weak and underdeveloped; they do not have a critical mass of reformists. These problems are very pronounced in Ukraine, and, in our opinion, the key issue is the lack of a reform ideology.

On the path to finding ideology for the reform of the Ukrainian economy and society, the Concept of Sustainable Development can become an effective tool for this. The UN World Conference on Environment and Development adopted the Declaration and recognized the concept of sustainable development as the dominant ideology of community development in the twenty-first century [7]. As a global strategy for humankind for the harmonization of man and the environment, the concept of sustainable development was embodied in the international document "Agenda 21, 1992". It has a local dimension. The creation of united territorial communities does not take into account the principles of sustainable development and ecosystem approach. Therefore, the reform of the administrative system and decentralization in Ukraine are a suitable time for implementing the foundations of sustainable development at the basic level of local communities.

The purpose of our research was to study the possibilities of integrating the principles of sustainable development into decentralization processes in Ukraine, to identify the key issues and obstacles to the implementation of sustainable development in Ukrainian communities.

LOCAL COMMUNITIES AS A BASE LEVEL FOR DECENTRALIZATION AND SUSTAINABLE DEVELOPMENT

1. Regulatory and Legal Basis of Sustainable Development for Local Self-Government

The International Sustainable Development Document "Agenda 21" puts strong emphasis on the local level, as noted in the following chapters [10]:

- Section 7. "Promoting Sustainable Development of Human Settlements";
- Section 14. "Promoting Sustainable Management of Agriculture and Rural Development";
- Section 26. "Recognizing and strengthening the role of indigenous peoples and local communities";
- Section 28. "Initiatives of Local Authorities in Support of the Agenda for the 21st Century".

The UNDP Municipal Program "Local Agenda" (MPD-21) is devoted directly to decentralization and implementation of sustainable development in local communities.

The Law of Ukraine "On Local Self-Government in Ukraine" [3] regulates the basic principles of local self-governance and defines a specific community as a territorial community, which is "the primary subject of local self-government, the main bearer of its functions and powers".

The European Charter of Local Self-Government [16] defines local self-government through the law and the ability of local self-government bodies to regulate and manage a substantial proportion of public affairs, under their own responsibility, in the interests of the local population. Councils or assemblies whose members are freely elected by secret ballot based on direct, equal, universal suffrage and which may be accountable to them by the executive bodies exercising this right.

The National Strategy of Ukraine's Environmental Policy foresees the integration of socio-economic development programs and local action plans for environmental protection, as well as strengthening the role of local self-government bodies in the process of the state environmental policy implementation, its improvement taking into account the Guiding Principles of Sustainable Spatial Development of the European Continent (Hanover, 2000) [2].

Thus, legal instruments create all opportunities for the development of local self-government based on sustainable development.

2. Ecosystem approach for decentralization

The understanding and implementation of the ecosystem approach principles is important for implementing the foundations of sustainable development at the basic levels. The ecosystem approach is a part of the sustainable development ideology, which was introduced into the international norm at the Sixth Conference of Parties V/6 (Nairobi, May 15-26, 2000) within the framework of the Convention on Biological Diversity [4]. The ecosystem approach is defined as a strategy for integrated management of the environment and living resources that ensures the conservation and sustainable use in an equitable manner. In general, the idea of an ecosystem approach is based on the fact that each territory is characterized by its own natural ecosystem with a special structure and functional parameters [1]. Its architecture and composition are special in a complex of landscape, climatic, soil conditions, plant and animal populations. An inseparable element of a local ecosystem is a person, as well as a local community (village, city), living in the woods of ecosystems, using its resources (geological, climatic, water, soil, vegetation, animals, etc.), and changing it. In other words, the ecosystem, having a certain potential of

resources, provides people with their services (Fig. 1) [14]. At the Sixth Conference of the Parties in Nairobi, the concept of "ecosystem services" was introduced along with the concept of "ecosystem approach".

It is at this basic level that the relationship between the community and a particular natural environment (ecosystem) is most closely interwoven and reflected in economic needs, cultural and spiritual traditions, and other ties. Native land is more than just a place of residence. The authors of the modern concept of bioregionalism substantiate the organic unity of the ethnos and the natural environment, and a significant difference in the ties (cultural, spiritual, and environmental) with the environment of the indigenous and arrived peoples. The notion of "archetype" is similar to the notion of bi-regionalism, which is substantiated by the works of the Swiss scientist K. Jung. The concept of an archetype makes it possible to find out the various essential features of every national culture, everyday life, traditions, and customs, as well as to trace the inextricable connection of each people with the land of their ancestors. In other words, the archetype is almost a mystical unity of man and the environment in which he lives and in which the memory of his ancestors lives. An archetype is something that cannot be learned, and is a constant of a particular ethnic group. The concept of sustainable development also enhances the role of indigenous peoples and local communities. In section 26.1., Agenda 21 states: 'Given the interconnection between the state of the environment, the sustainable development and the cultural, social, economic and physical well-being of indigenous peoples, due attention must be paid to promoting the role of indigenous peoples and local communities, as well as recognizing and strengthening this role.'

Such modern processes as globalization, urbanization, migration of the population are factors weakening the connection of a man with the natural environment.

Therefore, the local level is crucial for the implementation of sustainable development at the lowest levels of the society organization.

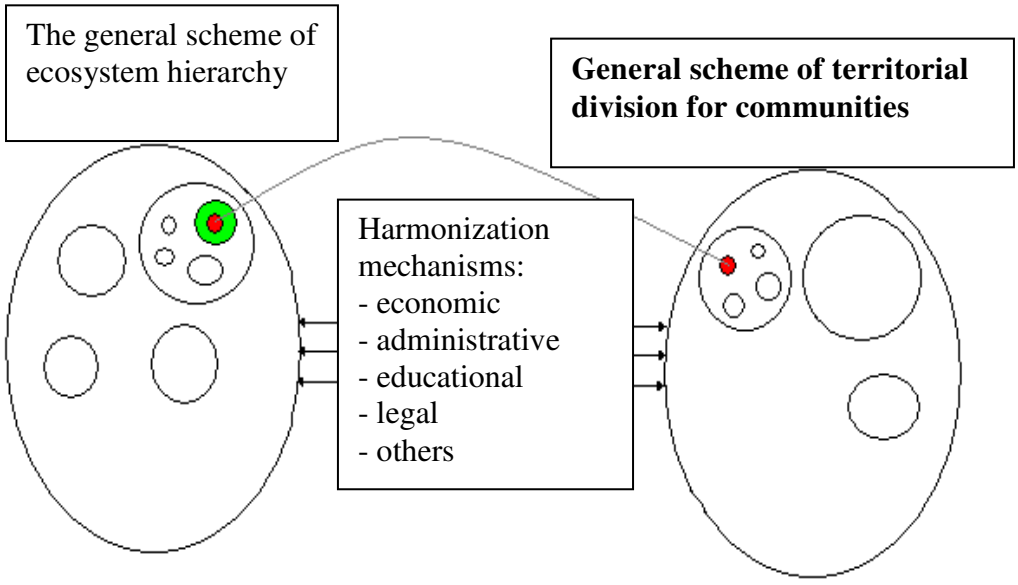

Fig. 1. The ecosystem structure and administrative organization

SOCIAL MOBILIZATION INSTRUMENTS FOR DECENTRALIZATION AND SUSTAINABLE DEVELOPMENT

The key task and problem in the way of decentralization is the voluntary formation of the primary (basic) communities, the establishment of their social communications. People living in authoritarian, centralized societies are difficult to integrate into local communities to solve any problems in the areas of residence. Moreover, the Law of Ukraine "On Local Self-Government in Ukraine" (Article 14) stipulates the formation of home, street and other self-government bodies that can get a part of their own competence in defending local interests. This is also foreseen in Agenda 21 (7.20g): 'To empower public groups, non-governmental organizations and individuals to take responsibility for the rational use and improvement of the environment through tools, methods and approaches that are based on participatory and predictable the concept of environmental protection.'

Social mobilization and community structuring involves the active involvement of all sectors of the population in solving priority social, economic, and environmental problems of local significance. Social mobilization can bring together all segments of society (men, women, youth, poor / rich, private sector, local authorities, civil society organizations, educational institutions) in partnership to achieve a common goal and lead to community involvement in the process of local development. Social mobilization brings the territorial community into a state (organizational, institutional, mental), when it is able to solve the problems that arose before it, using its own resources. It also involves changing the way people think that they have a specific problem, so that they unite, used their hidden potential to help themselves. We believe that today all conditions for the development of social communications are created in Ukraine, and the concept of sustainable development may be an effective ideological basis.

Thus, it is about the formation of cells in civil society and various forms of associations of citizens providing the so-called process of "activity from below", and, accordingly, more effective communication in the system of local authorities – the local community – the local ecosystem. A positive example is the active creation of civic organizations in Ukraine in recent years, especially associations of co-owners of multi-apartment residential buildings (ACMRB) (Table 1). These associations become the primary base for the creation of new collective management communications and an effective platform for centralization. They are becoming more interested in the reform of the local municipality (for example, water supply and wastewater systems, heating and energy saving, efficient use of resources and land improvement).

Table 1. Dynamics of the formation of associations of co-owners of multi-apartment buildings (ACMRB) in Boryslav (Ukraine)

Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Number of registered ACMRB	1	5	5	4	7	2	4	3	3	27	31	92

Thus, the very "small", but concrete steps of sustainable management and social mobilization, which are implemented by individual farms, community-owned multi-apartment buildings, street committees, and microdistricts, become the primary "seeds" of decentralization and the implementation of sustainable development.

Strengthening the role of local self-government in the process of administrative-territorial reform and the implementation of the sustainable development principles will create conditions for equalizing the qualitative and quantitative indicators of providing public services in local communities. The administrative and financial autonomy of territorial communities with the increase of their budget capacity will allow forming the necessary infrastructure and will increase the ecological standards of living for the inhabitants of the communities. Depending on the urgency of the needs, it is necessary to form objects of road, educational, medical, communal infrastructure gradually. At the same time, it is necessary to strive to use as much as possible the own and attracted funds of communities.

CONCLUSIONS

The concept of sustainable development does not lose its relevance as a strategy for harmonizing a man and a nature. Sustainable development can become an effective ideological platform for the development of local communities, reforming the administrative structure and for the decentralization in Ukraine.

International documents on sustainable development – The Agenda for the 21st Century, the UNDP Local Agenda, and the European Charter of Local Self-Government emphasize the importance of local level.

The current legislation of Ukraine in the spheres of local self-government, administrative reform, national strategy of environmental policy, regulating the basic principles of local self-government based on sustainable development, creates the best opportunities for the development of local communities.

An ecosystem approach, as a part of a sustainable development ideology and a strategy for integrated environmental management that ensures the conservation and sustainable use in a fair way, should be used as a guideline for the decentralization.

Implementation of the social mobilization tools under decentralization involves the formation of civil society cells and various forms of citizen associations providing the so-called "activity from below" process, and, accordingly, a more effective link in the system of local authorities – the local community – is a local ecosystem.

Strengthening the role of local self-government in the process of administrative-territorial reform and the implementation of the sustainable development principles will create conditions for equalizing the qualitative and quantitative indicators of providing public services in local communities.

REFERENCES

1. Голубець М., 2000. Екосистемологія. Львів: Поллі, 316.
2. Закон України «Про основні засади (стратегію) державної екологічної політики України на період до 2020 року» №2818-VI від 21 грудня 2010 року / Відомості Верховної Ради України, 2011, N 26, ст.218.

3. Закон України «Про місцеве самоврядування в Україні» №28/97-ВР від 21 грудня 1997 року / Відомості Верховної Ради України, 1997, N 24, ст.170
4. Екосистемний підхід / Додаток до Рішення КС V/6 Конференції сторін Конвенції про біологічне різноманіття. – Найробі. – 15 – 26 травня 2000 р., 40-46.
5. Концепція сталого розвитку населених пунктів. Постанова Верховної Ради України від 24.12.1999 р. № 1359-XIV.
6. Вольвач Ф., 2002. Стійкий екологічно безпечний розвиток і Україна: Навч. посіб. К.: МАУП, 104.
7. Цайтлер М., 2009. Проблеми природоохоронного управління агломераціями міст (на прикладі Дрогобицької урбоагломерації). Сучасні проблеми збалансованого природокористування : Матер. IV-ї наук.-практ. конф. Кам'янець-Подільський, 86-87.
8. Цайтлер М., 2016. Сталий розвиток – ідеологічна платформа реформування місцевих громад. Стан природних ресурсів, перспективи їх збереження та відновлення (Мат. III Міжн.наук. конф., 12–14 жовтня 2016 р.). Дрогобич, 137-139.
9. Цайтлер М., 2015. Впровадження засад сталого розвитку в системі «освіта–місцевий рівень» у громадах України. Acta Carpathica 24. Rzeszow, 39-44.
10. Agenda 21 – United States. Archived from the original on 8 October 2017. https://www.un.org/esa/agenda21/natlinfo/countr/usa/natur.htm.
11. Dasgupta, P., 2007. The idea of sustainable development. Sustainability Science. 2 (1): 5–11.
12. Kläy A., Zimmermann A., Schneider F., 2016. Statt Eingreifen wider Willen – reflexiv transformative Wissenschaft. Bulletin der Vereinigung der Schweizerischen Hochschuldozierenden, 42(3/4), 46–52.
13. Wullenweber K., 2000. Wortfang. Was die Sprache über Nachhaltigkeit verrät. in: Politische Ökologie. München 63/64, 23–24
14. Key Questions in the Millennium Ecosystem Assessment, 2005. Ecosystem and Human Well-being: Synthesis. Island Press, Washington, 26-101
15. European ecosystem assessment – concept, data, and implementation // EEA Technical Report 6/2015.
16. European Charter of Local Self-Government European. Treaty Series. No. 122, 6. https://rm.coe.int/168007a088.
17. Jörby Sofie, 2002. Local Agenda 21 in four Swedish Municipalities: a tool towards sustainability. Journal of Environmental Planning and Management, 45 (2): 219–244
18. Cotter B., Hannan, K., 1999. Our Community Our Future: A Guide to Local Agenda 21. Commonwealth of Australia, Canberra, 189.
19. Shaker R., 2015. The spatial distribution of development in Europe and its underlying sustainability correlations. Applied Geography, 63, 304-314.
20. Stoica M., 2012. The ecosystem approach to ecological restoration management case study – Trotus hydrographic basin. Management Research and Practice, vol. 4, no. 3, 57.
21. Zeitler M., 2013. Die Schlüsselfragen für die Umsetzung der nachhaltigen Entwicklung in der ukrainischen Gemeinde (Drohobytsches Ballungsgebiet – als Beispiel). Acta Carpathica 23. Rzeszow, 153-159.

АНОТАЦІЯ

ІНТЕГРАЦІЯ ЗАСАД СТАЛОГО РОЗВИТКУ У ПРОЦЕСИ ДЕЦЕНТРАЛІЗАЦІЇ УКРАЇНИ

У статті розглядаються засади сталого розвитку та екосистемного підходу як ідеологічного підґрунтя для розвитку місцевого самоврядування в умовах децентралізації. Всесвітня Конференція ООН з питань навколишнього природного середовища і розвитку ухвалила Декларацію та визнала концепцію сталого розвитку домінантною ідеологією розвитку громад у XXI столітті.

Реформування адміністративного устрою в Україні, спрямоване на децентралізацію, створює сприятливі умови для впровадження та інтеграції засад сталого розвитку на базовому місцевому рівні організації суспільства.

У статті проаналізовані вимоги міжнародних документів щодо сталого розвитку місцевих громад, які акцентують особливу увагу на місцевому самоврядуванні – «Порядку денному на 21 сторіччя», Муніципальної Програми ПРООН «Місцевий порядок денний» (МПД-21), Європейської хартії місцевого самоврядування. Наведено нормативно-правові засади національного законодавства України, які регламентують інтеграцію сталого розвитку і місцевого самоврядування.

Визначено сутність концепції екосистемного підходу як стратегії інтегрованого управління довкіллям у місцевих громадах, що забезпечує збереження та стале використання в справедливий спосіб. Ідея екосистемного підходу базується на тому, що для кожної території характерна своя природна екосистема з особливою структурою та функціональними параметрами. Її архітектура та склад для кожної території є особливими за комплексом ландшафтних, кліматичних, грунтових умов, рослинного та тваринного населення. Невіддільним елементом локальної екосистеми є людина, як і місцева громада (село, місто), які проживають в екосистемі. Екосистема як лоно проживання громади, володіючи потенціалом ресурсів, надає їй екосистемні послуги – геологічні, кліматичні, водні, ґрунтові, рослинні, тваринні тощо. Запропоновано поняття «екосистемний підхід», «екосистемні послуги» застосовувати як керівні принципи при децентралізації та управління в українських громадах.

Описано метод соціальної мобілізації та охарактеризовано її роль для децентралізації, утворення осередків громадянського суспільства, інтеграції засад сталого розвитку. Впровадження інструментів соціальної мобілізації в умовах децентралізації передбачають утворення осередків громадянського суспільства та різних форм об’єднань громадян, які забезпечують так званий процес «активність знизу», а відповідно більш ефективний зв'язок у системі місцева влада – місцева громада – локальна екосистема.

Посилення ролі місцевого самоврядування у процесі адміністративно-територіальної реформи та впровадження засад сталого розвитку створить умови для вирівнювання якісних та кількісних показників надання публічних послуг у місцевих громадах. Управлінська й фінансова самостійність територіальних громад при зростанні їх бюджетної спроможності дозволить формувати необхідну інфраструктуру й підвищуватиме екологічні стандарти проживання мешканців

громад. У залежності від гостроти потреб слід поетапно формувати об’єкти дорожньої, освітньої, медичної, комунальної інфраструктури, використовуючи при цьому якомога більше власних та залучених коштів громад.

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STUDY OF MEDICINAL PLANTS IN THE FLORA OF SKOLE DISTRICT

Abstract. The article presents the results of the study of medicinal plants in the flora of the Skole district. A systematic analysis showed that 92 species of medicinal plants were identified as 46 families and 5 divisions.

The absolute majority of flora is represented by angiosperms (91.3%). They belong to 2 classes Liliopsida and Magnoliopsida. The leading place in the number of species is Magnoliopsida. The leading families include Asteraceae 14.1% and Rosaceae 13.0%.

In addition, biomorphological, environmental analyzes and species abundance analysis were conducted. The largest proportion is plants with abundance Sol (27,1%), Sp (27,1%), Cop1 (22,8%).

The biological features of endangered, rare medicinal plants are described. The measures of conservation, reproduction and increase of the number for the certain types of medicinal plants are proposed.

Keywords: family, species, flora, medicinal plants, abundance, biomorphs.

INTRODUCTION

The interest of the population in the use of medicinal plants, as well as drugs obtained on their basis, is because medicinal herbs with the correct dosage are practically non-toxic, relatively affordable, effective and, in some cases, have no analogues among synthetic ones.

Medicinal plants are a natural source of vitamins and therapeutic biologically active substances and compounds that are most consistent with the structure of the human body do not cause negative side effects [12; 17].

In recent years, worldwide, there has been a particular increase in interest in the healing properties of plants, a significant increase in demand for them. For therapeutic purposes, all kinds of new species are involved, dozens of new therapeutic preparations of plant origin appeared.

Most of the medicine is made from wild plants, therefore resource science of wild medicinal plants becomes of great practical importance. To date, the protection and rational use of medicinal plants is topical. The main causes of stock reduction are anthropogenic impact, which is accompanied by a permanent negative impact on vegetation under conditions of technological progress, intensive use of medicinal plants and violation of harvesting rules.

Rational use and increase of raw material reserves of medicinal plants is possible only with a deep analysis of the productivity of industrial habitats of species. In this connection, there is a need for detailed research on ecological biological characteristics of medicinal plants, the study of their distribution in natural groups, mapping, determination and evaluation of stocks in the studied region, development of measures aimed at renewal and protection.

In modern conditions, when there is a great anthropogenic and technogenic impact on natural vegetation groups, it is especially important to study the phytogeosis of forest and meadow phytocoenoses, because the meadow and forest vegetation today are subjected to intense influence because of human activity.

Therefore, having studied the flora of this area in detail, we can evaluate the economic value, the degree of human influence, the possibilities of practical use, the protection of plant communities, etc.

MATERIALS AND METHODS

We conducted Flora research during 2016-2017.

The object of research was wild medicinal plants, which grow on the territory of Skole district.

Field studies were conducted according to the generally accepted technique of floristic research. As the main method, route diagnostic was used.

The vegetation of all the common types of groups - forest, linden, bush - was investigated, interconnections of plant objects with biotopes and features of relief were traced. The search for rare and endangered plant species, especially those that are under protection, was conducted.

Information about the species found was entered in the field diary, which indicated the places of growth, abundance.

The identification of herbarium specimens was carried out by the "Determiner of higher plants of Ukraine" [4] and described the families.

The clearness was determined by an approximate method on the Drude scale [3].

In this system, the assessment of the abundance of the species adopted the following grading:

Soc (socialis) 100-81 % – the plants are merged with its aboveground parts, forming a background;

Cop3 (copiosae) 60-81 % – plants are very abundant;

Cop2 (copiosae) 40-60% – plants are abundant;

Cop1 (copiosae) 30-40% – plants are quite abundant;

Sp (sparsae) 10 -30% – plants are rare;

Sol (solitariues) – single plants are found;

Un (unicum) – one plant is found on the square.

RESULTS AND DISCUSSION

As a result of the research carried out on the territory of the Skole district, 92 species of medicinal plants belonging to 46 families were found.

An absolute majority of medicinal plants flora is represented by corn-plants, which account for 91.3%. They belong to 2 classes of Liliopsida and Magnoliopsida, which respectively have 39 families of 84 species, Polypodiophyta and Lycopodiophyta (2.2%), (1.0%) Equisetophyta and Pinophyta (3.3%) (Table 1) .

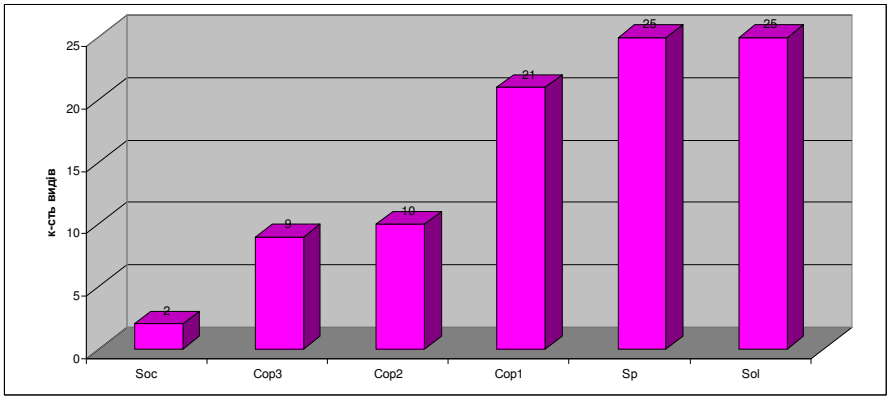
Table 1. Systematic analysis of the flora of medicinal plants

Type, class	Родина		Вид	
	abs. q-ty	%	abs. q-ty	%
Equisetophyta	1	2,2	1	1,0
Lycopodiophyta	2	4,3	2	2,2
Polypodiophyta	2	4,3	2	2,2
Pinophyta	2	4,3	3	3,3
Magnoliophyta	39	84,8	84	91,3
Клас Magnoliopsida	32	69,6	75	81,5
Клас Liliopsida	7	15,2	9	9,7

On the scale of O. Droude, in the territory of the Skole district, 9 species of wild medicinal plants are abundantly growing, 10 species are abundant, 21 species are rarely found, 25 species are rare, 25 species are single, and 2 species are enclosed with aboveground parts.

In Diagram 1, the ratio of the abundance of species on the of O. Droude scale is presented.

Diagram 1



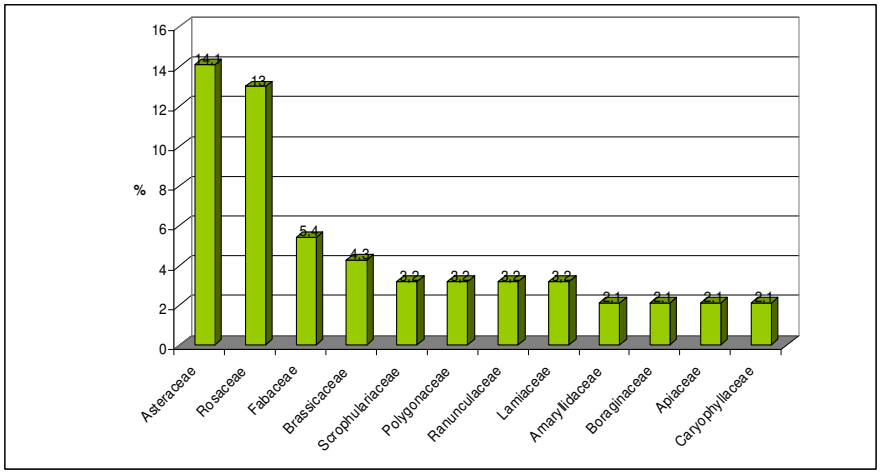
The clarity of the wild medicinal plants species of the Skole district

According to the researches results, 40 species of medicinal plants growing on the territory of the Skole region can be harvested as medicinal raw materials. They include: *sambucus nigra L, betula pendula Roth, polygonum bistorta L., capsella bursa-pastoris L., sorbus aucuparia L., achillea millefolium L., taraxacum officinale L., hypericum perforatum L., lamium album L., leucanthemum vulgare Lamb, equisetum arvense L., tanacetum vulgare L., artemisia absinthium L., prunella vulgaris L., sanguisorba officinalis L., robinia pseudoacacia L., thlaspi arvense* тощо.

56 % grow rarely and separately, therefore it is necessary to protect their nature habitats.

For thehplants of the Skole district, medicinal plants belong to 46 families. 15 families, each of which has two or more species (Diagram 2), form the leading part of the family spectrum in the number of species.

Diagram 2



The leading part in the family spectrum of wild medicinal plants in the Skole district

46 families, each with one or more species (Table 2), form the total family spectrum in the number of species.

Table 2. Full family spectrum by number of species

Place of the family in the spectrum	Family	Number of species	%
1	Rosaceae	12	13,0
2	Betulaceae	1	1,0
3	Amaryllidaceae	2	2,1
4	Asteraceae	13	14,1
5	Scrophulariaceae	3	3,2
6	Apocynaceae	1	1,0
7	Sambucaceae	1	1,0
8	Polygonaceae	3	3,2
9	Melanthiaceae	1	1,0
10	Fabaceae	5	5,4
11	Ranunculaceae	3	3,2
12	Caryophyllaceae	2	2,1
13	Lamiaceae	3	3,2
14	Primulaceae	1	1,0
15	Liliaceae	1	1,0
16	Boraginaceae	2	2,1
17	Ramnaceae	1	1,0
18	Hypericaceae	1	1,0
19	Apiaceae	2	2,1
20	Brassicaceae	4	4,3
21	Viburnaceae	1	1,0
22	Oxalidaceae	1	1,0
23	Aristolochiaceae	1	1,0
24	Convallariaceae	1	1,0
25	Urticaceae	1	1,0
26	Tiliaceae	1	1,0
27	Trilliaceae	1	1,0
28	Poaceae	1	1,0
29	Pinaceae	2	2,1
30	Plantaginaceae	1	1,0
31	Cupressaceae	1	1,0
32	Equisetaceae	1	1,0
33	Violaceae	1	1,0
34	Papaveraceae	1	1,0
35	Solanaceae	2	2,1
36	Huperziaceae	1	1,0
37	Ophioglossaceae	1	1,0

38	Fagaceae	1	1,0
39	Orchidaceae	2	2,1
40	Chenohjdiaceae	1	1,0
41	Lythraceae	1	1,0
42	Gentianaceae	1	1,0
43	Lycopodiaceae	1	1,0
44	Rubiaceae	1	1,0
45	Dryopteridaceae	1	1,0
46	Onagraceae	1	1,0

The most numerous are the families Asteraceae 14.1% and Rosaceae; species share of the medicinal plants flora is 13.0%. Along with them, families of Fabaceae are dominated by 5.4% (5 species), Brassicaceae 4 species (4.3%), Ranunculaceae, Scrophulariaceae, Polygonaceae and Lamiaceae include 3 species each (3.2%).

Seven families have 2 species (Apiaceae, Solanaceae, Amaryllidaceae, Orchidaceae, Pinaceae, Caryophyllaceae, Boraginaceae).

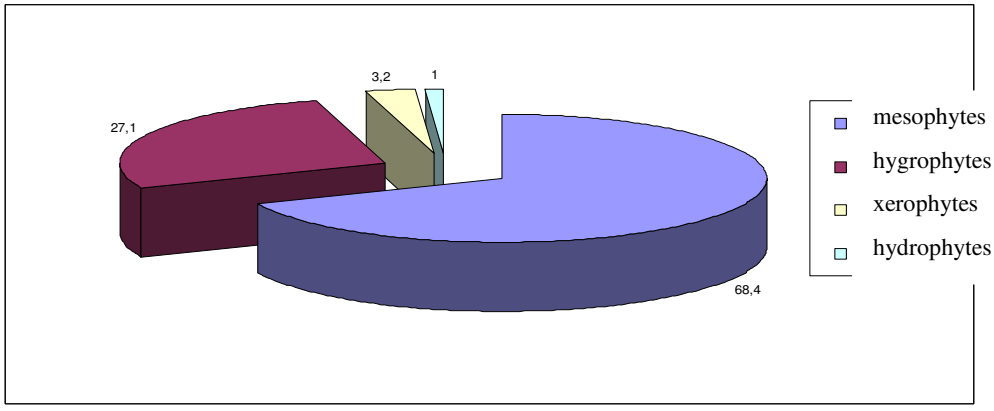
31 families have one species. Among them are Trilliaceae, Sambucaceae, Arosupaceae, Gentianaceae, Chenohjdiaceae, Ophioglossaceae, Cupressaceae, Urticaceae, Violaceae, Aristolochiaceae, Viburnaceae, Primulaceae and others.

In the flora of the Skole district, 8 species (8.6%) of ephemera (*Leucojum vernum* L., *Stellaria nemorum* L., *Pulmonaria obscura* L., *Tussilago farfara* L., *Corydalis cava* L., *Allium ursinum* L., *Galanthus nivalis* L., *Primula veris* L.) are found.

Over the period of vegetation, 80 species (86.9%) are perennials, 10 species (10.8%) are annual and 2 species (2.2%) are biennial.

The analysis of the species composition for plants in relation to moisture requirements showed that by the number of growing species, the representatives of the ecological group of mesophytes have 63 species, representing 68.4% of the population (dominant species of the species *Astrantia major* L., *Vinca minor* L., *Carduus nutans* L., *Veronica officinalis* L., *Sorbus aucuparia* L., *Hypericum perforato* L., *Taraxacum officinale* L., etc.). 25 species represent hygrophytes (*Lycopodium annotinum* L., *Leucojum vernum* L., *Alnus glutinosa* L., *Polygonum aviculare* L., *Ranunculus repens* L., *Coronaria floscuculi* L., *Mentha aquatica* L.) with a share of 27.1%. The last place in the spectrum of groups in relation to the water are xerophytes and hydrophytes, which share respectively make up 3.2% (3 species) and 1.0% (1 species) (Diagram 3).

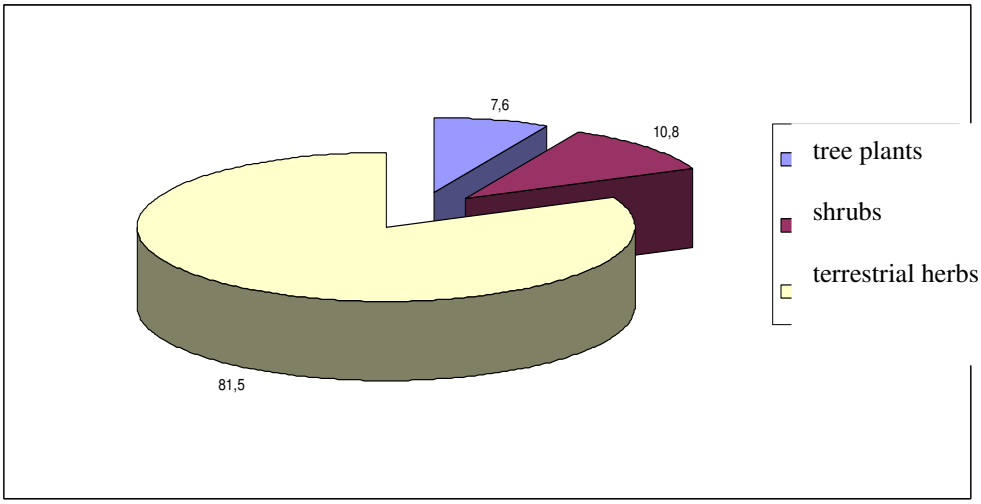
Diagram 3



Distribution of medicinal plants by environmental groups

For life forms (Serebryakov's classification), the identified species are distributed as follows: tree plants – 7 species, which is 7.6%; Shrubs - 10 (10.8%) species and terrestrial herbs 75 (81.5%) species (Diagram 4).

Diagram 4



Distribution of medicinal plants by life forms

Rare and endangered species of plants in the Skole district include *Astrantia major L., Leucojum vernum L., Atropa bella-donna L. , Primula veris L., Galanthus nivalis L., Huperzia selago L., Botrychium lunaria Sw., Platanthera bifolia L., Dactylorhiza maculata L., Scopolia carniolica Jacq., Corydalis cava L.*, та інші.

CONCLUSIONS

As a result of the research carried out on the territory of Skolesky district, we found a growth of 92 species of medicinal plants belonging to 46 families and 5 divisions.

91.3% of their species composition are representatives of Magnoliophyta (84 species). Among the classes, Magnoliopsida occupies 81.3% (75 species) of the species by species.

The leading families include Asteraceae 14.1%, Rosaceae 13.0%. Families of the Fabaceae are 5.4% and Brassicaceae 4.3%, respectively.

The largest number of species is rare and isolated.

REFERENCES

1. Визначник рослин України, 1965. К.: Урожай, 1-456.
2. Гродзинський А.М., 1992. Лікарські рослини: Енциклопедичний довідник. К.: Українська енциклопедія, 1 – 544.
3. Друде О., 2003. Екологія рослин. К.: Наука, 45-51.
4. Доброчаева Д.Н., 1987. Определитель высших растений Украины.. К.: Наук. думка, 1 – 548.
5. Кархут В.В., 2001. Ліки навколо нас. К.: Здоров'я, 232 с.
6. Мінарченко В.М., 2005. Лікарські судинні рослини України (медичне та ресурсне значення). К.: Фітосоціоцентр, 8-14.

7. Мінарченко В.М., Тимченко І.А., 2002. Атлас лікарських рослин України (хорологія, ресурси охорона). К.: Фітосоціоцентр, 89-112.
8. Мінарченко В.М.,1996. Флора лікарських рослин. Луцьк: Едельвіка, 12-23.
9. Носаль М.М., Носаль І.М., 1991. Лікарські рослини та способи їх застосування у природі. – Житомир, 23-274
10. Серебряков И.Т., 1964. Жизненные формы высших растений и их изучение. Полевая геоботаника. М.: Наука, 146 – 205.
11. Ahmed SM, Nordeng H, Sundby J, Aragaw YA, de Boer HJ., 2018. The use of medicinal plants by pregnant women in Africa: A systematic review. J Ethnopharmacol, 224, 297-313.
12. Bhutani K.K., 2003. Herbal medicines an enigma and challenge to science and directions for new standardization and evaluation of herbal drug formulations. Indian Journal of Natural Products, 19 (1), 3-8.
13. Cannone N., Sgrobati S., Guglielmin M., 2007. Unexpected impacts of climate change on alpine vegetation. Frontiers in Ecology and the Environment, 7, 360-364.
14. Daniyal M., Akram M., 2015. Antifertility activity of medicinal plants. J Chin Med Assoc., 78(7), 382-388.
15. Dixit V.K., N. P. Yadav, 2008. Recent approaches in herbal drug standardization. Integr. Biol., 2 (3), 195-203.
16. Flora Europaea: Vol. 1 (2nd ed.) / Eds. T.G.Tutin, N.A.Burges, A.O.Chater, J.R.Edmondson, V.H.Heywood, D.M.Moore, D.H.Valentine, S.M.Walters, D.A.Webb, J.R.Akeroyd, M.N.Newton. - Cambridge: Cambridge University Press, 1993, 481 p.
17. Lehmann H., 2015. Medicinal plants in France, between pharmacy and herb trade: historical and legislative aspects. Ann Pharm Fr., 73(5), 391-398.
18. Madalski J., 1938. O owocujacych okazach Stratiotes aloides L. w Polsce. Acta Soc. Bot. Pol., 15, №3, 245-250.
19. Matuszkiewicz W., 2007. Przewodnik do oznaczania zbiorowisk roslinnych Polski. Warszawa: PWN, 28-450.
20. Patel P.M., N.M. Patel, R.K. Goyal, 2006. Quality control of herbal products. The Indian Pharmacist., 5 (45), 26–30.

АНОТАЦІЯ

ВИВЧЕННЯ ЛІКАРСЬКИХ РОСЛИН У ФЛОРІ СКОЛІВСЬКОГО РАЙОНУ

Лікарські рослини є складовою частиною природи і відігають надзвичайно важливу роль як у природі, так і в житті людини. Проте, флора лікарських рослин на даній території щороку суттєво зменшується. Це пояснюється безконтрольним використанням природних ресурсів багатьох цінних лікарських рослин. Ці чинники призвели до катастрофічного зменшення природних ресурсів багатьох видів флори, розвитку тенденції до скорочення сировинного ареалу більшості цінних видів і, як наслідок, перехід їх до розряду рідкісних.

Використання лікарських рослин у народній та офіційній медицині має багатовікову традицію. Вони здавна користуються великою популярністю серед населення. Однак, хоча цілющі властивості лікарських рослин загальновизнані, вивчення перспектив раціонального використання та застосування їх у медицині нерідко ведеться однобоко. Так, у науково дослідних закладах дослідження фармакотерапевтичної цінності лікарських рослин спрямоване головним чином на вивчення окремих діючих речовин, сировини, призначеної для хіміко-фармацевтичної промисловості. Безпосередньому ж комплексному дослідженню рослин приділяється ще недостатньо уваги. Внаслідок цього

не використовуються природні лікарські засоби, надзвичайно корисні при багатьох хворобах.

Не достатньо вирішеною є проблема вивчення в цьому плані інших регіонів, зокрема перспективними є дослідження природних умов та рослинних ресурсів Сколівського району та з'ясувати можливості використання даної території як бази для збирання, вирощування та заготівлі цінної лікарської сировини.

Лікарські рослини застосовують в науковій і народній медицині як ефективний природний, біологічно дійовий засіб для лікування різних захворювань, а також підвищення стійкості організму до них. До лікарських рослин відносять такі, що містять біологічно активні речовини та використовуються для заготівлі лікарської сировини. Властивості лікарських рослин зумовлені наявністю комплексу біологічно-активних (алкалоїдів, сапонінів, глікозидів, фітонцидів, вітамінів та ін.).

На території Сколівського району нами виявлено зростання 92 видів лікарських рослин, які належать до 46 родин та 5 відділів.

Абсолютна більшість флори представлена покритонасінними рослинами (91,3 %). Належать вони до 2 класів Liliopsida і Magnoliopsida. Провідне місце за кількістю видів займає клас Magnoliopsida.

До провідних родин належать Айстрові 14,1%, Розові 13,0%. Поряд домінує родина Бобові 5,4 % та Хрестоцвіті 4,3 %. Найменш чисельними є родини: Звіробійні, Калинові, Первоцвіті, Цибулеві, Барвінкові, Бузинові.

У результаті проведеного екологічного аналізу на досліджуваній території за вимогами до вологості переважають мезофіти 63 види, що становить 68,4%. За життєвими формами переважають трави 75 видів (81,5%).

На території Сколівського району дуже рясно зростають 9 видів, рясно – 10 видів, досить рясно – 21 вид, рідко – 25 видів, зустрічаються поодиноко 25 видів та 2 види, які змикаються надземними частинами.

Чимало видів лікарських рослин потребують охорони і занесені до Червоної книги України (білоцвіт весняний, баранець звичайний, беладонна звичайна, гронянка півмісяцева, первоцвіт весняний, любка дволиста, цибуля ведмежа, пальчатокорінник плямистий). Проведені дослідження вказують на доцільність роботи в напрямку збереження, відтворення та збільшення кількості популяцій деяких видів лікарських рослин.

Будь-яке втручання у природні екосистеми призводить до втрати біорізноманіття, до зменшення кількості аборигенних видів. Як наслідок, порушується природна рівновага й структура угруповань. Пропонуємо такі заходи щодо охорони видів лікарських рослин, а саме: організовувати підсів лікарських рослин на луках, вигонах, балках; для збереження запасів лікарських рослин у природних біотопах, слід рекомендувати їх до введення у культуру, наприклад, на пришкільних ділянках; виявляти цінні рослини та включати їх до заповідних.

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THE FOUNDING OF THE FRANCISCAN GARDENS IN THE DESIGN OF THE CONVENT GARDENS

Abstract. During designing the gardens of the monastery creator should delve into the historical assumptions. Depending on the rules of the order number of the referenced green is varied. Franciscan garden were limited to patio and a small garden. Because this was the rule of the order- give up to material goods. For this reason, the monasteries were located in the cities, for small surfaces. Kalwaria Pacławska is located in a place with very good natural conditions: clean air, soil, water. The local forests are a sanctuary for many species of plants and animals. This area is covered by multiple forms of protection, in order to save valuable communities.

St. Francis-maintainer of the order – he was the patron of ecologists. According to this design are increasingly "meadows flower of St. Francis". These are the communities to protect biodiversity, in every sense of the word. In Kalwaria Pacławska pedestal at the St. Francis was established flower bed inspired by his adoring pointing in the direction of nature.

Keyword: St. Francis, wirydarz, biodiversity, meadow flower, Kalwaria Pacławska, lawenda wąskolistna, *Lavandula angustifolia, Echinacea purpurea*, rudbekia, *Rudbeckia*.

INTRODUCTION

An integral part of the founding of the monastery were distinct forms. Depending on the rules of the order differed among themselves. Common elements that you can specify are patio and gardens. [15] Contemporary surroundings monasteries takes new forms, classic elements are often replaced by new. Kalwaria Pacławska is since many years the Franciscans. According to its Patron-Saint. Francis-special attention on taking care of nature. The natural conditions of the region are conducive to this activity. The purity of the water, air and soil are biodiversity of flora and fauna.

METHODS

The article used available literature, articles, the regulation of the Minister of environment of 9 October 2014 year on the protection of species of plants. Used also with materials available on the websites. The test results are based on several months of observations and tests. Uses own photography.

RESULTS

In November 1979 the year of St. Francis announced by Pope John Paul II, the patron of ecologists. This was due to his unusual praise works of God, the beauty of nature. In the iconography of the very often depicted in the company of animals: wolves, birds-of his friends. Was the book "*The flowers of St. Francis*". This is a gun created probably in the 13th century. Since there are many translations for different languages, some of the texts have been enriched with new content. It contains a number of short stories depicting scenes from the life of a Saint. Find in them we can texts providing its relation to nature. [10] we can perceive the emotional approach to animals: "*birds, brethren mine, be very grateful to God, the creator, his* "[17] Pope took the attitude of protection of defenseless creatures. Francis worthy follow despite the passage of many years, often Called "the first environmentalist" [3] .

Patron of the Franciscan-St. Francis of Assisi-lived at the turn of the 12th and 13th centuries. He came from a wealthy merchant family. As a young man he took part in the war, which events gave beginning to its getting closer to God. Had a vision in which he was commissioned to rebuild the Church. In order to raise financial resources seemed like a family-run property. As a result of these events fell into conflict with her father and eventually decided to start life the emperor. His activity led, inter alia, in the leper colony, which in places of isolation people with leprosy from the rest of society. Adopted a very modest dress-Brown tunic, resigned from the wearable footwear. Created a rule of religious life, which was approved by the Pope, and along with fellow focused around him began to build order. [13]

Originally Franciscans lived in or near cities. By selecting the locations searched for places to life in peace, poverty and silence. Renounced material possessions, they had life beggars Franciscan gardens were small, their size was limited by the fabric of the city. On these small areas of cultivated plants for the purposes of their own. [12] the main point in the assumptions of the monastery was surrounded by a Franciscan cloister. Depending on the amount of space in front of the monastery was a small garden, which he served as decorative – usable [11].

Kalwaria Pacławska is a small town located in the municipality of Fredropol on top of a hill (465 m), 24 km from Przemysl. In this small village, situated on the sidelines, in the hills and forests, is one of the most famous Marian shrines in Poland. [5] the rise of Kalwaria Pacławska dates back to the year 1665. Its founder and founder was Andrzej Maksymilian Fredro, Bończa coat of arms. Local legend holds that the impetus for its creation was an event in the life of Fredro. In the course of hunting got lost in the forest. Seeking the way huntsmen at some point released a deer with a burning cross between the horns. This event triggered the thought about the construction of the Church of the monastery in place. [1] During the construction of the Calvary equally works consisting in the creation of the fortifications. It had to strengthen the gate Przemysl and be one of a series of fortresses on the river Wiar. The Church and monastery are surrounded by fortress, and from its outer side dug a moat. The order of Friars Minor Conventual was a sanctuary for the Poles-Christians in a society in which dominated the population of Greek Catholics. The aim of the Convention outside the religious worship was to protect local people against the Cossacks and the Tatars. In 1688 the year Andrzej Maksymilian Fredro brought to Calvary of the Franciscans, who to this day have the care of the monastery. [7]

Nature in Kalwaria Pacławska and the area is characterized by the presence of many valuable species of plants and animals, natural landscape, the ossidiana hotel offers its guests the soil and air. For these reasons, cited in the June 2001 year reserve Kalwaria Pacławska area of 173.1800 ha. It is a nature reserve. Was created to keep the forest and elements of the cultural landscape for educational purposes and research. [18] The monastery Buildings are part of the surrounding landscape, giving a sense of calm and relaxation. The location of the Kalwaria Pacławska attracts not only pilgrims, but also to spend time in nature. Beautiful apartments invites you to hiking, meditations, and enjoy the nature changing over the next seasons.

The founding of the garden in Kalwaria Pacławska deviates from the original assumptions of Franciscan Monasteries located in towns and small size. Because of the locations away from the city, in a place with low density construction features a large, open space.

An integral part of each assumption monastery was a close-up. It was surrounded by a cloister. In the center of it was well, a fountain, a sculpture or a tree. Was a place for contemplation. Hotel was on the set of a rectangle or a square. Criss was perpendicular paths, divide it into four quarters. Quarters were filled with flowers, small shrubs and herbs. Plant not used random-was dominated by species, which assigned was the symbolism of the Christian [7]

Contemporary picture of wirydarz in Kalwaria Pacławska is not like the implementation shown in the textbooks on the history of gardens. The classic layout, the layout remained on the square, surrounded on four sides of the high walls. Garden Centre creates a diameter of 4 m

is a place where stone paths converge. This area is not landscaped, during the summer there are issued decorative flower pots with flowers. In the middle of the square there is a concrete plate, which covers well, which was aligned with the surface of the ground. The path was laid out from the local raw material which is the broken gap between sandstone rocks full of grass, natural look, is not very practical because of the difficulty to care for. The path has no curbs. The lawn is heavily, mowed down low. The species composition creates primarily *Festuca rubra rubra*, *Festuca rubra commutate*, *Festuca rubra*, *Lolium perenne*, *Poa pratensis*. The whole thing is much neglected, negligence is visible.

Fig 1. View on a wirydarz, photo by T.Markowicz

The surroundings of the monastery buildings and is surrounded by vegetation. Area in front of the sanctuary of the park, which is home to many of the old trees. At the moment, many of them due to its age is starting to decline. This forces to work to supplement the stand in order to preserve the values of the Park. Out of many species growing *Acer*, *Aesculus hippocastanum*, *Fraxinus excelsior* and *Quercus*.

Fig 2. the park in front of the Church, photo by T.Markowicz

According to the idea of the patron saint of the order on the conservation of biodiversity assume the flower bed with perennials referring to the meadows flower fairy's. Francis. Biodiversity can be defined as "a wealth of life forms on Earth, the variety of species, the genetic variability of intraspecific, as well as the variety composition of natural systems. of ecosystems and landscapes. Diversity is a feature of nature, resulting from the diversity of life forms and layouts, in which occur, ecological functions, which serve and genetic variation, which in themselves contain. The shortest definition defines biodiversity as the variability of life forms at all levels of biological organisation or generally genes, species and ecosystems

found in the region. " [16] In nearby forests, many species of animals that do not exist anywhere else. A significant impact on this is the fact that the land Of 1,000 is characterized by the fact that has one of the larger numbers of sunny days in a year. The surrounding agricultural fields, fruit bushes and trees are a source of food for many species, and scrub and forests are a sanctuary for them. Kalwaria Pacławska is an ideal place for bird watchers. It has been observed here about 70 bird species. The most interesting is the *Strix uralensis*, not in any other area of Polish. Is a bird Carnivore, which comes from the Scandinavian Peninsula and the cold regions of Asia. In addition, you can meet here the *Ciconia record*, *Dryocopus martinus*, *Pernis apivirus*, *Bubo Bubo*, *Aquila pomarina* and dozens of other interesting bird species. Outside the birds can be found here a whole range of different species of animals ranging from insects, amphibians, reptiles and mammals. Sometimes appear from the Bieszczady Mountains: *Lynx Lynx* and *Canis lapus.* Constantly forests are inhabited by *Meles meles*, *Mustela erminea*, *Cervus elephus*, *Caproelus caproelus*, *Vulpes Vulpes*, *Sus*, *Erinaceus europaeus*, *Sciurus vulgaris* and a variety of other species. [19]

Created flower bed, which was called the " Flower bed of biodiversity ". Its theme was the creation of the artwork, which will attract the eye from early spring until late autumn. In addition, its task is to lure butterflies and insects-friends. Francis. In the summer of 2015 year erected a small chapel. Francis is the patron saint of ecologists. She stands on stand King 24 sandstone. The same material were used to complete the surface. Around him were two wooden benches and lighting were installed.

Fig 3. The statue of St. Francis in Kalwaria Pacławska, photo by A. Błądzińska

Rabat established in Kalwaria Pacławska, differs from a typical flower meadow, which is sown with a mixture of grass seeds and flowering perennials. [20] Due to the representative character of the place, a rebate has been created with proper care and will look attractive throughout the growing season and some species also in the winter. In the project used a wide range of plants: bulbs, ornamental grasses, perennials and shrubs. Wavy lines and loose groups of plants dominate. Planting is devoid of geometric shapes, but it does not deprive the rebates of aesthetic values.

To create this rabat following onion plants were used: crocuses (Crocus), tulips (Tulipa), narcissi (Narcissus), snowdrop sprig (Galanthus nivalis), hyacinths (Hyacinthus), which will be the first flowering plants in spring. A wide range of perennials were used, blossoming at different dates. Among others: Rudbeckia, different varieties of coneflower (Echinacea), daylilies (Hemerocallis), lilies (Lilium), ornamental garlic (Allium aflatunense), periwinkle (Vinca), thyme (Thymus), narrow-leaved lavender (Lavandula angustifolia), rose (Rosa) and many more. The whole was padded with bark from conifers.

Fig.4 "Flower bed of biodiversity" in the process of starting, photo by A. Błądzińska, A. Tekiela

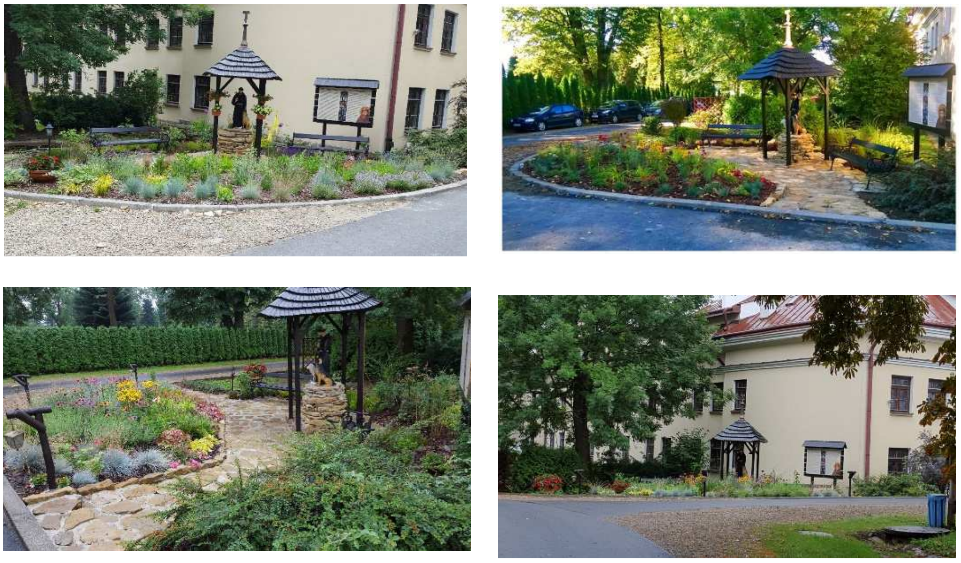

Fig. 5 "Flower bed of biodiversity" after the assumption, photo by A. Tekiela

Many of the applied plant has a symbolic meaning. Assigning vegetation meanings is known for centuries. Very strongly this phenomenon is noticeable in the Christian culture. Plenty of species

associated with the cult of the mother of God is closely or Jesus Christ. In the project discounts not forgotten such plants. Here there are lilies – the symbol of innocence, purity, rose-the martyrdom of Christ, hyacinth-longing for heaven, Christian prudence, peace of conscience [14].

In creating the discount in accordance with the principle of biodiversity should be paid attention to the presence of insects. Is the use of melliferous plants and lure. In the area of Kalwaria Pacławska commonly occurs a large number of species of insects, which have an impact on many biological processes taking place in the soil and the proper functioning of the entire environment. These include natural *Bombus terrestris*, *Formica rufa*, *Melolontha Melolontha*, *Apis mellifera*. An interesting species that can be seen is the *Papilio machaon*, is the largest butterfly. [4]. Currently it is observed the process of extinction of many species of butterflies. This is due to the intensely carried out cultivation of agricultural, forestry monocultures, especially conifers. Traditionally found in the agricultural landscape balks and buffer strip is used for crops. In this way, destroyed habitats are life, maintenance of many species of insects, birds, mammals. Increase in mineral fertilizing fields, and use of plant protection products, the growth of cities and industrial zones has a negative effect on the abundance of butterflies. [2] the areas of Kalwaria Pacławska constitute an enclave in which can be saved from extinction. In order to "call" butterflies for rabatę uses plants lure. These include *Lavandula angustifolia*, *Echinacea purpurea*, *Rudbeckia.*

Lavandula angustifolia is small shrubs known since the middle ages. She performed in patio which is the classic assumptions herbaceous perennial plant. Is a plant originating from the Mediterranean countries. Withstand climatic conditions Polish if it is in a place sheltered from the wind, the colder the winter requires. It owes its popularity to the intense scent, even after cutting and drying flowers. Sometimes referred to as well as lavender "medical advice", as it can be used in herbalism. It has a positive impact on the work of the digestive system, has an antispasmodic and sedative. Reaches a height of approximately. 50-60 cm. Blooms in June and July, after felling dried inflorescences repeat flowering. It is recommended that regular cut, in order to ensure a rich, flowering. [6]

Fig 6. *Lavandula angustifolia*, photo by A. Błądzińska

Echinacea is native to North America. In this kind comes a lot of varieties varying in height, colour of flowers. It is a plant with very decorative, large petals. It has stiff stems, therefore, despite achieving up to 1.5 meter does not fall over. They are characterized by high resistance to disease and pests. Apply discounts on the nature of the naturalistic, rural gardens. In addition to ornamental planting may her prickly head can be used in floristics in the compositions. It has medicinal properties, can be used to enhance immunity, support the treatment of wounds, burns and infections of the upper respiratory tract [8].

Rudbeckia as *Echinacea* come from North America. They are not demanding plants, grow well on a sunny, prefer damp soil. It composes very well with *Echinacea* due to the same type of inflorescence-basket (both are derived from plant-*Asteraceae*). They have yellow flowers, which are characterized by long service life [9].

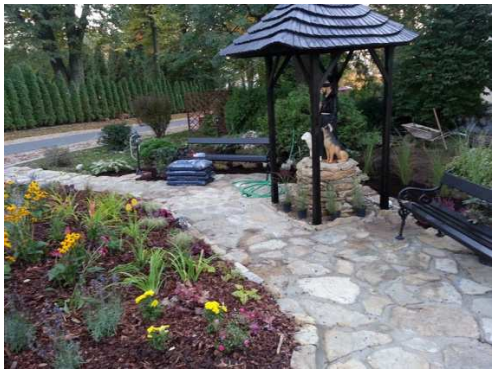

Fig 7. *Rudbeckia* on the flower bed of biodiversity, photo by T.Markowicz

CONCLUSIONS

When designing a modern gardens the monastic grammar you should delve into the stories of the order and in the traditional evolution of green. Over the years, such assumptions are subject to change in and out of the rigid adherence to the rules of prior centuries. Originally a Franciscan convents were located in cities, have a limited amount of space. The order of the Franciscans in Calvary is located in an open space, on the ground with a low index of buildings away from the hustle and bustle of the city. There are conditions conducive to the protection of many species. According to the patron saint of ecology-St. Francis. In its project uses plants lure insects, especially butterflies and symbolic.

REFERENCES

1. Barcik J. 1973. Fundacja klasztoru franciszkanów w Kalwarii Pacławskiej. Prawo Kanoniczne. 16 (1-2), 89-128.
2. Buszko J., Nowacki J. 2000. Zagrożenia i możliwości ochrony motyli (Lepidoptera) w Polsce. Wiadomości entomologiczne. 18 (Supl. 2), 213-220.
3. Jaromi Stanisław OFM Conv. 2004. 25 rocznica ogłoszenia św. Franciszka patronem ekologów. Zielony Zeszyt REF, 4-6.
4. Jujka-Radziewicz M., Okołów E. 2012. Co Kryje Natura, Przewodnik po wybranych obszarach Natura. Ogólnopolskie Towarzystwo Ochrony Ptaków Marki, 84.
5. Korzec M. 2003. Przemyśl i okolice. Wyd. Krosno, 111-112.
6. Latocha P. 2006. Rośliny ozdobne w architekturze krajobrazu część IV. Wyd. Warszawa, 154-155.
7. Majdecki L. 2002. Historia ogrodów (tom. I). Wyd. Warszawa, 64-67.
8. Marcinowski J. 2002. Byliny ogrodowe – produkcja i zastosowanie. Wyd. Warszawa, 205.
9. Maternicka G. 2013. Katalog ozdobnych roślin ogrodowych. Wyd. Warszawa, 249-250.
10. Mazurkiewicz R. 1994. Zrozumieć średniowiecze. Wyd. Tarnów, 120.
11. Mitkowska A. 2003. Polskie Kalwarie. Wyd. Wrocław, 186-192.
12. Pierścionek B. 2012. Ogrody użytkowe klasztorów Bernardyńskich. Wyd. Kraków, 2-3.
13. Prejs R. 2004. Osoba i przesłanie św. Franciszka. Wyd. Lublin, 12-16.

14. Pudelska K., Mirosław A. 2013. Symbolika średniowiecznych ogrodów przyklasztornych i ich roślinność. Wyd. Lublin, 52-53.
15. Różańska A. 2005. Podstawy architektury krajobrazu część II. Wyd. Warszawa, 65-69.
16. Sienkiewicz J. 2010. Koncepcje bioróżnorodności - ich wymiary i miary w świetle literatury w Ochrona Środowiska i Zasobów Naturalnych. Wyd. Warszawa, 7.
17. Staff L. (przekł.) 1978. Kwiatki świętego Franciszka z Asyżu. Wyd. Warszawa, 4-5.

Strony internetowe:

1. www.crfop.gdos.gov.pl, dostęp w dniu 10.01.2017
2. www.kalwariapaclawska.pl, dostęp w dniu 03.01.2017
3. www.luczaj.com/kwietna.htm, dostęp w dniu 13.01.2017

STRESZCZENIE

ZAŁOŻENIA OGRODÓW FRANCISZKAŃSKICH W PROJEKTOWANIU OGRODÓW PRZYKLASZTORNYCH

Projektując ogrody przyklasztorne należy zagłębić się w historyczne założenia. W zależności od reguły zakonu ilość występującej zieleni jest zróżnicowana. Bardzo często franciszkańskie ogrody ograniczone były do wirydarza i niewielkiego ogrodu użytkowego. Spowodowane było to regułą zakonu – wyrzekaniem się dóbr materialnych. Z tego powodu klasztory lokalizowane były w pobliżu miast, zazwyczaj na niewielkich powierzchniach. Kalwaria Pacławska położona jest w miejscu posiadającym bardzo dobre warunki naturalne: czyste powietrze, gleba, wody. Tutejsze lasy stanowią ostoję dla wielu gatunków roślin i zwierząt. Teren ten objęty jest wieloma formami ochrony, w celu ocalenia cennych zbiorowisk. Przepiękne połoniny zachęcają do pieszych wędrówek, rozmyślań i podziwiania przyrody zmieniającej się wraz z upływem kolejnych pór roku.

Nieodłącznym elementem klasztoru Franciszkanów był wirydarz. Miał on być miejscem do kontemplacji i łączności z Bogiem dla zakonników. Położony był zawsze na planie kwadratu lub prostopadłościanu, zaś cztery kwatery wypełnione były ozdobnymi roślinami oraz ziołami. Istniejący wirydarz w Kalwarii Pacławskiej nie pełni już pierwotnych funkcji. Roślinność ograniczona została do trawnika, niekiedy ozdobionego kwiatami jednorocznymi w donicach, umiejscowionych w centralnym miejscu wnętrza.

Święty Franciszek – opiekun zakonu – powołany został patronem ekologów. W myśl tą projektowane są coraz częściej „łąki kwietne świętego Franciszka". Są to zbiorowiska mające chronić bioróżnorodność, w każdym tego słowa znaczeniu. W Kalwarii Pacławskiej przy postumencie świętego Franciszka powstała rabata, inspirowana Jego uwielbieniem, skierowanym w kierunku natury. Ze względu na reprezentacyjny charakter miejsca, zastosowano ozdobne rośliny, m.in.: krokusy (*Crocus*), tulipany (*Tulipa*), narcyzy (*Narcissus*), śnieżyczkę przebiśnieg (*Galanthus nivalis*), hiacynty (*Hyacinthus*), rudbekie (*Rudbeckia*), różne odmiany jeżówki (*Echinacea*), liliowce (*Hemerocallis*), lilie (*Lilium*), czosnek ozdobny (*Allium aflatunense*), barwinek (*Vinca*), macierzankę (*Thymus*), lawendę wąskolistną *(Lavandula angustifolia),* różę *(Rosa).* Użyto szerokiej gamy traw oraz roślin kwitnących w różnych terminach, we wszystkich porach roku. Zastosowano rośliny cebulowe, które będą zdobić rabatę od samej wiosny, kolejno zakwitać będą poszczególne byliny, aż do późnej jesieni. Rabata dekoracyjna będzie także zimą, gdyż zdobić będą ją przekwitłe kwiatostany niektórych gatunków oraz trawy, które atrakcyjnie wyglądać będą oszronione mrozem lub obsypane śniegiem. Na uwagę zasługują oczary wirginijskie (*Hamamelis virginiana*), cieszące żółtymi, pomarańczowymi i czerwonymi kwiatami na przełomie zimy i wiosny. W projekcie rabaty uwzględniono rośliny przywabiające motyle (lawenda, rudbekia, jeżówka) oraz gatunki symboliczne, ściśle związane z charakterem miejsca. Użyto roślin niewysokich, aby nie przesłaniały one pomnika świętego Franciszka.

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QUALITY ANALYSIS OF WATER SUPPLY SOURCES BY HYGIENIC INDICES USING AN EXAMPLE OF THE SPECIALIZED REGIONS IN THE LVIV REGION

Abstract. The article highlights the research results for the hygienic indices of water quality from various water supply sources in Drohobych, Sambir and Stryy districts of the Lviv region. The samples of water from the sources of centralized water supply in the cities Drohobych, Stryy, Sambir, Boryslav, Rudky were analyzed, and water was found to meet hygienic requirements. The analysis of the results shows that the anthropogenic environment in the cities has a negative impact on the quality of groundwater in the cities Drohobych and Stryy, and samples of water bodies do not meet the requirements by the microbial count and the coli index. In the cities Boryslav and Sambir, well water meets the standards for both hygienic indices. The research results confirmed that individual wells are the most problematic type of water supply in the countryside. In the villages Stupnytsia, Urizh, Brezhnytsia, Nezhukhiv, samples of the well water exceed the established the norms for drinking water in two indices (1.1 – 9.28 times, coli-index – 110 times). In the villages of Baranivtsi and Dolishnie, well water meets the standards for two hygienic indices.

Keywords: water quality, hygienic indexes, centralized water supply, well, Lviv region.

INTRODUCTION

According to the World Health Organization (WHO), 80% of all diseases in the world are associated with poor drinking water quality and violations of hygienic and environmental standards for water supply [11-19]. Providing the population with quality drinking water is one of the main problems of humanity. This problem becomes more and more complicated every year, being more dangerous. More than a billion people use low-quality water. Because of this, three and a half million children die every year. Most Ukrainians consume water from surface sources - lakes, ponds, and rivers. About 30 million people consume water from the Dnipro River [1, 2, 8].

The decreasing of drinking water quality causes an increase in the disease incidence rate of the population from the use of low-quality water, which leads to a decrease in the capacity for work, a reduction in the life expectancy, and leads to material and financial losses in the state. Drinking water that does not meet hygienic and hygienic requirements, is the threat of massive diseases of the population, exacerbates the social situation. The incidence of cancer and atherosclerosis in the population are constantly increasing and there is a significant amount of contaminated water [7].

About 60% of the tested drinking water samples from the water supply line in all regions of Ukraine do not meet the safety requirements for human health [3, 4, 10]. Today, there is no state system for monitoring the groundwater quality due to the termination of the hygienic-epidemiological stations. According to the data obtained by hygienic-epidemic station in previous years in the Lviv region, about one thousand water samples from public wells and about 30% of investigated samples showed an increased level of bacterial contamination and up to 10% did not meet the requirements for physical and chemical indices. Last year, the share of drinking water samples that did not meet the hygienic norms for hygienic-chemical indices, which significantly exceeds the country's average indices – 12,9%, and in the Lviv region – 0,9%. Therefore, the analysis of the water quality by hygienic indices for different sources of water supply in selected regions of Lviv region is very relevant.

The purpose of the work is to analyze the quality of water supply sources according to hygienic indices, for example, in certain regions of Lviv oblast.

RESEARCH METHODS FOR ANALYSING WATER QUALITY

According to the new standard DSanPiN 2.2.4-171-10, the quality of drinking water is estimated by the hygienic indices: the TBC and the coli index.

Determination of the microbial count in tap water. 1 ml of the test sample of water is added with a sterile pipette in each of 3 sterile Petri dishes. In each dish, pour 15 ml of molten and cooled to 45 °C MPA. Its contents is mixed cautiously, with slight circular movements in a closed cup. Dishes are left horizontally until the agar is sealed, and then put in the thermostat for 24 hours at 37 °C [9].

Determination of the coli index in water by the fermentation method. 100 ml of water are added with sterile Mori pipette in 3 flasks with 10 ml Aikman's concentrated medium. Then 10 ml of water are added to 3 test tubes with 1 ml of Aikman's concentrated medium, and 1 ml of water is added with 10 ml of pipette in 3 other test tubes with 10 ml of diluted media. Seeding are grown in a thermostat at 37 ° C for one day [9].

Studies were conducted in accordance with generally accepted bacteriological methods (requirements of the DSP, GOST) [5,6].

The object of the study was water from certain settlements in Drohobych, Sambir and Stryy districts (scheme 1).

Scheme 1

Investigated sources of water supply	Depth, m
Drohobych district	
Drohobych (central water supply)	-
Boryslav (central water supply)	-
Drohobych (well water)	8
Boryslav (well water)	12
Stupnytsia (well water)	5
Urizhж (well water)	15
Novyy Kropyvnyk (well water)	5
Sambir district	
Sambir (central water supply)	-
Rudky (central water supply)	-
Sambir (well water)	10
Rudky (well water)	20
Baranivtsi (well water)	12
Side (well water)	10
Berezhnytsia (well water)	5
Stryy district	
Stryy (central water supply)	-
Stryy (well water)	-
Nezhukhiv (well water)	11
Dolisnie (well water)	15
Stankiv (well water)	14

The study of hygienic indices was carried out in October-November 2017. All investigated wells have cladding made of concrete rings, and the depth of the wells ranges from 5 to 20 m.

RESEARCH RESULTS

Analysis of the quality for the water from the sources of urban centralized water supply. Scientists and practitioners investigate the problem of providing people with quality drinking. Centralized water supply of cities, villages and industrial enterprises is a multipart complex of technical and economic and hygienic measures, and rational problem solving determines the level of hygienic arrangements in settlements, provides normal living conditions, guarantees the constant work of industry. The water quality of local water supply sources is regulated by the hygienic norms of Ukraine DSanPiN 2.2.4-171-10 for drinking water.

The main source of water in the cities of Lviv region is centralized water supply. Therefore, the first stage of our work was the analysis of samples of centralized water in the cities Drohobych, Stryy, Sambir, Boryslav, Rudky for hygienic indices. The monitoring data was entered in the table.

Table Hygienic indices of investigated waters

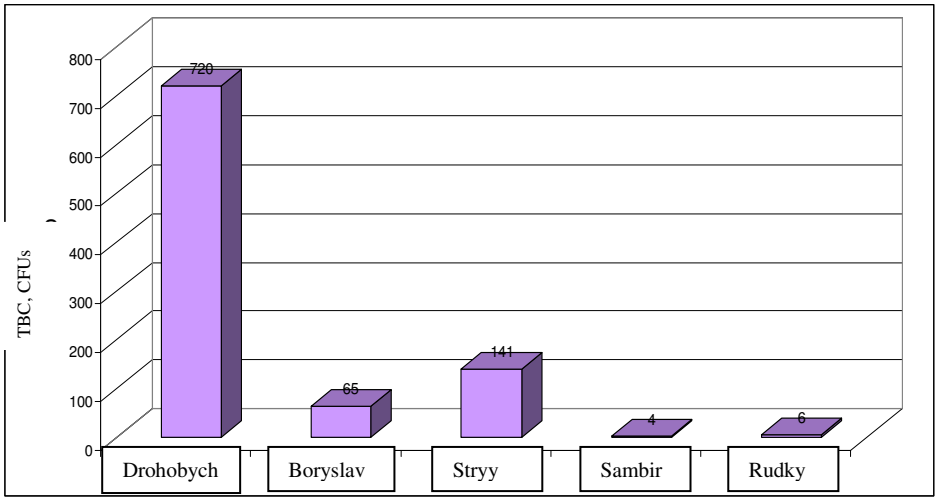
Study area	TBC	Coli index
Drohobych	6	0
Boryslav	8	0
Stryy	11	0
Sambir	13	0
Rudky	7	0

The water coming from the reservoirs to the central water supply system is pre-treated at the water supply stations, because of which its quality is brought in line with the requirements of DSanPiN 2.2.4-171-10 [6].

The investigated samples meet the regulatory requirements for drinking water (DGSU). This result was foreseen because water from urban water supply system is constantly undergoing centralized chlorination treatment.

Analysis of the quality for the well water in urban areas. In the cities of Western Ukraine in general, and in the Lviv region in particular, the use of private wells is widespread along with centralized water supply. During October-November 2017, we examined the hygienic indices well water in the cities Drohobych, Stryy, Sambir, Borislav, Rudky for hygienic indices. Monitoring data are shown in Diagrams 1-2.

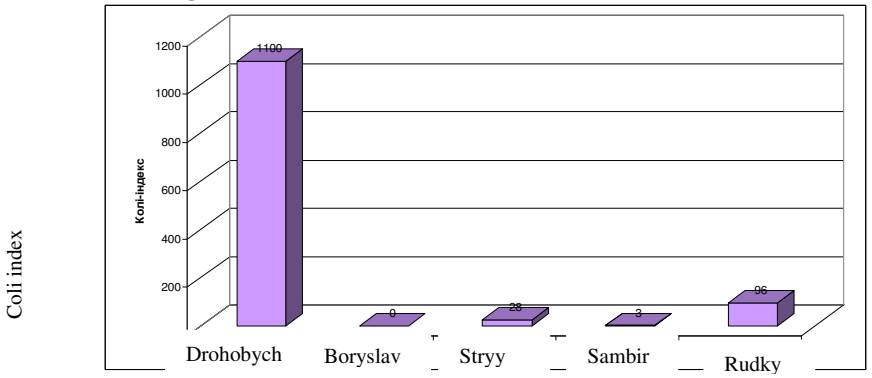
Diagram 1 TBC for well waters from the studied cities



The results of the analysis indicate that the total bacterial count (TBC) of the analysed waters varies within the range of 4-720 CFUs. Normative documents limit the number of CFU in drinking water as not exceeding 100 CFUs.

As it can be seen from Diagram 1, samples of well water from the cities Sambir, Rudky and Boryslav meet these requirements. According to the environmental passport of the Lviv region, a significant excess of hygienic indices due to the spring flood was recorded in 2016 in the Sambir district. A complex of methods for cleaning drinking water was implemented. According to the results in Sambir and Rudky, they have had a positive effect.

Diagram 2 Coli-index for well waters from the studied cities



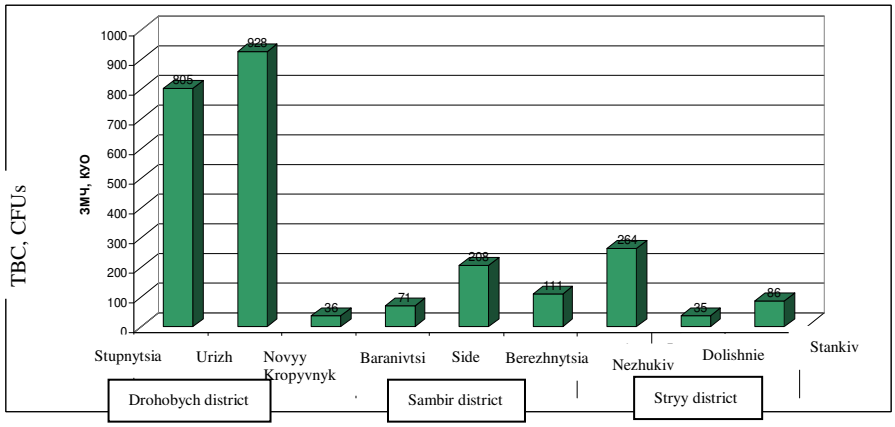
Well waters from the cities Stryy and Drohobych do not comply the norms by TBC, obviously this is due to significant anthropogenic pressure in the cities.

As it can be seen from Diagram 2, the coli-index exceeds the norm (no more than 10 CFUs) in the cities Drohobych, Stryy and Rudky in 2.8-11.0 times. Excess of this indicator in drinking water can cause a number of diseases in the population and is probably due to irregular cleaning of wells and pumping systems.

Analysis of the groundwater quality in rural settlements. The rural population acutely faces the problem of providing high-quality drinking water, as the main source of water supply remains wells and surface water, which consumption is associated with technogenic and agricultural loads on water resources.

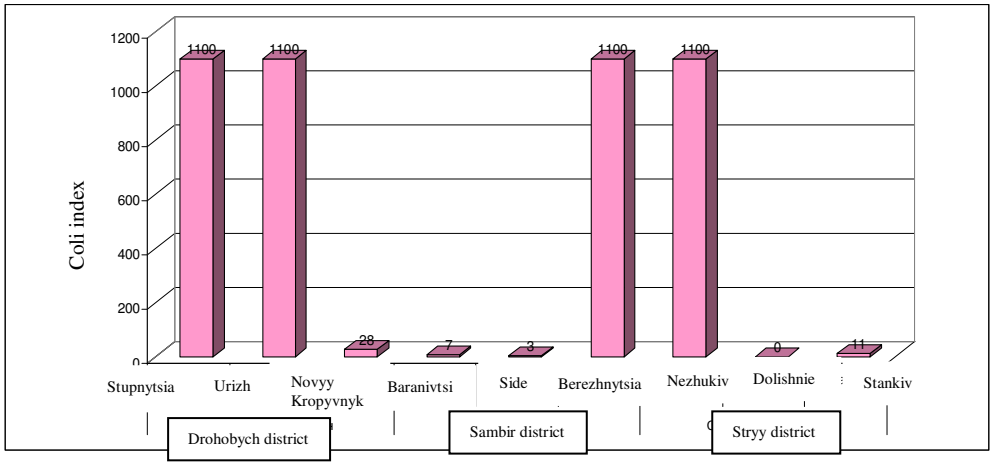
During October-November 2017, the hygienic indices of the well waters in the villages of the Drohobych, Stryy and Sambir districts were analyzed by the hygienic indexes. Monitoring data are shown in Diagrams 3-4.

Diagram 3 TBC for well waters from the studied villages



As it can be seen from Diagram 3, in the studied settlements of Drohobych district, the TBC norm is exceeded in the well waters in the villages Stupnytsia and Urizh by 8.05 – 9.28 times. In the Sambir district, the TBC exceeds the norm in the villages Side and Berezhnytsia by 1.1 – 2.08 times. In the Stryy district, the TBC exceeds the norm by 2.64 times in the village Nezhukhiv. This is probably due to the location of the village on the Drohobych-Stryy highway and considerable anthropogenic pressure. In the villages Dolishnie and Stankiv, waters meet the requirements; this is due to the considerable distance of these villages from large cities and highways.

Diagram 4 Coli-index for well waters from the studied villages



As can be seen from the Diagram 4, the coli-index of the studied waters varies within 3 - 1100 CFUs. It should be noted that the coli-index exceeds the norm in all villages of Drohobych district, as well as in the village Berezhnytsia (Sambir district) and in the village Nezhukhiv (Stryy district).

One of the main causes for contamination of the well water by E. coli is unsatisfactory hygienic and technical condition of the wells (the absence or damage of boards, roofs, covers, buckets), a close location at a distance less than 20 meters to the sources of pollution, as well as not conducting repair for more than one year, cleaning and decontamination of wells, as provided by the hygienic rules. In addition, some wells are shallow, rarely cleaned and located near commercial buildings.

CONCLUSIONS

1. During October-November 2017, research was conducted on the quality of water from different sources of water supply in the Drohobych, Sambir and Stryy districts of the Lviv region based on hygienic indices.
2. Water from the sources of centralized water supply in the cities Drohobych, Stryy, Sambir, Boryslav, Rudky meets the requirements by the microbial count in 1 cm^3 and by the coli index.
3. The analysis of the results shows that the anthropogenic environment of the cities has a negative impact on the quality of the well waters in the cities Drohobych and Stryy, and samples of the waters do not meet the requirements by the microbial count in 1 cm^3 and by the coli index. In the cities Boryslav and Sambir, well water meets the standards for both hygienic indices.

4. The research results confirmed that the most problematic type of water supply in the countryside is the individual wells. In the villages Stupnytsia, Urizh, Berezhnytsia, Nezhukhiv, samples of the water from the wells exceed the established norms for drinking water by two indices (1.1 – 9.28 times, in the coli-index – 110 times). In the villages Baranivtsi and Dolishnie, well water meets the standards for both hygienic indices.

REFERENCES

1. Алфьорова А.А., Нечаєв О.П., 1997. Замкнені системи водного господарства промислових підприємств, комплексів і навіть районів. Москва, 258 с.
2. Бережнов С.П., 2006. Питна вода як фактор національної безпеки. СЕС профілактична медицина, №4, 8-13.
3. Бриндзя І.В., 2011. Оцінка якості поверхневих вод Прикарпаття за її фізико-хімічними показниками. Наукові записки Тернопільського національного педагогічного університету. Серія Біологія, №2 (47), 7-11.
4. Гончарук В.В., 2007. Концепція вибору переліку показників і їх нормативних значень для визначення гігієнічних вимог і контролю за якістю питної води в Україні. Хімія і технологія води, Т.29, №4, 297-355.
5. ГОСТ 2874-82 «Вода питна. Гігієнічні вимоги і контроль за якістю». Київ, 200, 59 с.
6. Державні санітарні норми та правила «Гігієнічні вимоги до води питної, призначеної для споживання людиною»: ДСанПіН 2.2.4-400-10. Київ, 2010, 104 с.
7. Директива Ради 98/87/ЕЭС “Про якість води, призначеної для споживання людиною” від 3 листопада 1998 р., 210 с.
8. Звіт Державної санітарно-епідеміологічної станції за 2012 рік. Київ, 2013, 46 с.
9. Івасівка А.С., Клепач Г.М., 2010. Мікробіологія і вірусологія. Методичні вказівки до лабораторних робіт для студентів напряму підготовки «Біологія». Дрогобич, 89 с.
10. Прокопов В.О., Кузьмінець О.М., Соболь В.А., 2008. Стан децентралізованого господарсько-питного водопостачання України. Гігієна населених місць, №51, 63-67.
11. Ahsan MS, Akber MA, Islam MA, Kabir MP, Hoque MI., 2017. Monitoring bacterial contamination of piped water supply in rural coastal Bangladesh. Environ Monit Assess., 189(11):597.
12. Chowdhury S., Al-Zahrani M., 2014. Water quality change in dam reservoir and shallow aquifer: analysis on trend, seasonal variability and data reduction. Environ Monit Assess, 186(10):6127-43.
13. Daud MK, Nafees M, Ali S, Rizwan M. et al, 2017. Drinking Water Quality Status and Contamination in Pakistan. Biomed Res Int., 2017:7908183.
14. Gunnarsdottir MJ, Gardarsson SM, Jonsson GS, Bartram J., 2016. Chemical quality and regulatory compliance of drinking water in Iceland. Int J Hyg Environ Health., 219(8):724-733.
15. Guo A, Bowling JM, Bartram J, Kayser G. Water, Sanitation, and Hygiene in Rural Health-Care Facilities: A Cross-Sectional Study in Ethiopia, Kenya, Mozambique, Rwanda, Uganda, and Zambia. Am J Trop Med Hyg., 97(4):1033-1042.
16. Haijoubi EH, Benyahya F, Bendahou A, et al, 2017. Study of the bacteriological quality of water used in the agro-food industry in the North of Morocco. Pan Afr Med J., 26:13.

17. Kumpel E., Albert J., Peletz R., de Waal D., et al, 2016. Urban Water Services in Fragile States: An Analysis of Drinking Water Sources and Quality in Port Harcourt, Nigeria, and Monrovia, Liberia. Am J Trop Med Hyg., 95(1):229-38.
18. Rotiroti M, McArthur J, Fumagalli L, et al, 2017. Pollutant sources in an arsenic-affected multilayer aquifer in the Po Plain of Italy: Implications for drinking-water supply. Sci Total Environ., 578:502-512.
19. Sakai H., Kataoka Y., Fukushi K., 2013. Quality of source water and drinking water in urban areas of Myanmar. Scientific World Journal, 2013:854261.
20. Shourian M, Moridi A, Kaveh M., 2016. Modeling of eutrophication and strategies for improvement of water quality in reservoirs. Water Sci Technol., 74(6):1376-1385.
21. Soares ACC, Carmo RF, Bevilacqua PD., 2017. Social knowledge and the construction of drinking water preference. Cien Saude Colet., 22(10):3215-3223.

АНОТАЦІЯ

АНАЛІЗ ЯКОСТІ ДЖЕРЕЛ ВОДОПОСТАЧАННЯ НА ПРИКЛАДІ ОКРЕМИХ РАЙОНІВ ЛЬВІВСЬКОЇ ОБЛАСТІ ЗА ГІГІЄНІЧНИМИ ПОКАЗНИКАМИ

Погіршення якості питної води викликає підвищення рівня захворюваності населення від вживання неякісної води, що веде до зниження працездатності, скорочення тривалості життя, а також призводить до матеріальних та фінансових втрат у державі. Питна вода, яка не відповідає санітарно-гігієнічним вимогам, несе в собі загрозу масових захворювань населення, загострює соціальну ситуацію. Захворюваності населення на рак і атеросклероз невпинно зростають і в тому є значна вина забрудненої води. Близько 60 % досліджених проб питної води з водогону по всіх регіонах України не відповідають вимогам безпеки для здоров'я людей. Сьогодні відсутня державна система контролю за якістю криничних вод, у зв'язку з припиненням роботи санепідемстанції.

За даними санепідемстанції у попередні роки в Львівській області близько тисячі проб води з громадських криниць і близько 30% досліджених проб показували підвищений рівень бактеріального забруднення та до 10% – не відповідали вимогам за фізико-хімічними показниками. Минулого року питома вага проб питної води, що не відповідали санітарними нормам за санітарно-хімічними показниками, що значно перевищує середні показники по країні – 12,9%, а у Львівській області – 0,9%. Тому аналіз якості гігієнічних показників вод з різних джерел водопостачання окремих районів Львівської області є дуже актуальним.

Метою роботи є аналіз якості джерел водопостачання за гігієнічними показниками на прикладі окремих районів Львівської області.

Згідно нового стандарту ДСанПіН 2.2.4-171-10, якість питних вод оцінюють за гігієнічними показниками: ЗМЧ і колі-індексом. Дослідження проводились згідно загально прийнятих бактеріологічних методик (вимог ДСП, ГОСТ).

Об'єктом дослідження була вода з окремих населених пунктів Дрогобицького, Самбірського і Стрийського районів. Досліджуючи гігієнічних показників проводили у жовтні-листопаді 2017 р. Усі досліджувані криниці мають облицювання з бетонних кілець, а глибина криниць коливається від 5 до 20 м.

Встановлено, що вода з джерел централізованого водовідведення у містах Дрогобич, Стрий, Самбір, Борислав, Рудки відповідає вимогам за кількістю мікроорганізмів в 1 $см^3$ і колі-індексом.

Аналіз результатів свідчить, що антропогенне середовище міст має негативний вплив на якість криничних вод у містах Дрогобич і Стрий, і зразки криничних вод не відповідають вимогам за кількістю мікроорганізмів в 1 $см^3$ і колі-індексом. У містах

Борислав і Самбір кринична вода відповідає нормативам за обома гігієнічними показниками.

Результати досліджень підтвердили, що найпроблемнішим видом водозабезпечення у сільській місцевості є індивідуальні криниці. У селах Ступниця, Уріж, Бережниця, Нежухів зразки криничних вод перевищують встановлені норми для питних вод за двома показниками (ЗМЧ – у 1,1 – 9,28 разів, колі-індекс – у 110 разів). У селах Баранівці і Долішнє кринична вода відповідає нормативам за двома гігієнічними показниками.

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ASSESSMENT OF THE METHODS FOR OBTAINING ALCOHOLIC EXTRACTS FROM JUNIPER GALBERRIES (*JUNIPERUS COMMUNIS* L.)

Abstract. Among the known medical plants we can select *J. communis* (*Juniperus communis* L., *Cupressaceae*), which are famous for their medical properties. In composition of galberries *J. communis* there is a large number of different biologically-active substances, which have anti-inflammatory, sensible, antiseptic action. Among them are: essential oils, vinegar, apple and ant acid, invert sugar (to 40%), beeswax (to 0.7%) in inozitol, vitamin C, uniperin, pectin, bitter, resinous (to 9.5%) and other substances. Our research shows that to receive ethanol extracts from the galberries of *J. communis* with a high content of polyphenols (0.17±0.02 mg/g biomass) and ascorbic acid (2.8±0.74 mg/g biomass) the most expedient is the method which includes mechanical crushing (to 1-2mm particles) of raw material with a seven days infusion at the 70% ethanol. An alternative method is to insert a whole galberries of *J. communis* in 70% ethanol over a period of 21 days. Alcohol extracts obtained in this way have a high content of polyphenols (0.15± 0.013 mg/g biomass) and ascorbic acid (2.99 ± 0.36 mg/g biomass).

Key words: galberries of *Juniperus communis*, ethanol extracts, polyphenols, ascorbic acid.

INTRODUCTION

Juniperus communis is a medicinal, edible, essential oil, phytoncide, wood, resinous, decorative and phytomeliorative plant [8, 12, 19]. The fruit (galberries) of *J. communis* are used as medicinal raw materials. The seed galberries are berry-like, green ripening in 18 months to purple-black with a blue waxy coating. They are spherical, 4-12 millimeters in diameter, and usually have three (occasionally six) fused scales, each scale with a single seed. Galberries contain sugar (up to 40%), dyes, organic acids (ant, acetic, apple), resins (9.5%), essential oil (up to 2%) which contains terpenes camphene, cadine, terpineol, pinene, borneol, and also minerals (manganese, iron, copper, aluminum) are; In needles to 0.27% of ascorbic acid [10]. Essential oils, pitches, saponins, tannic and dyes are found in the root [5, 10, 11].

The results of scientific studies have shown that essential oil of juniper galberries (*J. communis* L.) has strong antioxidant properties [10]. Antioxidant and antimicrobial activity is associated with the extracts of *J. communis* L. varieties, in particular with *Staphylococcus aureus* [16]. Antibacterial action (in relation to *Mycobacterium tuberculosis*) has been found in juniper infusions, from which the relevant substances were extracted [3].

In folk medicine of Ukraine, water infusions, alcoholic tinctures, sugar syrups of *J. communis* galberries are used for treating colds, infections of the genitourinary system of the body [11]. The traditional medicine uses the incense berries internally in the hypostases, malaria, diseases of the kidneys, cystitis, gout, reumatism, as a part of the mixes at metabolic polyarthritis; externally – as distracting and soothing rinse aid at the inflammation of the gums, at mist herpes, itching. The essential oil of juniper berries (*J.communis* L.) is traditionally used for medicinal and flavoring purposes [4]. Galberries of *J. communis* are used as a spice, especially in European cuisine, due to its distinctive flavor [20].

This literature analysis shows that preparations made from *J. communis* raw materials have a high pharmacological effect, and substances have a high biological activity. All this

prompted us to carry out an analysis of the content of some biologically-active substances in Juniper berry alcoholic extracts, a different method of its obtaining.

The purpose of this research is to evaluate the methods of obtaining biologically-active extracts from *J. communis* galberries using 70% ethanol.

Objects of the research. Extraction of biologically-active substances by means of 70% ethanol from *J. communis* galberries.

MATERIALS AND METHODS OF THE RESEARCH

The material for research were the galberriess of *J.communis* gathered in October, 2016 in the territory of the village of Dovhe-Hirske (Carpathian region, Ukraine).

Preparation of 70% alcoholic extracts from galberries of *J. communis* (10% m / v). 10 g of air-dry galberries were crushed in a laboratory mill at 1000 rpm. The following methods of galberries crushing were used: 1) without crushing, 2) 30 sec (to linear sizes of particles 0.5-2 mm), 3) 50 sec (up to 0.5-1 mm), 4) 100 sec (up to 0.25-0.5mm). Then, 70% ethanol was added to the crushed galberries, infused throughout 31 days at 20±2 ^{0}C in a dark place, and stirred daily (for one minute).

The kinetics of the extraction of polyphenols 70% with ethanol from the galberries of *J. communis* of different degree of crushing was carried out by the spectral method for 32 days obtained on the device SF-2000 (“Spectrum”, RF) at wavelengths corresponding to the absorption maxima of the main polyphenolic compounds: 265 nm-gallic acid, Protonatechin Acid; 280 nm – catechin, epicatechin, epicatetechinate, lactic acid; 312 nm – coffee acid, chlorogenic acid; 354 nm – routine, quercetin; 525 nm – anthocyanins and their derivatives.

Polyphenols assay in alcoholic extracts galberries of *J. communis* by modified Folin-Ciocalteu method [6]. Each tested sample was applied with 0.2 ml of alcoholic extract (10%, m/v) of the juniper galberries diluted 10 to 200 times (with the exception of control). 0.4 ml of the Folin-Ciocalteu reagent and 0.6 ml of alkaline 20% sodium carbonate were added to each sample, stirred and adjusted to 5 ml with distilled water. After two hours, the optical density of the experimental samples was determined on a spectrophotometer at a wavelength of 765 nm regarding the control containing 70% ethanol instead of the investigated extract.

The mass concentration of polyphenols (X, mg/g) in the alcoholic extracts of *J. communis* galberries in terms of gallic acid was found out using the formula:

$$X = \frac{C \cdot n \cdot V}{m}, \text{ where}$$

C – mass concentration of gallic acid, found on the calibration graph, mg/ml;
n – dilution of the initial extract in the photometric sample;
V – volume of extract, ml;
m – hinge of biomass, g.

Ascorbic acid (AA) assay in alcoholic extracts galberries of *J. communis* by Murri method [14]. To the studied samples, containing 3 ml of diluted (100-200 times) alcoholic extract of *J. communis* galberries, we added 0.3 ml of 0.025% Tilmans solution (2.6 – dichlorophenolindophenol). After 35 seconds it was photometrised at 530 nm in a ditch with a working length of 1cm against the control sample. The control sample consisted of 3 ml of distilled water and 0.3 ml of dye.

The content of AA (X, mg /%) in the alcoholic extracts of *J. communis* galberries, was calculated by the formula:

$$X = \frac{C \cdot n \cdot V}{m \cdot 10}, \text{ where}$$

X - amount of AA, μg / g of raw mass;
C - content of AA, found on the calibration graph, μg / ml;
n - dilution of the initial extract in the photometric sample;

V - volume of extract, ml;
m - hinge of biomass, g;
10 - conversion factor.

Statistical analysis. All experiments were performed at least in triplicates. Arithmetic mean (M), standard error of mean value (m), Student's t-test (t) and probability (p) were determined for each selection of indices using the programme Microsoft Office Excel 2007.

RESULTS OF THE RESEARCH AND ITS DISCUSSION

According to the literature [10, 12*], J. communis* galberries is a depot for important biologically-active substances (BAS), which determine the healing properties of the plant [17]. These include polyphenols and ascorbic acid (AA) [12]. Polyphenols provide health benefits such as antioxidant, antiviral, anti-microbial, anti-carcinogenic, anti-inflammatory, antitumor, analgesic, antipyretic activities [2, 7, 15]. AA is an important metabolite of plants necessary for their growth [18], an indicator of the orientation of oxidation-reducing processes, has antioxidant activity, determining the resistance of plants to stress conditions. In the human body, AA actively participates in almost all processes of life. First of all, AA performs two main functions in the body: provides immune protection and stabilizes mental activity. Its deficit leads to a general deterioration of health, as a result of weakening the immune system, the human body is often subjected to viral diseases and colds [9].

Water-alcohol mixtures are common extragent of BAS from plant raw materials [1]. Often, especially in folk medicine, 70% of it is ethanol. In addition, the latter is a good extragent of polyphenols from plant material [15]. Therefore, we used 70% ethanol to obtain the extracts of *J. communis* galberries.

It is known that the main surface of the mass transfer is the grinding area, which increases with the decrease in the particle size [1]. Therefore, for the intensification of the extraction processes of the target substances from the galberries of *J. communis*, we used shredding of raw materials and daily (one-minute mixing).

In the presented work we tested four methods of obtaining alcoholic extracts from dry galberries of *J. communis*: infusion in 70% of ethanol of uncrushed galberries; four infusions of galberries of different degree of crushing: linear sizes of particles: 1) 0,5-2mm, 3) 0.5-1mm, 4) 0.25-0.5mm.

Estimation of the optimal method for extraction of BAS with galberries of *J. communis* with 70% ethanol was carried out on the content of polyphenols and ascorbic acid in the corresponding extracts, depending on the degree of crushing of the raw material and the time of extraction.

The study of the kinetics of the extraction of polyphenols with 70% ethanol from the galberries was carried out as described above. According to the results of the spectral method, it was established that the extraction of polyphenols with 70% ethanol from uncrushed galberries (method I) is actively carried out in the first 7 days. At 7 days, the yield of polyphenols is about 67% of the maximum value, which is fixed for 21 days. With further infusion of raw materials, the growth of extinction for most polyphenols is not observed, and after 28 days it decreases. Thus, the completeness of the extraction of polyphenols with 70% ethanol from the uncrushed galberries of *J. communis* is completed by 21 days.

The study of the extraction process with 70% ethanol from galberries of *J. communis* crushed by means of second method showed that on the 7th day the extinctions of the studied polyphenols are maximal and higher by 5% as compared with the first method. With further infusion of the raw materials, the extraction curves of the polyphenols have oscillatory appearance, and after 28 days they are reduced. Thus, the completeness of the extraction of polyphenols with 70% ethanol from crushed (up to 0.5-2mm) galberries of *J. communis* is completed by 7 days.

Extraction of polyphenols with 70% ethanol from the raw material crushed by the third method ends at 11 days – the extinction of the investigated polyphenols is maximal and higher

by 6 to 7% in comparison with the first method. With the further tension of raw materials, the growth of extinction of polyphenols is not observed, and the curves have oscillatory appearance. In addition, after 28 days of extraction, as in previous experiments, the extinction of polyphenols is reduced. Thus, the completeness of the extraction of polyphenols with 70% ethanol from crushed (up to 0.5-1mm) galberries of *J. communis* ends at 11 days, and alcoholic extracts are characterized by the high content of polyphenolic compounds.

Extraction of polyphenols with 70% ethanol from the raw material crushed by the fourth method ends at 11 days – the extinctions of the studied polyphenols are maximal. Compared with the third method, the extinction values of most polyphenols are close to each other. When further infusion of raw materials there was no reliable growth of extinctions observed – the curves have oscillatory appearance, and after 28 days of infusion, as in the previous versions of the experiment, fall. Thus, the extraction of polyphenols with 70% ethanol from the crushed (up to 0.25-0.5mm) galberries of *J. communis* ends at 11 days, and the corresponding alcoholic extracts are characterized by a high content of polyphenolic compounds.

Comparing the kinetics of the extraction of polyphenols with 70% ethanol from the crushed galberries of *J. communis*, we noticed that in II - IV methods of crushing the values of their extinctions are close. In particular, as we see in Figure 1, on the 7th day of extraction, the extinction curves of the polyphenols of the studied extracts (50-fold dilution), obtained by the II-IV methods are close. Taking into account the saving factor (extraction time and energy costs for raw material cruching), it is possible to assume that the second method, which includes the least time (30 seconds) of crushing galberries of *J.communis* (to 0.5-2 mm particles) and their infusion for 7 days is the most optimal way to obtain biologically-active extracts.

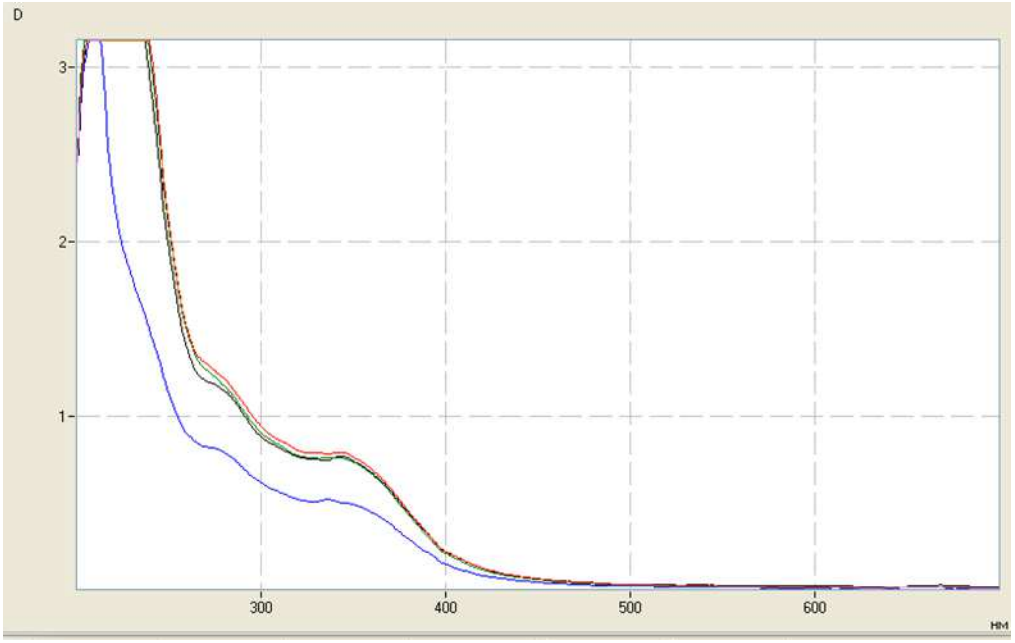

Fig. 1. Curves of extinction of polyphenols 70% of alcohol extracts (x50) galberries of *J.communis*, different ways of obtaining:

1 – from the uncrushed galberries (method I);
2 – f om crushed (up to 0,5 - 2 mm) galberries (method II);
3 – from crushed (up to 0,5-1 mm) galberries (method III);
4 – from s crushed (up to 0,25 - 0,5 mm) galberries (method IV).

The obtained data on the determination of the velocity and completeness of extraction of polyphenols 70% by ethanol from the galberries of *J.communis* by spectral method is consistent with the results of their quantitative determination in the corresponding extracts by the modified Folin-Ciocalteu method (see above). As we see from the data (see Table 1 and Fig. 2), the total content of polyphenols in extracts and the first method of obtaining increases from 7 to 21 days, methods II and III – up to 7 days, method IV – up to 11 days. Note that with further infusion of raw materials, there is no significant increase in the content of polyphenols in extracts of II-IV methods of obtaining (see Table 1). In addition, by comparing the content of polyphenols for 21 days in the extracts of methods I-IV of obtaining, we see (Table 1) that there is no significant difference between them. Thus, alcohol extracts, obtained by infusing uncrushed galberries during 21 days in quantitative content of polyphenols, are not inferior to the extracts obtained from the crushed galberries.

Table 1.

Kinetics extraction of polyphenols by 70% ethanol from galberries *J. communis* of different methods of obtaining

Method of mechanical crushing		Polyphenol content, mg/g biomass		
		7 extraction day	11 extraction day	21 extraction day
I	Uncrushed galberries	0,10±0,01	0,10±0,01	0,15±0,013
II	Crushed particles up to 0.5 – 2mm	0,17±0,02 *t=3,13; p*≤0,05	0,15±0,014 t=2,91; p≤0,05	0,16±0,013 t=0,54; p=0
III	Crushed particles up to 0.5 – 1mm	0,16±0,02 t=2,68; p≤0,05	0,19±0,017 t=4,56; p≤0,01	0,17±0,014 t=1,04; p=0
IV	Crushed particles up to 0.25 – 0.5mm	0,15±0,02 t=2,23; p≤0,05	0,21±0,018 t=5,34; p≤0,01	0,17±0,014 t=1,04; p=0

* t – Student's t-test;

* p – reliability of the difference, calculated relative to the first method of extraction.

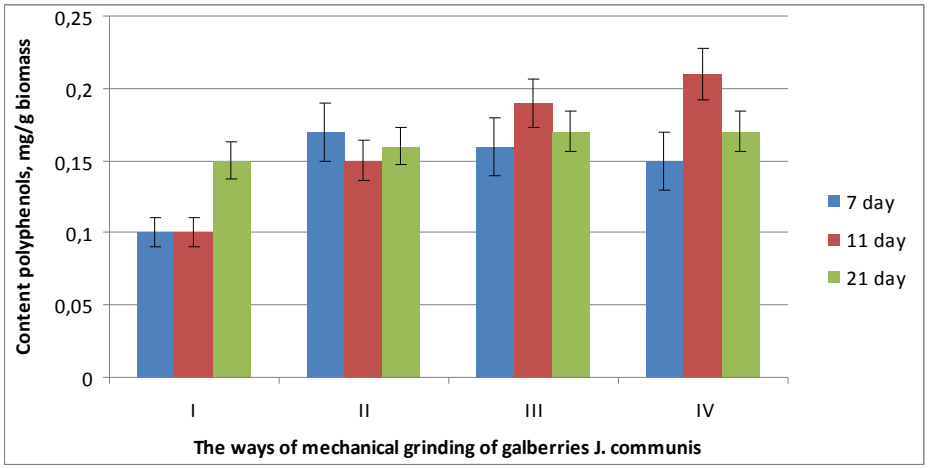

Fig. 2. Kinetics of the extraction of polyphenols from the galberries of *J.communis* by 70% ethanol depending on the method of mechanical crushing of raw materials:

1 – without crushing (method I);
2 – crushing to 0.5-2 mm of particles (method II);
3 – crushing to 0.5-1mm (method III);
4 – crushing to 0.25- 0.5 mm (method IV).

Therefore, for the production of biologically-active extracts from the galberries of *J. communis* enriched with polyphenols, it is possible to recommend the method II, which includes the crushing of dry raw materials (to linear sizes of particles from 0,5 to 2 mm), followed by 70% ethanol inhibition for 7 days and daily stirring (within 1 min). The extracts obtained by this method contain the highest content of polyphenols – 0.17±0.02 mg/g biomass. In the absence of crushing mills, for example, in household conditions, we can also recommend the method of obtaining extracts – the use of uncrushed galberries of *J.communis* in 70% of ethanol for 21 days with the daily one-minute stirring. The content of polyphenols in such extracts is 0.15 ± 0.013 mg/g biomass.

The study of the kinetics of extraction of ascorbic acid (AA) with 70% ethanol from the *J. communis* galberries was carried out by the Murri method for 32 days as described above. According to the data obtained (see Table 2 and Fig. 3), it is established that the content of AA in the 70% alcoholic extracts of *J. communis* galberries is rather high and consistent with the literature data [13]. In particular, according to the first method of extraction, the content of AA in the extracts is the highest (2.99±0.36 mg/g biomass) at 21 days of infusion, for the second method – 25 days (3.27 ± 0.67), in the third way – for 21 days (2.77±0.34), for the fourth method – for 25 days (3.27 ± 0.47). With the further infusion of raw materials (up to 32 days), the content of AA in alcoholic extracts of various methods of obtaining is slightly reduced.

Table 2

The content of ascorbic acid (mg/g biomass) in the 70% alcoholic extract of *J. communis* galberries under different methods of obtaining

Method of obtaining	Day of extraction							
	7	11	14	18	21	25	28	32
I	2,43±0,52	1,53±0,20	1,34±0,05	2,12±0,18	2,99±0,36	2,45±0,46	2,38±0,13	2,25±0,15
II	2,80±0,74	2,08±0,09	2,34±0,11	2,11±0,21	2,79±0,30	3,27±0,67	3,12±0,37	2,51±0,36
III	1,17±0,20	1,98±0,08	1,40±0,15	1,77±0,17	2,77±0,34	2,63±0,12	2,71±0,41	2,43±0,26
IV	1,01±0,19	1,21±0,04	1,03±0,04	1,61±0,05	3,02±0,22	3,27±0,47	2,81±0,23	2,98±0,37

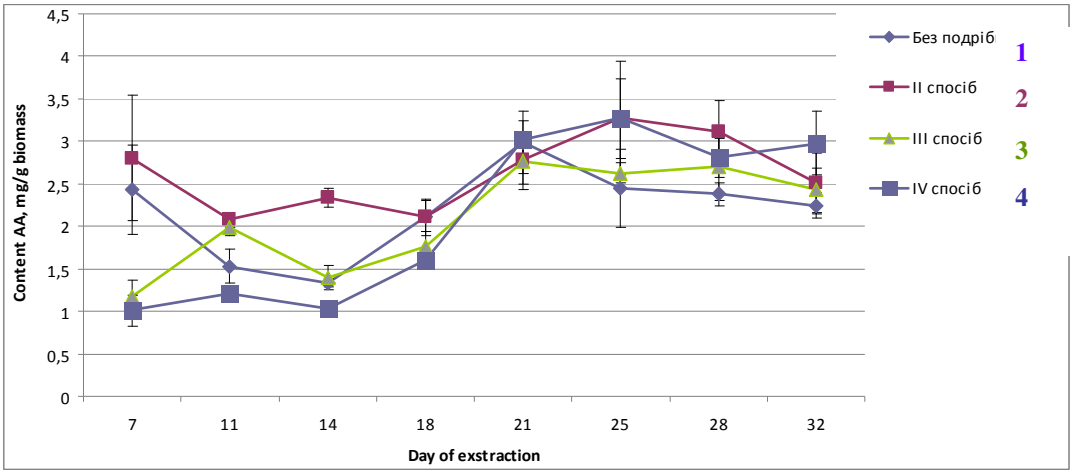

Fig. 3. Kinetic curves ascorbic acid extraction from *J.communis* galberries by 70% ethanol depending on the method of mechanical crushing of raw materials:

1 - without crushing (I method);

2 - crushing of particles to 0.5-2 mm (II method);

3 - crushing of particles to 0,5-1 mm (III method);

4 - crushing of particles to 0.25-0.5 mm (IV method).

Comparing the kinetics of AA extraction from the galberries of *J. communis*, we see (Table 2 and Fig. 3) that its content is the highest on the 25th day in alcoholic extracts of the first and fourth methods of obtaining (3.27±0.67 and 3.27±0.67 respectively). However, there is no significant difference between the content of AA for 7 and 25 days in the extracts of the second method of obtaining (t = 0.47, p = 0). There is also no significant difference (p=0) between the content of AA in extracts and the method of obtaining between 7 and 21 days of infusion. Consequently, the two methods can be recommended for obtaining alcoholic extracts from *J. communis* galberries enriched with AA: I – infusion of uncrushed galberries in 70% of ethanol for 21 days; II – infusion of crushed (up to 0.5-2 mm) galberries in 70% ethanol for 7 days with a daily (one-minute) stirring.

CONCLUSIONS

It has been established that for the intensification of the extraction of biologically-active substances from the galberries of *J. communis*; it is advisable to apply crushing of raw materials to linear sizes of particles of 0.5-2 mm.

It has been shown that infusion of the crushed (up to 0.5-2mm) galberries of *J. communis* in 70% of ethanol for 7 days with daily (one-minute stirring) is the most optimal and fastest way to obtain biologically-active extracts. These extracts contain a high content of polyphenols (0.17±0.02 mg/g biomass) and ascorbic acid (2.8±0.74 mg/g biomass).

An alternative is to infuse uncrushed galberries of *J. communis* in 70% ethanol over a period of 21 days with a daily (one-minute) stirring. Extracts obtained in this way have a high content of polyphenols (0.15 ± 0.013 mg/g biomass) and ascorbic acid (2.99 ± 0.36 mg/g biomass).

REFERENCES

1. Azmir J., 2013. Techniques for extraction of bioactive compounds from plant materials A review. Journal of Food Engineering, v. 117(4), 426-436.
2. Burri SCM., 2017. Antioxidant capacity and major phenol compounds of horticultural plant materials not usually used. J. Funct Foof, 38(Pt A), 119-127.
3. Carpenter C. D., 2012. Anti-mycobacterial natural products from the Canadian medicinal plant *Juniperus communis*. J Ethnopharmacol., v.143(2), 695-700.
4. Dalby A. (2002). Dangerous Tastes: The Story of Spices. University of California Press. p. 33.
5. Fierascu I., 2018. Genoprotective, antioxidant, antifungal and anti-inflammatory evaluation of hydroalcoholic extract of wild-growing *Juniperus communis* L. (*Cupressaceae*) native to Romanian southern sub-Carpathian hills. BMC Complement Altern Med, v.18(1): 3.
6. Fomina I. M., 2012. Determination of Polyphenolic Compounds in Wheat germination method for Folin-Chokaltyu. Modern problems of processing and food industries technology and mechanization. Ed.: KSTUA name P. Vasilenko, iss. 131.
7. Franco D., 2008. Polyphenols from plant materials: exstraction and antioxidant power / Electronic Journal of Environmental, Agricultural and Food Chemistry, 7(8), 3210-3216.
8. Garcia D., 1998. Interaction between juniper *Juniperus communis* L. and its fruit pest insects: Pest abundance, fruit characteristics and seed viability. Actu Oecologicu 19 (6), 517-525.
9. Heimer K. A, 2009. Examining the evidence for the use of vitamin C in the prophylaxis and treatment of the common cold. Journal of the American Academy of Nurse Practitioners, v. 21 (5), 295-300.
10. Höferl M., 2014. Chemical Composition and Antioxidant Properties of Juniper Berry (Juniperus communis L.) Essential Oil. Action of the Essential Oil on the Antioxidant Protection of *Saccharomyces cerevisiae* Model Organism. Antioxidants (Basel), v. 3(1), 81-98.

11. Kovalyova V. M. , 2000. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Flag, 545-549.
12. Malyk O. G., 2010. Biologically active substances and medicinal products made from *Juniper ordinary* / Biology of Animals, v. 12(1), 37-43.
13. Monastyrska S., 2016. Antioxidant action of extracts of some medical plants. Visnyk of the Lviv University. Series Biology, iss.73, 409-412.
14. Musienko M.M., 2001. Spectrophotometric methods in the practice of physiology, biochemistry and ecology of plants. K.: Phytosociocenter, 97-129.
15. Rajbhar K., 2015. Polyphenols: methods of exstraction. Sci. Revs. Chem. Commun., v. 5(1), 1-6.
16. Taviano M.F., 2011. Antioxidant and antimicrobial activities of branches extracts of five *Juniperus* species from Turkey. Pharm Biol., v.49(10), 1014-1022.
17. Tovstukha E.S., 2003. Newest phytotherapy. K.: Ukrainian academy of original ideas, iss., 285-290.
18. Vitamin C is essential for plant growth. ScienceDaily, 2007 /www.sciencedaily.com/releases/ 2007/09/070923205844.htm.
19. Voloshanska S.Ya., 2014. Pharmacological Properties of *Juniperus communis* L. and eculiarities of its Extension within Drohobych Region. Scientific Bulletin of UNFU, iss. 24.4, 179-184.
20. William C. M., 1998. Non-wood forest products from conifers. Food and Agriculture Organization of the United Nations (by William M. Ciesla). Chapter 8: Seeds, Fruits, and Cones, 84-88.

АНОТАЦІЯ

ОЦІНКА СПОСОБІВ ОТРИМАННЯ СПИРТОВИХ ЕКСТРАКТІВ ІЗ ШИШКОЯГІД *JUNIPERUS COMMUNIS* L.

Серед лікарських рослин значний інтерес має *J. communis*. Шишкоягоди *J. communis* є депо важливих біологічно активних речовин (БАР), які визначають лікувальні властивості рослини. До їх числа належить поліфеноли й аскорбінова кислота (АК). Поліфеноли рослин є сприятливими для здоров'я людини, виявляючи антиоксиданту, противірусну, антимікробну, антиканцерогенну, протизапальну, протипухлинну, анальгетичну, жарознижуючу дії. АК бере активну участь майже у всіх процесах життєдіяльності. Насамперед, вітамін С виконує в організмі два основні завдання: забезпечення імунного захисту і стабілізації психічної діяльності.

У народній медицині застосовуються водні настої, спиртові настоянки, цукрові сиропи шишкоягід *J. communis,* які рекомендуються при простудних захворюваннях, лікуванні інфекцій сечостатевої системи організму. Пропоновані способи застосування препаратів з *J. communis* мають аматорський характер, відсутні різносторонні дослідження щодо фармакотоксикологічних властивостей екстрактів зі сировини рослини, стандартизації їх та передбачуваності дії на живий організм залежно від доз і способів введення, фізико-хімічних властивостей біологічно активних речовин, побічних впливів тощо.

Метою роботи є оцінка методів отримання біологічно активних екстрактів з шишкоягід *J. communis* за використання 70% етанолу.

Матеріалом для досліджень слугували шишкоягоди *J. communis*, зібрані у жовтні 2016 р. на території с. Довге-Гірське Дрогобицького району (Україна).

У представленій роботі апробовано чотири способи отримання спиртових екстрактів із сухих шишкоягід *J. communis*: I – настоювання у 70 % етанолі цільних шишкоягід, II – IV настоювання шишкоягід різного ступеня подрібнення: II – лінійні розміри частинок –

0,5 – 2 мм, III – 0,5 – 1 мм, IV – 0,25 – 0,5 мм. Для інтенсифікації процесів екстрагування цільових речовин використано щоденне (однохвилинне) перемішування та подрібнення сировини.

Оцінку оптимального способу екстрагування БАР із шишкоягід *J. communis* 70 % етанолом, здійснювали за вмістом поліфенолів й аскорбінової кислоти у відповідних екстрактах залежно від ступеня подрібнення сировини й часу екстрагування.

Нашими дослідження, показано, що для інтенсифікації процесу екстрагування біологічно активних речовин із шишкоягід *J. communis* доцільно застосовувати подрібнення сировини до лінійних розмірів частинок 0,5 – 2 мм. Встановлено, що настоювання подрібнених (до 0,5 – 2 мм) шишкоягід *J. communis* у 70% етанолі упродовж 7 діб з щоденним (однохвилинним) перемішуванням є оптимальним та швидким способом отримання біологічно активних екстрактів. Зазначені екстракти містять високий вміст поліфенолів (0,17±0,02 мг/г біомаси) та аскорбінової кислоти (2,8±0,74 мг/г біомаси). Альтернативним є спосіб настоювання цільних шишкоягід *J. communis* у 70% етанолі упродовж 21 доби із щоденним (однохвилинним) перемішуванням. Отримані таким способом екстракти містять високий вміст поліфенолів (0,15±0,013 мг/г біомаси) та аскорбінової кислоти (2,99±0,36 мг/г біомаси).

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THE INFLUENCE OF SOWING TERMS OF DIFFERENT SORTS OF WHITE MUSTARD ON THE MORPHOLOGICAL INDICES AND SEED PRODUCTIVITY IN THE WESTERN REGION OF UKRAINE

Abstract. One of the important factors of agricultural industry development is the usage of those crops, which play a huge role in food, fodder and raw material production. Oil-bearing crops have the corresponding complex of economic-valuable signs. In recent years, the interest in growing white mustard *(Sinapis alba L.)* increased significantly. At the present stage of development of the agro-industrial complex of Ukraine white mustard is a valuable oilseed crop, which has a wide range of usage in fodder production, food, technical and pharmaceutical industries.

The research was carried out at the experimental plot of Drohobych Ivan Franko State Pedagogical University during 2017, which relates to soil and climatic zones of the Western Ukraine (Precarpathian region). Morphological indices and productivity of different sorts of white mustard were investigated at the period of sowing in different terms.

INTRODUCTION

At the present stage of development of the agro-industrial complex of Ukraine white mustard, valuable oilseed crop, has a wide range of usage in fodder production, food, technical and pharmaceutical industries [1].

White mustard (*Sinapis alba* L.) is an annual herbaceous oilplant, that belongs to genus Mustard (*Sinapis*) of the family Cabbage (Brassicaceae). Aboveground part of the plant grows up to 80 cm. The plant has a well-developed root system, its stem is stiff, straight, branched at the top and reaches a height of 50-80 cm. White mustard's raceme is multi flowered tassel, which consists of 25-100 separate flowers with 9 cm long pedicel. 0,7–1,2 cm long flower leaves are white and yellow. The flowers have a strong smell of honey [8, 11].

Mustard fruit is a pod with long sword-shaped beak, covered with short stiff hairs, 2-4 cm long. There usually are formed 4-6 globular yellow seeds inside the pod. Seeds are small, round with a smooth surface, about 1 mm in diameter, slug in water, spicy and bitter. 1000 seed weight is 4-6 grams [4, 7].

Mustard is an important oilseed crop; oil is produced from its seeds, which quality is not inferior to sunflower one. Mustard seed contains from 35 to 47 % fat. In addition to it, the mustard seed contains 25-32% of protein and 1.7% of essential oil [11-13]. Mustard oil is widely used for food, as well as in many branches of industry, in particular bakery, confectionery, and pharmaceutical one. Due to the essential oil content of mustard, it is used in cosmetology and perfumery [6, 14-17].

Mustard is also used as a forage crop. The head of the plant (60-70% of seeds) contains 25-32% of protein, 12% of fat, 9% of fiber and alkaloids (sinigrin, tannalbinum) [8, 18-20].

Due to the rational system of tillage, integrated use of high-yielding chops, fertilizers, herbicides and other elements of the technology, mustard is economically beneficial crop, which is characterized by great biological and economic properties: a rash, resistant to cracking, has a short vegetation period, good forbear for grain crops. The plant has a short vegetation period, the field is released in July-August, which allows quickly prepare this field for sowing winter crops [3, 10].

The research was carried out at the experimental plot of Drohobych Ivan Franko State Pedagogical University during 2017, which relates to soil and climatic zones of the Western Ukraine (Precarpathian region).

MATERIALS, CONDITIONS AND METHODS OF FIELD STUDIES

The program of our research was the influence of sowing terms of different sorts of white mustard on the morphological indices and seed productivity in the western region of Ukraine. The study was carried out with sorts Podolyanka, Carolina and Talisman. 2 factors were used for the research, where the factor A is sorts of white mustard (Podolyanka, Carolina and Talisman) and the factor B is a sowing date (on April, 14, on April, 24 and on May, 4).

Table 1. Research scheme

Number	Research versions	
	White mustard sorts	Sowing terms
1	Podolyanka	April 14(th)
2	Carolina	April 14(th)
3	Talisman	April 14(th)
4	Podolyanka	April 24(th)
5	Carolina	April 24(th)
6	Talisman	April 24(th)
7	Podolyanka	May 4(th)
8	Carolina	May 4(th)
9	Talisman	May 4(th)

The study was performed in accordance with the methodology of field experiments to study the main methods of agricultural crops cultivation (B. A. Dospekhov, 1985) [5].

As a result of the performed research it was supposed to investigate:

1. Phenological observation of sowing white mustard, which was carried out (by visual method), marking the date of approaching growth and development phases: germination, stooling, gemmation, flowering, fetation (formation of pods) and seed maturation.
2. Biometric analysis of plant samples: the linear sizes of plants and their morphological characteristics (using metric measurements).
3. The analysis of technological properties of seed: weight of 1,000 seeds (by paired batches).
4. Records of harvest: method of continuous collection of white mustard plants from each plot, their threshing and weighing.
5. Mathematical processing of data was performed by Dospekhov's variation statistics in1985 by using the computer Pentium IV (program was developed by the Department of crop production and grassland farming of Lviv national agrarian University).

RESEARCH RESULTS AND DISCUSSION

White mustard was sown after spring grain crops (oats). After harvesting the previous one and stripping the areas from the nutritious remnants, the peeling of the stub was carried out at a depth of 8-12 cm with the disk implements. Three weeks before the ploughing, herbicide roundup was introduced at a rate of 3 l / ha in order to destroy perennial weeds.

Ploughing was carried out in early November at a depth of 20-22 cm. In spring, a leveling of soil, pre-sowing cultivation (at a depth of 6-8 cm) and pre-sowing ground ditching before the sowing of white mustard were done.

Sowing was carried out according to the experimental scheme, starting from April 14 and ending May 4, the interval between the terms of sowing was 10 days.

The seeds were sown with a manual seed drill with a disk coulter of vegetable seeders type SU−4.2. The mustard is planted in a white rough way with an intermediate row of 45 cm, the depth of wrapping of the seed is 2-3 cm, the seeding rate according to the experimental scheme (2 million pieces per hectare).

A care of sowing the white mustard consisted in hoeing spaces between rows and destruction of weeds. During the vegetation period we carried out three intercropping cultivation and weeding plants. In order to protect from annual grain and dicotyledonous weeds in all areas of the experiment, the herbicide Butyzan 400, 40% normally 2,0 l / ha was introduced to the stains of mustard white plants [10].

Insecticide Fastak 10% – 0,15 l/ha was sprayed against pests (cruciferous flea beetles and pollen beetle). Against diseases spraying was not performed.

White mustard was harvested with technical ripeness when the seeds were brown and firm to the touch. Optimum humidity of seeds is 8%.

The results of our research showed that in the Western region, the sowing time affect the morphological parameters and yield structure of white mustard (see table. 2). Stem length ranged from 69 to 98 cm, and inflorescences from 30 to 42 cm. The highest rates were in sorts of first term of sowing in April, 14. At this sowing time the best linear dimensions of the stem and inflorescences had the class Talisman. In this variant, the length of the stem of white mustard was 98 cm and the length of the inflorescence was 42 cm.

The second term of sowing was somewhat different from the linear size of the plant. The highest rates were again in the Talisman sort and the lowest was in the Carolina sort.

The third term of sowing (May, 4) provided the smallest rates of the linear size of white mustard sorts. The smallest length of stems and inflorescences was found in the Caroline sort – 69 cm and 32 cm.

Analyzing all the terms of the sowing, it should be noted that the best morphological characteristics of the plant were characteristic of the Talisman variety, and the lowest were the plants of the Caroline variety.

The timing of the mustard seeding is one of the most important elements of technology, which affects its productivity indices [4].

The number of seeds per pod and their weight also depends on variety and sowing time. Analyzing the obtained results, we can say that the sowing terms influence on the number of seeds per pod, and these elements of structure is a key indicator in determining the yield of white mustard.

Table 2. The effect of different varieties and dates of sowing on the linear dimensions of the plants of white mustard

Number	Research variant		Linear dimensions, cm	
	Sorts of white mustard	Sowing terms	Stems	Inflorescence
1	Podolyanka	14 April	93	37
2	Carolina	14 April	78	39
3	Talisman	14 April	98	42
4	Podolyanka	24 April	89	32
5	Carolina	24 April	75	36
6	Talisman	24 April	91	38
7	Podolyanka	4 May	82	30
8	Carolina	4 May	69	32
9	Talisman	4 May	84	35

As can be seen from Table 3, the number of seeds per pod at different times of sowing varied within the range of 8.8-11.1 pieces. The results of our research showed that the highest rates were in sorts in early sowing (April, 14). The largest number of seeds is 11.1 pcs. The plants of the Talisman sort were sown on April 14th.

During three sowing periods, the largest number of seeds in the pod was marked in the Talisman sort, and the smallest in the Podolyanka sort.

Table 3. Influence of rates and terms of sowing on quantitative parameters of seeds of white mustard

Number	Research variants		Quantitative indices	
	Sorts	Sowing terms	The number of seeds per pod	The mass of 1000 seeds, g
1	Podolyanka	April 14(th)	9,8	5,2
2	Carolina	April 14(th)	10,5	4,6
3	Talisman	April 14(th)	11,1	5,8
4	Podolyanka	April 24(th)	9,5	4,8
5	Carolina	April 24(th)	10,1	4,2
6	Talisman	April 24(th)	10,5	5,4
7	Podolyanka	May 4(th)	8,8	4,6
8	Carolina	May 4(th)	9,4	4,0
9	Talisman	May 4(th)	9,5	5,1

Weight of 1000 seeds is one of the important elements of the yield structure. As can be seen from the table 3, the highest mass of 1000 seeds of all plants of white mustard was established for the first sowing time (April, 14). The highest 1000 seed weight was observed in plants of the class Talisman and was at 5.8 g.

The third sowing date (May, 4) provided the smallest weights of 1000 seeds of all the sorts of white mustard, compared with other sowing dates.

After analyzing the indicators of the linear size of the stem, inflorescence, the number of seeds per pod and the mass of 1000 seeds, we note that the highest values were established in plants of the Talisman type with the sowing date (April 14), therefore this variety is best suitable for growing in the conditions of the western region of Ukraine.

Yield is an integrative indicator, which depends on a large extent on the weather conditions that occur during the vegetation period, seed sowing, sowing terms, and other factors of the environment [6].

On the basis of the conducted researches it is established that the sorts Carolina and the Talisman provided significantly higher seed yield compared to the Podolyanka one (see table.4).

Table 4. The seed yield of white mustard depending on the sorts and sowing time

Number	Research variants		Yield cwt/ha
	Sorts	Term	
1	Podolyanka	April 14(th)	18,3
2	Carolina	April 14(th)	19,7
3	Talisman	April 14(th)	20,7
4	Podolyanka	April 24(th)	16,5
5	Carolina	April 24(th)	17,9
6	Talisman	April 24(th)	18,7
7	Podolyanka	May 4(th)	15,1
8	Carolina	May 4(th)	16,4
9	Talisman	May 4(th)	17,0

The yield was determined by the terms of sowing and agrometeorological conditions. From Table 4 one can see that the highest yield - 20.7 cwt / ha white mustard was obtained on the Talisman sort with the sowing date April, 14. The lowest yield of white mustard seeds (15.1 cwt / ha) was established in Podolyanka plant with sowing date May, 4. The highest crop was characterized by plants of white mustard, grown for early sowing (April, 14).

CONCLUSIONS

1.Soil and climatic conditions of the Western region of Ukraine are favourable for the cultivation of high and stable yields of white mustard.

2.The sowing of seeds of different varieties of white mustard, significantly affect the growth and development of plants, morphological parameters and seed yield.

3.The best sowing date in all studied sorts of white mustard were established early (April, 14). Early sowing time better contributed to the growth and development of plants, and increased germination and survival of white mustard.

4.Early sowing significantly affects morphological parameters. It increases the linear dimensions of the plants and improves the formation of pods, increasing in them the number of seeds and weight of 1000 seeds. The highest of these rates were set at sort Talisman at the sowing date of April, 14. In this variant, the stem length was 98 cm, length of the inflorescence – 42 cm, number of seeds per pod – 11 pieces and a 1000 seed weight of 5.8 grams. The lowest rates were in Podolyanka in case of late sowing (May, 4).

5.The sowing dates significantly influence the seed yield. The highest of these rates were set in early sowing. The highest yield of seeds – 20,7 kg/ha were installed in sort Talisman at sowing time (April, 14). A few less seed yield were found in plants of the sort Carolina and the lowest (15.1 C/ha) in the sort Podolyanka in case of late sowing (May, 4).

6.The results showed that in soil-climatic zone of the Western region of Ukraine for the best morphological characteristics and seed yield were the sorts of white mustard Talisman and Carolina. It is established that the most favourable sowing date for plants of white mustard is April, 14.

REFERENCES

1. Архипенко Ф.М., Войтовик М.В., 2000. Гірчиця, як олійна та кормова культура. К.: Нора−прінт, вип.1,48-51.
2. Блащук М.І., Тетерещенко Н.М., 2014. Вплив строків сівби на продуктивність гірчиці білої. Науково-технічний бюлетень Інституту олійних культур НААН, № 21, 65-74.
3. Васильєв В.П., Лісовий М.П., 1993. Довідник по захисту польових культур. 2-ге вид., перероб. і допов. К. : Урожай, 224.
4. Гаврилюк М.М., Салатенко В.Н., 2007. Олійні культури в Україні. К. : Основа, 415.
5. Доспехов Б.А., 1985. Методика полевого опыта. М.: Агропромиздат, 351.
6. Козленко О.М., 2011. Продуктивність олійних культур залежно від елементів технологій вирощування. К., 20.
7. Литвин С.Г., 2012. Олійні культури на Україні. К.: Вища освіта, 50.
8. Мазур В.О., Процiв П.Б., Гамалій С.М., 2009. Гірчиця : посібник. Ів.Франківськ : Симфонія форте, 88.
9. Шувар І.А., Бойко І.Є., Лис Н.М., 2009. Гірчиця біла та її ефективне використання в біологізації землеробства. Львів: АНАУ, 3-8.
10. Шувар І.А., Бінерт Б.І., 2011. Гірчиця: значення, ботаніко-біологічна характеристика, технологія вирощування. Львівський національний аграрний університет, 36.

11. Agerbirk N., Warwiek SI, Hansen PR et all, 2008. Sinapis phylogeny and evolution of glucosinolates and specific nutrile degrading enzymes. Phytochemistry 69, 2937-2949.
12. Antova G.A., Angelova-Romova M.I., Petkova Zh.Y., Teneva O.T., Marcheva M.P., 2017. Lipid composition of mustard seed oils (*Sinapis alba* L.). Bulgarian Chemical Communications, v. 49, spec. iss. G,55-60.
13. Bożena Barczak, Wojciech Kozera, Tomasz Knapowski, Maria Ralcewicz, 2011. Selected yield components in white mustard (*Sinapis alba*) versus Sulfur tertilization. Journal of Central European Agriculture, v. 12 (2), 380-389.
14. Dipti Kaspate, Tina Saldanha, Swati Narkhede, Bhagyarshree Karmarkar, Karan Shan, 2015. acute oral toxicity of *Sinapis alba* in swiss albino mice. Asian Journal of Pharmaceutical and Clinical Research,v. 8, iss. 2, 182-184.
15. Gesch R.W., Isbell T.A., Oblath E.A., Allen B.L., Archer D.W., Brown J., Hatfield J.L., Jabro J.D., Kiniry J.R., Long D.S., Vigil M.F., 2015. Comparison of several Brassica species in the north central U.S. for potential jet fuel feedstock. Industrial Crops and Products, v. 75, pages 2-7.
16. Hassan F.U., Arif M., 2002. Response of white mustard (*Sinapis alba* L.) to spacing under rainfed conditions, 2012. J. Anim.Plant Sci., v. 22(1), 137 – 141.
17. Jeong-Hyeon Lim, Hyung-Wook Kim, Ju-Hyun Jeon and Hoi-Seon Lee, 2008. Acaricidal Constituents Isolated from *Sinapis alba* L. Seeds and Structure-Activity Reletionships. Journal of Agricultural and Food Chemistry, v. 56 (21), 9962 – 9966.
18. McCaffrey J.P., Harmon B.L., Brown J., Brown A. P., Davis J.B., 1999. Assessment of *Sinapis alba, Brassica napus* and *S. alba×B. napus* hybrids for resistance to cabbage seedpod weevil, Ceutorhynchus assimilis (Coleoptera: Curculionidae). Journal of Agricultural Science, Cambridge, v. 132, 289-295.
19. Sandro Palmieri, Renato Iori, Onofrio Leoni. Myrosinase from *Sinapis alba* L.: A New Method of Purification for Glucosinolate Analyses, 2002. J. Agric. Food Chem., v. 34, 134-140.
20. Zohara Yaniv, David Granot, Efraim Lev, Dan Schafferman. Biodiversity and Uses of White Mustard (*Sinapis alba* L.), Native to Israel, as a Plant with Economic Potential, 2002. Journal of Herbs, Species and Medicinal Plants, v. 9, iss. 4, 319 – 327.

АНОТАЦІЯ

ВПЛИВ СТРОКІВ СІВБИ РІЗНИХ СОРТІВ ГІРЧИЦІ БІЛОЇ НА МОРФОЛОГІЧНІ ПОКАЗНИКИ ТА УРОЖАЙНІСТЬ НАСІННЯ В УМОВАХ ЗАХІДНОГО РЕГІОНУ УКРАЇНИ

Одним із важливих факторів розвитку сільськогосподарського виробництва є найбільш повноцінне використання можливостей тих культур, які відіграють значну роль у виробництві продуктів харчування, кормів та сировини для промисловості. Відповідний комплекс господарсько-цінних ознак мають олійні культури. За останні роки значно підвищився інтерес до вирощування гірчиці білої *(Sinapis alba* L.*)*. На сучасному етапі розвитку агропромислового комплексу України гірчиця біла − цінна олійна культура, яка має широкий спектр використання у кормовиробництві, харчовій, технічній і фармацевтичній промисловостях.

Дослідження проводились із сортами Подолянка, Кароліна і Талісман. Для проведення досліджень було закладено двофакторний дослід, де фактор А – сорти гірчиці білої (Подолянка, Кароліна і Талісман) і фактор В – строк сівби, який варіював на трьох рівнях з кроком 10 днів (14 квітня, 24 квітня і 4 травня). Дослідження виконувались

у відповідності до методики проведення польових дослідів з вивчення основних прийомів вирощування сільськогосподарських культур.

Насіння висівали ручною сівалкою з дисковим сошником овочевої сівалки типу СО − 4,2. Сіяли гірчицю білу рядковим способом з міжряддям 45 см, глибина загортання насіння – 2-3 см, строки висіву насіння проводилися відповідно до схеми досліду, норма висіву насіння 2 млн. штук на 1 га.

Догляд за посівами гірчиці білої полягав у розпушенні міжрядь і знищенні бур'янів. За період вегетації ми проводили три міжрядні обробітки і прополку рослин. У боротьбі проти однорічних злакових та дводольних бур'янів на всіх ділянках досліду вносили гербіцид Бутізан 400, 40% к.е у нормі 2,0 л/га, до сходів рослин гірчиці білої.

Результати проведених досліджень показали, що в умовах Західного регіону України строки сівби впливають на морфологічні показники та урожайність насіння гірчиці білої. Найвищими ці показники були встановлені при ранніх строках посіву. Найвища урожайність насіння – 20,7 ц/га була встановлена у рослин сорту Талісман при строках посіву 14 квітня. Дещо нижча урожайність насіння була виявлена у рослин сорту Кароліна, а найнижчою (15,1 ц/га) урожайністю характеризувалися рослини сорту Подолянка із строком сівби 4 травня. Довжина стебла становила від 69 до 98 см, а суцвіття – від 30 до 42 см. Найвищими лінійними розмірами стебла та суцвіття характеризувалися рослини гірчиці білої сорту Талісман за першого строку сівби − 14 квітня, зокрема довжина стебла становила 98 см, а довжина суцвіття – 42 см. Найбільша маса 1000 насінин - 5,8 г була зафіксована також у рослин сорту Талісман.

Результати досліджень показали, що у ґрунтово-кліматичних умовах Західного регіону України найкращими за урожайністю та морфологічними показниками рослин гірчиці білої виявилися сорти Талісман і Кароліна, а строком сівби – 14 квітня.

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A METHOD FOR RAPID ASSESSMENT OF WATER QUALITY CONSIDERING THE INFLUENCE OF MILITARY ACTIVITIES

Abstract. The article represents a quality parameters research of the surface waters of Yavoriv firing ground and proposes an improved method for hydro chemical monitoring that foresees establishing the specific pollutants that pose a significant risk to the aquatic environment. There has been carried out a water quality assessment according to the sanitary norms applicable standard MPC. There has been identified and analyzed hydro physical and hydro chemical parameters of the water samples. The list of core indicators showed that its values came nearer to the limit or was more elevated and by its origin could be invoked in the course of military activities.

Measured inflated rate of oxidation confirms the pollution by sewage. The exaggeration of this index's values indicates the presence of organic impurities, which are caused by oil pollution, fuel lubricant materials (FLM), surface-active substances (SAS), oils, antifreezes and other organic substances that are used during the exploitation of combat vehicles or other military activities.

Key words: *environmental monitoring, integrated characteristics, technogenic load, pollutants, military activities, firing ground, water pollution index.*

INTRODUCTION

Human activity is causing great harm to the natural environment that leads to the deterioration of the environmental situation. The condition for the ecological balance establishment is the organization of ecological monitoring of natural resources, which consists in the regulation of environmental laws in various industries and the optimization of theirs usage and creation new research methods. In the present environment, under the organization of their complex usage, the serious errors are allowed but environmental effects of which practically are not taken into consideration. This approach leads to a critical environmental situation that prevails today.

Quite an unfortunate situation now is with water cover, therefore, the priority direction of research are water resources of Ukraine, which misallocation results in scarcity of drinking water and for household needs. This fact remains a problem not only for Ukraine but also for other countries, especially third world countries.

Lviv region, compared to other regions of Ukraine, occupies the 9th place in terms of discharges of untreated and poorly treated wastewater in surface waters [1]. This figure reflects a big problem, if we take into account the fact that there is the Main European watershed in Lviv region, which affects the pollution of the headwaters and, in turn, leads to regional pollution in the basins of Dniester, Dnieper, Western Bug and San. As a result, the significant part of the Ukrainian population receives poor quality water (including drinking) [1]. Of course, these pollutions attract the attention of the European community, and therefore the Water Framework Directive (WFD) was included in the European agreement on Association [2, 3],

the purpose of which is to harmonize environmental legislation with the EU laws. Interrelations between Ukraine and the EU contribute to the implementation of certain strategies concerning the harmonization and adaptation of the system of environmental-legal requirements that would mitigate the human influence on environmental pollution and would help to maintain the ecological balance of the environment.

These requirements are based on systematic observations using the operating methods of obtaining objective and reliable results. Directives have no direct legal force, but are mandatory for all EU members. Member countries undertake to carry out continuous monitoring of water bodies on the content of nutrients such as nitrates and phosphates, the total contents of phosphorus and nitrogen, which increased index accelerates the eutrophication process and it is 'in the first place' within the EU rules. The ultimate goal of the directives is to achieve concentrations close to background components of the natural background conditions [13-20].

In accordance with the water code of Laws of Ukraine, based on regulations of environmental safety of water use and the ecological quality standards of water bodies there is continuous environmental monitoring which is one of the most difficult types of monitoring that implements at the local, regional, national and global levels and provides the organization of the unified state system of control and automation systems for the collection, processing information about the state of natural resources, assessment of the capacity and the level of their use and inventory of sources of pollution, modeling of changes the ecological situation and development of universal management decisions [4-6].

The specific focus of environmental monitoring is the research of the techno genic load of the objects of the Armed forces of Ukraine (AFU), owned by the Ministry of Defense of Ukraine, and in their operational management and economic management. The authors [7] investigated the environmental situation which caused by the activities of military facilities, among which the most contaminated are considered to be firing grounds in the settlements of Yavoriv, Sarny, Yarmolyntsi, Vapniarka, Starychi, Vysoka Pich. Military trainings are accompanied by large anthropogenic loads, which cause soil erosion, alteration of aquifers, pollution by metal and household waste, detergents, pollutants of organic type, and others [6, 9-12]. The accumulation of such pollutants is accompanied by the pollution of the world ocean and causes pollution on a planetary scale. That is why European countries are working to ensure the balanced usage of such training with mandatory compliance with environmental legislation.

To overcome the above drawbacks, it is necessary to analyze and reorganize certain legislative, organizational and methodological activities, which would be systematized, regulated and adapted to site-specific water management.

Current state of the problem. In Ukraine, the definition of natural waters quality tend to carry only in terms of chemical structure of water, whereas the regulation and the practical implementation of European directives is determined by abiotic (physical and physical-chemical) and biotic indicators that determines ecological status for biological, hydro morphological, physical-chemical and chemical characteristics. According to the WFD the definition of an abiotic parameters is carried out by an analytical method, which refers to the operational methods for the determination of pollution, however, it has detrimental effects on living organisms of the aquatic environment due to the concentration limits of toxic substances needed for analysis, and requires a significant economic costs and different complexity of the experiment due to the lack of special equipment. Therefore it is necessary to introduce new research methods that would differ in a number of advantages. The main advantage of such methods is the efficiency and fairness of assessment with a specific list of parameters.

There are many techniques for the study of water quality, which include different amounts of the investigated physical, chemical, microbiological and bacteriological parameters [1]. The authors [3] have thoroughly analyzed the main methods for ecological assessment of water quality according to drinking, utility and fishery and found that there are a number of shortcomings of the systematic, biological and chemical nature. It was proved according to the WFD and installed by it the main indicators of activity in the water sector, the definition of

dangerous substances through a system of maximum permissible concentration (MPC) is not able to give an objective evaluation of the complex condition for the water object and describe the conditions of the aquatic ecosystem and its stability to pollution. In particular, this system does not indicate the list of pollutants, which may be caused by military or other spheres of activity. Taken into consideration the above, any research cannot give a comprehensive assessment of quality of water objects taking into account peculiarities of techno genic load of military activities and may be considered unreasonable and unreliable. Therefore, to ensure this condition, we propose an integrated method of water quality assessment on the basis of the definition of "water pollution index" (WPI), taking into account the specific pollutants that are formed as a result of the activities of troops and forces of the Ministry of Defense of Ukrain. Water quality is a characteristic of composition and properties of water that determines its suitability for a particular water user. For an objective assessment of water quality, it is necessary to determine a sufficient number of characteristics, the list of which varies (for drinking water, surface water and wastewater); according to the regulations of characteristics, they are divided into sanitary and hygienic characteristics, which do not affect the life and health of humans and fisheries.

For hygienic assessment examine: the quantity of suspended solids; the amount of floating substances; temperature; water index of pH; mineral structure; dissolved oxygen; biologically complete consumption of oxygen (BCO), chemical oxygen demand (COD); the presence of pathogens; the number lacto positive E. coli (LEC), the number coliphages in plaque forming units; the presence of viable helminth eggs and intestinal; the number of chemical substances [1].

For sanitary assessment of water the main parameters are the maximum permissible concentration (MPC); approximately permitted levels of substances (APL); limiting the signs of harm (sanitary-toxicological, general sanitary, organoleptic with details of its properties: smell, affecting the color, foam and film, giving a taste); the hazard class of substances [1].

Another form of classification of water quality indexes is to divide them into general and specific. General include indexes that are typical for all water bodies. The presence of specific indexes is caused due to local natural conditions and peculiarities of anthropogenic impact on the water body. Under this system, it is necessary to establish a list of pollutants arising because of actions of troops (forces) of the Ministry of Defense of Ukraine.

The purpose of the work. To propose an improved method for hydro chemical monitoring that means the establishment of specific pollutants, which are formed as a result of the impact of technogenic load of military activities on the methodology of the WFD are prioritized and included in the list of hazardous substances that pose a significant risk to the aquatic environment as well as to obtain objective and reliable results of the ecological status of water bodies.

THE RESEARCH METHODOLOGY

For improving the method of hydro chemical monitoring, we propose an integral method to calculate the "Water pollution Index" WPI.

IWP is an integral characteristic of water pollution, which may be used to determine the category of water quality on the main pollutants of anthropogenic impacts based on MPC, given pollutants, which arose in the course of military activities.

RESULTS OF EXPERIMENTAL STUDIES

Identify indicators differ for 7 categories that vary in size (table 1).

Table 1. Categories of quality and characteristics of natural water in terms of the water pollution index (WPI)

Quality category	Size of IWP
I- very clean	≤0,2
II- clean	>0,2-1
III- slightly polluted	1-2
IV- polluted	2-4
IV- dirty	4-6
VI- very dirty	6-10
VII – extremely dirty	>10

On the territory of Yavoriv firing ground, there were selected a few water bodies with regard to localization of a certain type of military techno genic load and were selected 5 samples, namely sample # 1 - the lake near the settlement of "Nemyriv", sample # 2 – the river near the settlement of "Verbliany", sample # 3 - river "Ryki", sample # 4 - lake "Inzenerne", the sample # 5 - the source of the "7 springs".

The ponds, from which samples No. 1-3 were taken, directly border with the places of shooting training from all kinds of weapons, namely, tank brigades, artillery, and small arms. For assessing the impact of the factor of life of the military camp were sampled from the lake "Inzenerne". Sample 5 – from the "7 springs", that is used as a source of drinking water, characterizes that the sample has no direct influence of the military-technological load selected for comparison.

There were analyzed various samples of surface water of Yavoriv firing ground in accordance with state requirements. There has been investigated the physical-chemical parameters of water quality and a sanitary-hygienic assessment of the composition and properties of natural waters, by identifying the main hydro physical and hydro chemical parameters by the method [9] (table 2).

Table 2. Results of the research hydro physical and hydro chemical indicators of surface water quality

The list of indicators	The measure unit	The norm of the current standard	Sample №1	Sample №2	Sample №3	Sample №4	Sample №5
			2017	2017	2017	2017	2017
Smell	marks	not > 2	3,0	3,0	2,0	3,0	2,0
Taste	marks	not > 2	2,0	2,0	2,0	2,0	2,0
Color	degrees	not > 35	15-20	20	10	30	5
Transparency	mg/dm3	not >1,5	1	1	0,5	2	0,5
pH	mg/dm3	6,0-8,0	7,70	7,64	7,8	7,12	7,34
Hardness	mmol-ekv /dm3	<7	4,60	3,4	4,0	4,6	4,6
Total iron	mg/dm3	not >0,3	0,3	0,35	0,3	0,4	0,3
Sulfates	mg/dm3	not >500	16	15	24	53	20
Chlorides	mg/dm3	not >100	46	35	64	19	53
Ammonia	mg/dm3	not >2,6	2,4	2,7	1,5	3,0	1,2
Nitrites	mg/dm3	not > 0,002	0,07	0,01	0,01	0,02	traces
Nitrates	mg/dm3	not >10	traces	traces	unknown	traces	5,8
Phosphates	mg/dm3	not >1	0,06	0,09	0,03	1,2	0,02
Free nitrogen	mg N/dm3	not >10	0,01	0,01	unkno wn	0,01	1,3
Oxidation	mg/dm3	not >5	9,6	8,8	6,9	25	6,2
Dry residue	g/dm3	not >1	0,271	0,215	0,311	0,231	0,322

RESULTS AND DISCUSSION

There was carried out the assessment of water quality according to the sanitary characteristics, the which calculation was based on analysis of total applicable standard MPC that included in the list of dangerous substances according to EU Directive and are the greatest threat to the aquatic environment. The results of the research indicate that according to the current MPC standard certain substances are exceeded. Such waters are considered as "dirty".

The concentrations of total iron was approached up to a critical boundary MPC which is capable of forming complex organic compounds that stain the water yellow-brown shades, and also indicates the concentration of mineral salts and gases, which give the water an unpleasant smell and increasing sediment. This greatly affects the chemical-organoleptic characteristics (odor and color).

Measured inflated rate of oxidation affirms about pollution by sewage. The exaggeration of this index's values indicates the presence of organic impurities, which are caused by oil pollution, fuel lubricant materials (FLM), surface-active substances (SAS), oils, antifreezes and other organic substances that are used during the exploitation of combat vehicles or other military activities. Sample 4 is the most polluted in all the above mentioned characteristics.

There has been identified and analyzed hydro physical and hydro chemical parameters of the water samples, whose values came near to the limit or more elevated, and its origin could be invoked in the course of military activities. Such indicators are identified 6: total iron, ammonia, nitrites, phosphates, biochemical oxygen demand and pH index.

The resulting list of substances, which may occur in the course of the activities of the troops, was attributed to a number of specific, according to the varieties of forms of classifications. Such pollutants are among the necessarily specific pollutants.

According to the standard formula (1) calculated and obtained value of IWP is 1.23.

$$ІВЗ = (\sum_{i}^{6} C_i / ГДК_i) / 6 , \quad (1)$$

where C_i – the average for the year value of indicator (during the year measured at least five times), MAC (ГДК) – maximum allowable concentration of the pollutant, 6 – the number of indicators which are assigned to specific.

CONCLUSIONS

There has been carried the assessment of water quality by integral method and assessed the status of surface waters of Yavoriv firing ground and determined the quality of water in 2017. According to calculated MAC – water belongs to the III category of quality as moderately polluted.

The research determined the list of pollutants taking into account to techno genic loads in the course of military activities, namely: iron (Fe 2), ammonia (NH4), nitrite (NO2-) and phosphate (PO43-) and physical- chemical characteristics of pH and oxidation.

The proposed integral method with the list of specific monitoring parameters will help to improve the standards of environmental trends and to evaluate objectively the influence of techno genic load of military activities for rapid response and minimize such influence.

REFERENCE

1. Міхалєва М. С., Столярчук П.Г., Бадікова Н.О., 2016. Електрофізичні параметри багатокомпонентних рідин у електромагнітному полі. Львів, 178с.

2. Осадча Н.М., Набиванець Б.Б., Яцюк В.М., 2013. Аналіз оцінки якості води в Україні та основні завдання її адаптації до Європейського законодавства. Наукові праці УкрНДГНІ, №2065, 46-52.
3. Романченко І.С., Світнєв А.І, Бутенко С.Г., 2006. Екологічна безпека: екологічний стан та методи його моніторингу: навч.посіб. К., 560 с.
4. Борисюк С.Л., 2011. Методологія створення системи комплексного моніторингу глобальних змін складової екологічної безпеки Збройних Сил України. Збірник наукових праць ЦНДІ ЗСУ, №3 (57), 5-12.
5. Борисюк С.Л., 2013. Аналіз сучасного стану екологічного моніторингу у військовій сфері. Збірник наукових праць Харківського університету Повітряних сил, № 2, 35
6. Руда О., 2010. Проблеми використання і охорона природних ресурсів Яворівського району Львівської області. Географічні основи збереження, використання і відтворення природних ресурсів. Наукові записки, № 1, 95-100.
7. Казмірчук В.О., Саврун Б.Є., Цибуля С.А., 2015. Система екологічного забезпечення збройних Сил України, шляхи та напрями її трансформування в систему управління екологічною безпекою. Військово-технічний збірник, № 13, 120-126.
8. Одосій Л.І., Стаднічук О.М., Свідерок С.М.та ін., 2015. Вплив техногенного навантаження військової діяльності на стан грунтово-водного середовища. Військово-технічний збірник, № 12, 91-95.
9. Стаднічук О., Платонов М., Михалина Г., Козак С., Одосій Л., Кропивницька Л., Грищук Г., 2014. Екологічна оцінка військових об'єктів на прикордонних територіях Львівської області. Acta Carpatica, №3, 79-84.
10. Дзисюк О.В., Козлов В.Є., Козлов Ю.В., 2013. Екологічний моніторинг стану регіонів військової діяльності штатними засобами вимірювальної техніки військ. Система обробки інформації, Випуск 1, 263-266.
11. Blanton E., Wilhelm N., O'Reilly C., Muhonja E., Karoki S., Ope M., Langat D., Omolo J., Wamola N., Oundo J., Hoekstra R., Ayers T., De Cock K., Breiman R., Mintz E., Lantagne D., 2014. A rapid assessment of drinking water quality in informal settlements after a cholera outbreak in Nairobi, Kenya. J Water Health, 13(3):714-25.
12. Church J., Verbyla ME., Lee WH., Randall AA., Amundsen TJ., Zastrow DJ., 2015. Dishwashing water recycling system and related water quality standards for military use. Sci Total Environ, 529:275-84.
13. Dalahmeh SS., Hylander LD., Vinnerås B., Pell M., Oborn I., Jönsson H., 2011. Potential of organic filter materials for treating greywater to achieve irrigation quality: a review. Water Sci Technol, 63(9):1832-40.
14. Directive 200/60/EC of the European Parliament and of the Council of 23 October establishing a frame-work for Community action in the field of water policy // Official Journal of the European Communities, 2000, L.327, 72p.
15. De la Mare W., Ellis N., Pascual R., Tickell S., 2012. An empirical model of water quality for use in rapid management strategy evaluation in Southeast Queensland, Australia. Mar Pollut Bull, 64(4):704-11.
16. Donner E., Eriksson E., Revitt DM., Scholes L., Lützhøft HC., Ledin A., 2010. Presence and fate of priority substances in domestic greywater treatment and reuse systems. Sci Total Environ, 408(12):2444-51.
17. Gross A., Azulai N., Oron G., Ronen Z., Arnold M., Nejidat A., 2005. Environmental impact and health risks associated with greywater irrigation: a case study. Water Sci Technol, 52(8):161-9.
18. Gu Q., Deng J., Wang K., Lin Y., Li J., Gan M., Ma L., Hong Y., 2014. Identification and assessment of potential water quality impact factors for drinking-water reservoirs. Int J Environ Res Public Health, 11(6):6069-6084.

19. Hoslett J., Massara TM., Malamis S., Ahmad D., van den Boogaert I., Katsou E., Ahmad B., Ghazal H., Simons S., Wrobel L., Jouhara H., 2018. Surface water filtration using granular media and membranes: A review. Sci Total Environ, 639:1268-1282.
20. Maimon A., Friedler E., Gross A., 2014.Parameters affecting greywater quality and its safety for reuse. Sci Total Environ, 487:20-5.
21. Maimon A., Tal A., Friedler E., Gross A., 2010. Safe on-site reuse of greywater for irrigation - a critical review of current guidelines. Environ Sci Technol, 44(9):3213-20.

АНОТАЦІЯ

МЕТОД ОПЕРАТИВНОГО ОЦІНЮВАННЯ ЯКОСТІ ВОДИ З ВРАХУВАННЯМ ВПЛИВУ ВІЙСЬКОВОЇ ДІЯЛЬНОСТІ

Згідно з водним кодексом Закону України, на основі нормативів екологічної безпеки водокористування та екологічних нормативів якості водних об'єктів, здійснюється постійний екологічний моніторинг який є одним із найскладніших видів моніторингу, що здійснюється на локальному, регіональному, національному та глобальному рівнях і забезпечує організацію єдиної державної системи контролю та автоматизації системи збору, обробки інформації про стан природних ресурсів, оцінювання потенціалу рівня їх використання та інвентаризації джерел їх забруднення, моделювання змін екологічної ситуації та розробка універсальних управлінських рішень.

Специфічним напрямком екомоніторингу є дослідження техногенного навантаження об'єктів Збройних сил України (ЗСУ), що перебувають у власності Міністерства оборони України, а також в їх оперативному керуванні та господарському ведені. Авторами досліджено екологічну ситуацію яка спричинена діяльністю військових об'єктів, серед яких найбільш забрудненими вважаються полігони у населених пунктах Яворів, Сарни, Ярмолинці, Вапнярка, Старичі, Висока Піч.

З метою удосконалення метододу гідрохімічного моніторингу пропонується інтегральний метод розрахунку «Індексу водного забруднення» ІВЗ.

На території Яворівського полігону обрано декілька водні об'єктів згідно з врахуванням локалізації певного виду військового техногенного навантаження та відібрано 5 проб, а саме: проба №1 – озеро поблизу населеного пункту «Немирів»; проба № 2 – річка поблизу населеного пункту «Вербляни»; проба № 3 – річка «Рикі»; проба № 4 – озеро «Інженерне»; проба №5 – джерело «7 джерел».

Водойми з яких взято проби №1-3 безпосередньо межують з місцями відпрацювання стрільб усіх видів озброєння, а саме танковими бригадами, артилерійськими установками, та стрілецької зброї. З метою оцінювання фактору впливу життєдіяльності військового містечка відібрано пробу з озера «Інженерне». Проба 5 – з «7 джерел», використовується як джерело питної води, характеризує пробу яка немає безпосереднього впливу військового-техногенного навантаження відібрана для порівняння.

Проведено оцінювання якості води згідно санітарних характеристик розрахунок яких проводився на основі аналізу загальних норм діючого стандарту ГДК.

Проба 4 є найбільш забрудненою за всіма відміченими вище характеристиками.

Визначено та проаналізовано гідрофізичні та гідрохімічні показники для всіх проб та отримано перелік основних показників, значення яких найбільше наблизились до граничних або дещо підвищеними та за своїм походженням могли б бути спричинені в ході військової діяльності. Таких показників виявлено – 6: загальне залізо, аміак, нітрити, фосфати, окислюваність та показник pH.

Проведено оцінювання якості води інтегральним методом та проведено оцінювання стану поверхневих вод Яворівського полігону та визначено категорію якості води на 2017 рік. Згідно обчисленого ІВЗ – вода належить до ІІІ категорії якості − як помірно забруднена.

В результаті досліджень визначено перелік полютантів з врахуванням техногенного навантаження в ході військової діяльності, а саме: залізо (Fe^{+2}), аміак (NH_4^+), нітрити (NO_2^-) та фосфати (PO_4^{3-}) а також фізико- хімічні показники pH та окислюваність.

Запропонований інтегральний метод з переліком специфічних параметрів контролю дозволить вдосконалити стандарти екологічного спрямування та об'єктивно оцінювати вплив техногенного навантаження військової діяльності для швидкого реагування та мінімізації такого впливу.

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STUDY OF WHEAT LEAF COMPOUNDS - AN EXAMPLE OF QTL ANALYSIS

Abstract. This work describes the principle of quantitative trait loci analysis (QTL) - statistical-genetic method, which combines genotypic and phenotypic data of plant organisms. This method allows to determine the genetic basis of quantitative traits mainly in crops. On the chosen example - analysis of leaf chlorophyll content in common wheat - we describe steps necessary to perform such analysis. The plant material we used for this study was doubled haploids (DH) population of common wheat (*Triticum aestivum* L.) The QTL analysis was performed using the public available program: WinQTL Cartographer 2.5

Keywords: QTL, loci, common wheat, CIM, IM, SMA, Win QTL Cartographer

INTRODUCTION

Wheat (*Triticum* L.), beside barley, is classified as the oldest and most important crop in the economy of cereal plants from the poaceae (*Poaceae* Barnh.) family, formerly called grasses (*Gramineae* Juss.). It is a pioneer among crops in terms of production, quantity and total sown area. In the EU, ordinary wheat occupies about 46% of the cereal area, which accounts for 47% of total cereal production. In addition, wheat is an important element in the total amount of cereals, which totaled in the years 2014-2016 an oscillating result of 51% [10]. The wheat obtained during the appropriate cultivation, according to available statistical data in 2009 in the EU, reached a tonnage of 9790 thousand. tone, half of which was intended for consumption. As a bread-making cereal, it has been with a man for unforgettable times. The temperate climate is conducive to wheat crops, and the features, i.e. the relatively low labor intensity or ease of transport, affect such a large area occupied by this type of grain [20]. The oldest evidence of the cultivation of this cereal comes from archaeological excavations in the Middle East and is dated to around 7000 BC. To Europe, wheat has reached in Neolithic, close to. 5000 years BC Originally, wheat was grown by the ancient Romans, and successively gained popularity among the cultures of ancient Greeks. On the territory of Poland wheat appeared between 1000-2000 BC, as evidenced by the traces of emmer wheat found in the Ojcowski caves [16]. Historically, wheat is allohexaploid (AABBDD), created thanks to two hybridizations. The first took place between 0.5 and 3.0 million years ago between two diploid species, which were provided with the genome "A" *(Trittcum uratu*) and the genome "B" (unknown species), as a result of doubling the chromosome wild tetraploid wheat (*Trittcum turgidum* ssp. Dicoccoides, AABB) was formed. The second hybridization occurred approx. 9,000 years ago. It should be emphasized that domesticated forms of wheat belong to a significant and still growing number of varieties [4].

Common wheat (*Triticum aestivum* L.) is currently considered as the basic source of food and plays the most important economic role. The area occupied by common wheat exceeds 90% of the total amount of wheat in the entire European Union, and the number of farmers cultivating it is approx. 170,000. farms around the world, so more than 12% of all farms that specializein the cultivation of various cereal varieties [2]. The purpose of modern common wheat breeding is obtaining cereals enriched with various qualitative features and resistance to disease. That is why every year to the The Polish National List new varieties with better

quantities especially yield are added. In the case of winter cereals, also good winter hardiness is important - a feature particularly desirable in our climate (more and more often in winter there is no snow cover). Growers constantly improve new varieties in terms of: yield quality, as well as many economic features, biotic - diseases, pests - and tolerance to abiotic stress - low and high temperatures, lack and excess of rainfall, soil acidification, etc. [8] Currently grown varieties are characterized by the highest level of yields among cereals, also by rich chemical composition and specific grain properties, which affect a wide spectrum of use of common wheat in the food industry mainly in the production of fresh bread and flour, and, although to a lesser extent in industry feed, pharmaceutical and cosmetics [11].

The genome of wheat is one of the largest plant genomes, oscillates at 17 Gb and single subgenomes are approx. 5.5 Gb. In 80% it consists of repetitive sequences, which made accurate sequencing of the genome a serious challenge. After many years, the genome of wheat has been fully sequenced [17]. This breakthrough is the reason for continuous production of new varieties. Knowledge of the wheat genome helps in the biotechnological control of many traits, among which the most commonly taken into account are resistance to pests or fungi, as well as tolerance to biotic and abiotic stress. The above modifications significantly contribute to more efficient agriculture [9].The possibility of using techniques, i.e. mapping or sequencing, leads to an increase in production and quality of the sequence of wheat genes. Acquired genomes allow for detailed analysis of wheat evolution, which can accelerate the characteristics of genes that are designed to control the most important agronomic processes; above all resistance to abiotic and biotic stresses [5].

QTL ANALYSIS

The derivation of new varieties with better features is possible, among others thanks to the use of genetic mapping. The main basis for mapping is the fact that genes or molecular markers segregate as a result of crossing-over (meyotic recombination) and it can be analyzed in the descendant generation. As Mendel's second law says, alleles in loci located in different chromosomes inherit independently of each other randomly creating all possible combinations in the gametes. Genes or molecular markers that are located in the same chromosome are linked and inherited jointly. The smaller the distance between them in the chromosome, the less likely it is to cross-over and increase the possibility of common inheritance [18].

In the case of studies carried out with common wheat, genetic mapping is, among others, a reference point on the basis of which individual contigs are ranked and attributed to specific chromosomes. The distance dividing the linked genes or molecular markers on the genetic map is expressed in centimorgans (cM), where 1 cM is defined as a place within the chromosome, where crossing-over occurs only once in a hundred meiosis [3].

Mapping is also used for direct identification of candidate genes determining quantitative traits mapped in QTL regions. Genes showing statistically significant linkage to the quantitative trait phenotype are represented on the genetic map by the QTL region and are likely to control analyzed traits. When positional candidates are identified in the QTL region, tools are used to identify genes directly involved in the analyzed process, e.g. gene ontology analysis. The genes thus identified may be sequentially introduced into another genetic background through marker-assisted selection (MAS), which may have an impact on the significant shortening of the process of deriving new forms with better agronomic values. Thus, QTL analysis in modern science plays the role of a link between a functional trait and a marker. The vast majority of phenotypic traits are determined by genes from different loci, i.e. a precisely defined area of the chromosome on which the given gene is located, as a result, it may hinder the trait analysis [13]. Identification of genes that are responsible for quantitative traits - QTL is thus defined as a statistical-genetic method that reveals the correlation between a genotype, which is visualized

with the use of morphological, isoenzymatic and genetic markers [12], and the phenotype of analyzed plants [19].

Assuming that a given gene may be responsible for more than one trait, due to the visualization of quantitative features, the influence of loci on a given feature can be determined with great precision. The first step to constructing high-density genetic maps is to derive the mapping population preceded by the choice of parental forms. The material used was 90 lines of doubled haploids - CSDH together with parental forms: CS and SQ1 of common wheat [6,7]. The mapping population is treated as a set of parental and recombinant genotypes in terms of segregating loci. Recombination frequency, calculated on the basis of the recombinants number present in the population, is used to calculate genetic distances between pairs of linked loci. According to the literature, in practice, the number of individuals in the majority of analyzed mapping populations varies from 50 to 250. The more numerous population, the greater the chance of obtaining a high density map [1].

In phase 11-13 according to the BBCH scale (leaf development, 1-3 leaves visible) when the plants reached about 15-20 cm, the material was cut, lyophilized (Free Zone 2.5 Labconco), ground in a ball mill (Retsch MM400) and analyzed (Cary 300 UV-VIS , Agilent) for chlorophyll content according to the methodology described by Lichtenthaler HK, Buschmann C (2001) [14]. The obtained results were averaged. The subsequent results of chlorophyll a, b, total chlorophyll content were used to work with the Win QTL Cartographer 2.5 program. Individuals of the mapping population were sown and cultivated under controlled conditions: 8/12 L / D, RH 60 ± 5% and temperature 21° C.

WINQTLCARTOGRAPHER 2.5

The QTL analysis was carried out using freely available program the WinQTLCartographer 2.5 (https://brcwebportal.cos.ncsu.edu/qtlcart/WQTLCart.htm). This program allows for analysis using a number of statistical methods: SMA (Single Marker Analysis), IM (Interval Mapping), CIM (Composite Interval Mapping), BIM (Bayesian Interval Mapping), MIM (Multiple Interval Mapping), MTA (MultipleTrait Analysis) [15].

SMA analysis allows finding a link between a single marker and a phenotype. Average values of traits for two groups of genotypes are compared. If there is a significant difference between these values, it is considered that in the close location with the analyzed marker there is a QTL affecting the examined feature. The IM analysis shows the linkage between quantitative trait locus - QTL and markers limiting a given QTL interval on the genetic map. Composite interval mapping - CIM allows to check the effect of QTLs at different intervals or chromosomes, which increases the precision of their detection. Another method is the MIM analysis that allows the reduction of QTLs interactions in one group of linkage. Thanks to this method, the obtained results are free from errors flowing from the presence of QTL in other regions of the chromosome. Testing the presence of QTL in a given map interval is done by calculating the LOD value. The QTL is identified in the region determined by the peak of the LOD curve, as long as it exceeds the critical value determined as a result of 1000 permutations.

The subsequent results of chlorophyll a, b, total chlorophyll content were used to work with the Win QTL Cartographer 2.5 program. The next step was statistical analysis - analysis of one-way variance, histogram (Fig. 1) and descriptive statistics. Thanks to statistical analysis, we obtain information whether the differences between the lines are greater than within the line.

The program can work using text files, excel files or files in the format required by the extension program: qrt, mcd.

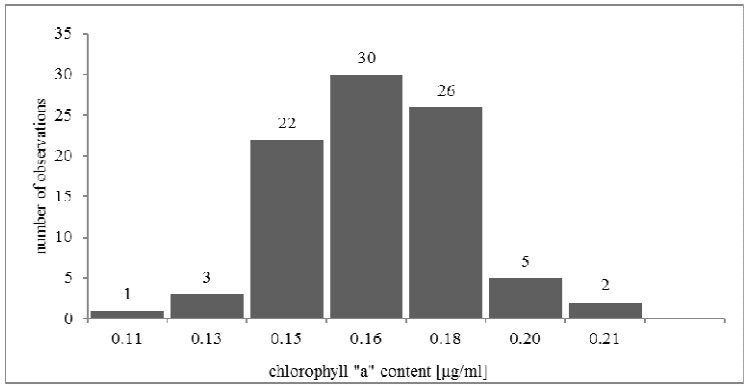


Fig. 1. Chlorophyll ″a″ content in the development phase of plant leaves in the CSDH population of wheat

Fig. 1 Zawartość chlorofilu "a" w fazie rozwoju liści roślin populacji CSDH pszenicy

In the case of Communications with the program using text files, before starting to work with the program, 4 different text files containing data should be prepared, which will enable the analysis (Fig. 2A – 2D).

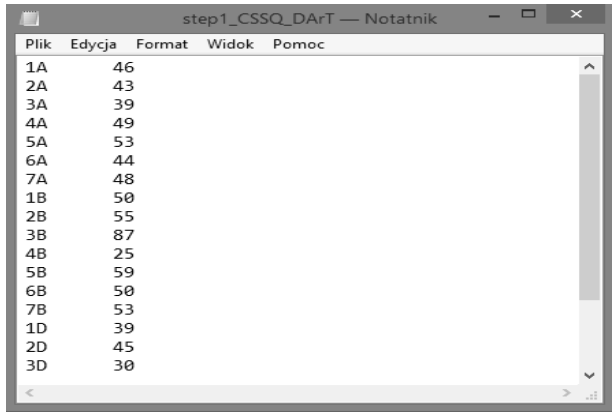


Fig. 2A. STEP 1

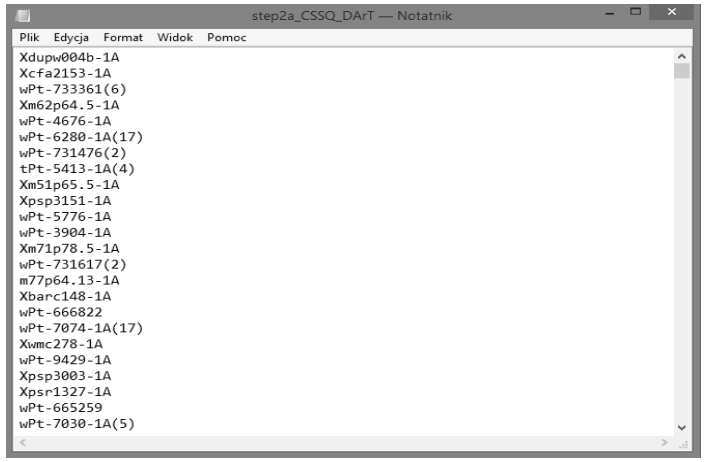


Fig. 2B. STEP 2

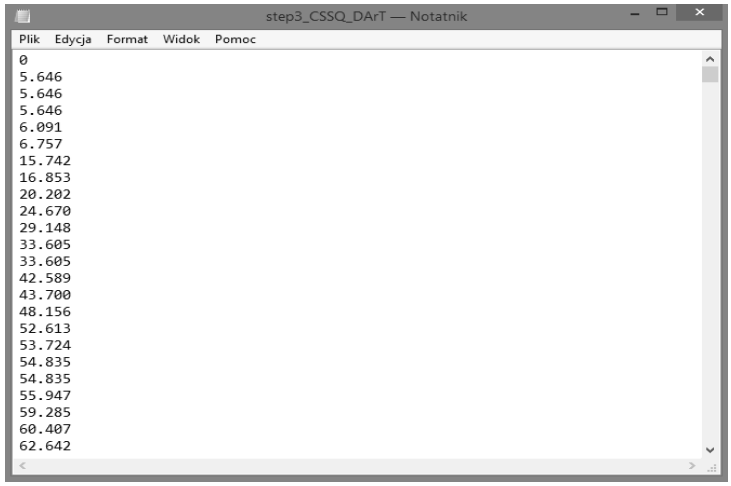


Fig. 2C. STEP 3

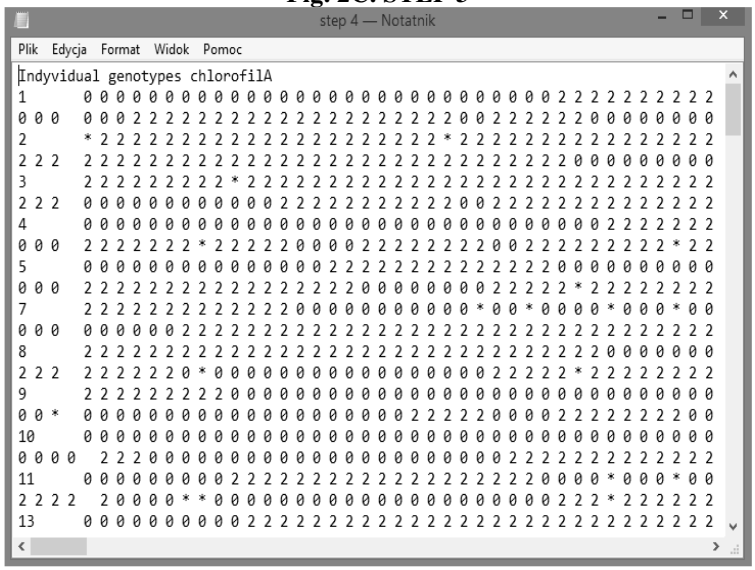


Fig. 2D. STEP 4

A file containing information on the number of markers on given chromosome – ″STEP 1″. We have 21 chromosomes (1A – 7D) – left column, number of markers on a given chromosome – right column. For example, chromosome 1A has 46 markers. Information obtained from the molecular map of the wheat genome.File containing information about markers (name of markers) - ″STEP 2″. The order of markers on chromosomes – the first marker of chromosome 1A – Xdupw004b, the second marker of chromosome 1A – Xcfa2153, etc.File containing information on the marker position on the chromosome (in cM) - "STEP 3". The first marker of the first and each subsequent chromosome has the position 0 (cM). The marker of the second chromosome of the first has the position of 5.646 (cM). A file containing a genetic map and phenotypic data - ″STEP 4″.After preparing the text files, you can proceed to the analysis in WinQTLCartographer 2.5. After starting, the main window of the program appears (Fig. 3), from which we select **New.**

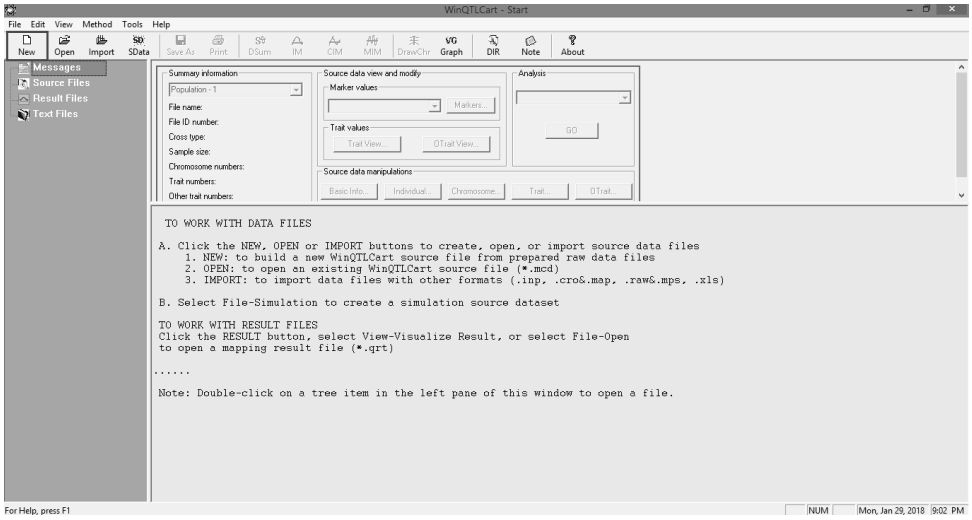


Fig. 3. Main window of the program WinQTLCartographer 2.5

A window will be displayed **Create New Source File – Basic Information – Step 1 of 6** (Fig. 4).

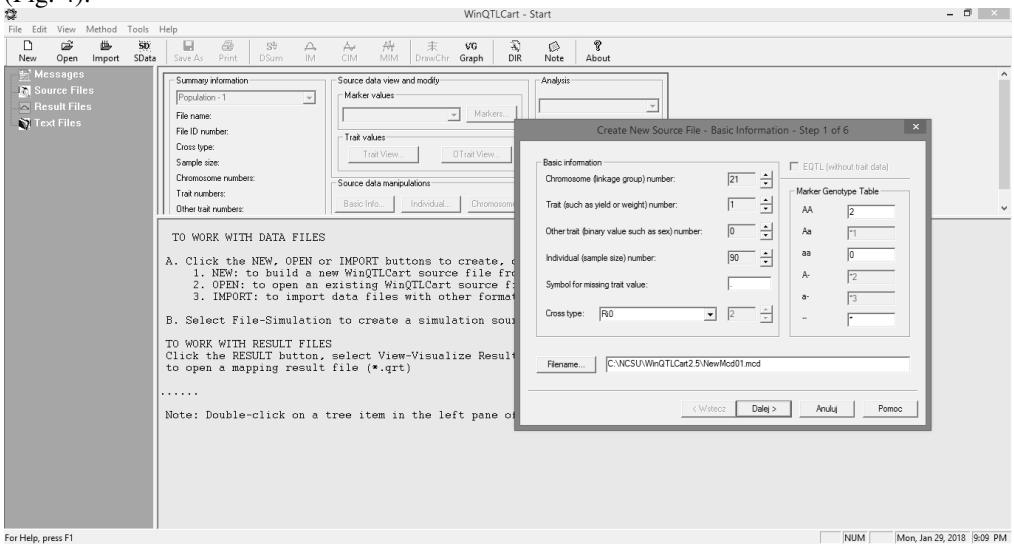


Fig. 4. Window Create New Source File – Basic Information – Step 1 of 6

The following data should be completed:

- We introduce the number of chromosomes – in our case 21,
- We introduce the number of analyzed features – in our case 1,
- We introduce the number of other features – in our case 0,
- We introduce the number of samples – in our case 90,
- In the **Cross type** window, selected the experimental design option based on the data. Can be chosen: **B1** – Backcross, with 1=parental line to which the F1 line was crossed. **B2** – Backcross, with 2=parental line to which the F1 line was crossed. **Ri0** – Recombinant inbred line, derived by doubled haploid lines. **Ri1** – Recombinant inbred line, derived by selfing. **Ri2** – Recombinant inbred line, derived by sib mating. **SF** – Selfed intercross line. Enter an integer indicating the generation. Limit of 2. **RF** –

Randomly mated intercross line. Enter an integer indicating the generation. **T(B1)SF** – Test cross, with genotyping done on an intercross (SF) and phenotyping on a cross (B1) derived from that intercross. Enter an integer indicating the generation. **T(B1)RF** – Test cross, with genotyping done on an intercross (RF) and phenotyping on a cross (B1) derived from that intercross. Enter an integer indicating the generation. **T(B2)SF** – Test cross, with genotyping done on an intercross (SF) and phenotyping on a cross (B2) derived from that intercross. Enter an integer indicating the generation. **T(B2)RF** – Test cross, with genotyping done on an intercross (RF) and phenotyping on a cross (B2) derived from that intercross. Enter an integer indicating the generation. In our case Ri0.

- Choose **Next**.
- A window will be displayed **Create New Source File – Map Information 1 – Step 2 of 6** (Fig. 5).

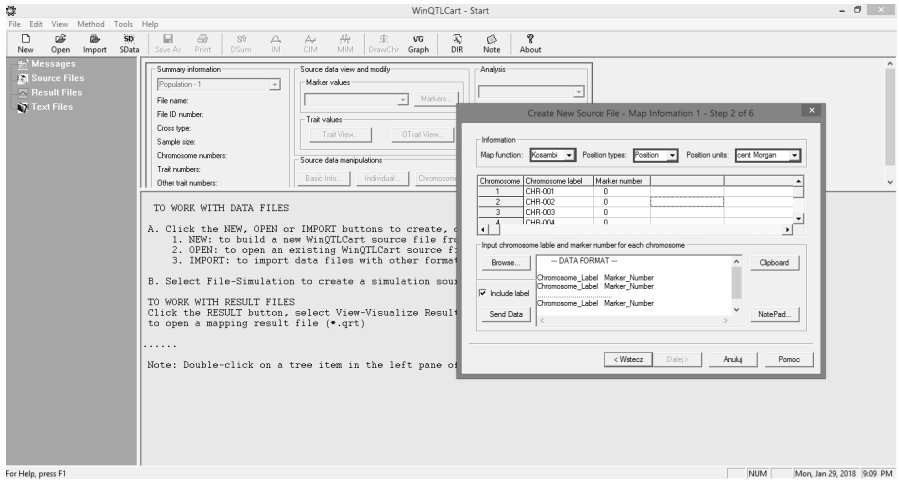


Fig. 5. Window Create New Source File – Map Information 1 – Step 2 of 6

The click **Browse**, selected the previously prepared ″STEP 1″ file from the **Open** window > **Send Data > Next > Browse > „Step 2" > Send Data > Position** (Fig. 6).

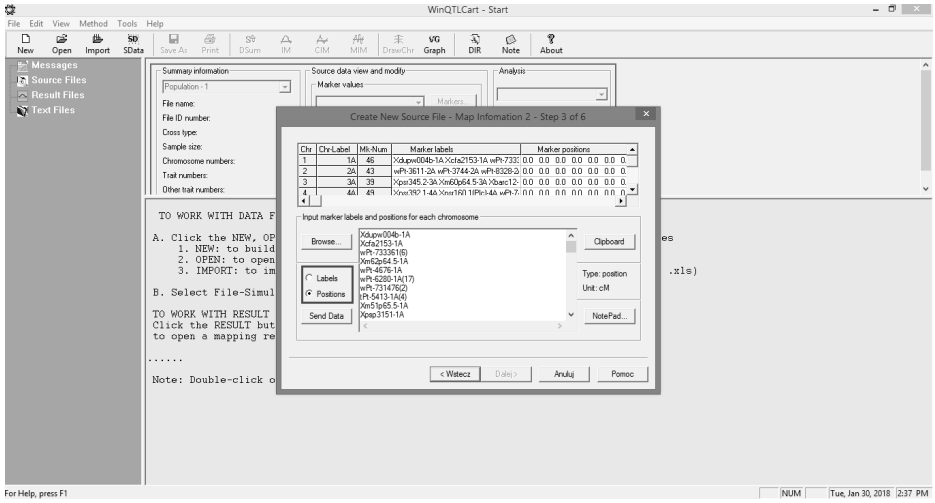


Fig. 6. Window Create New Source File – Map Information 2– Step 3 of 6

> Browse > „Step 3” > Next (Fig. 7) **>**

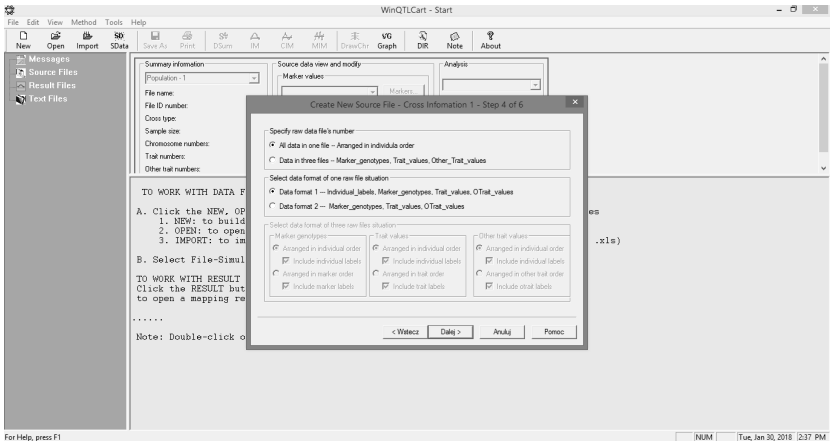


Fig. 7. Window Create New Source File – Map Information 1 – Step 4 of 6

Next > Browse > „Step 4” > Send Data >Next > Finish (Fig. 8).

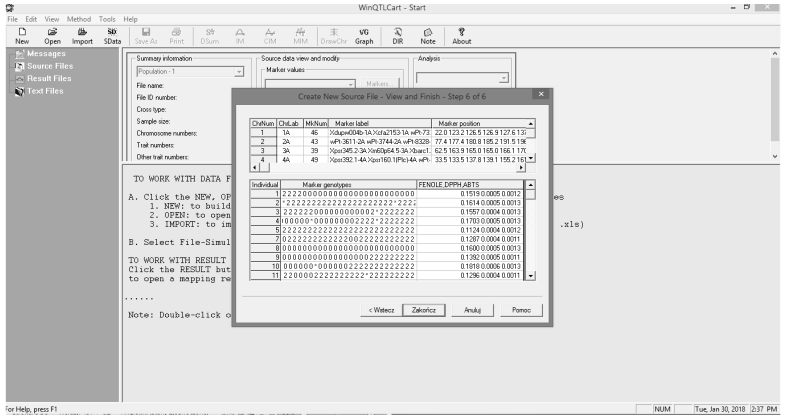


Fig. 8. Window Create New Source File – View and Finish – Step 6 of 6

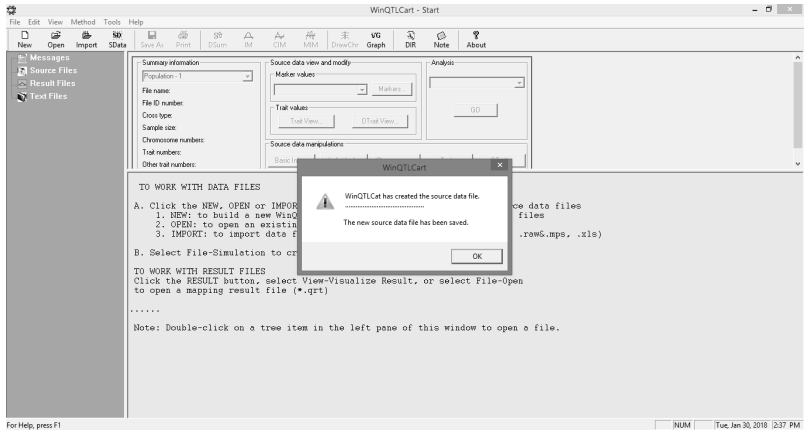


Fig. 9. Window WinQTLCart

A message will appear asking you to create and save the data file. Click **OK.** (Fig. 9).

Next, the program window appears (Fig. 10) containing:
Menu – 1.
Toolbar – access to the main program options – 2.
Tree Pane – file management, displays and organizes files – 3.
Data Pane – displays the data of the currently selected file – 4.
Form Pane – shows available analytical methods – 5.

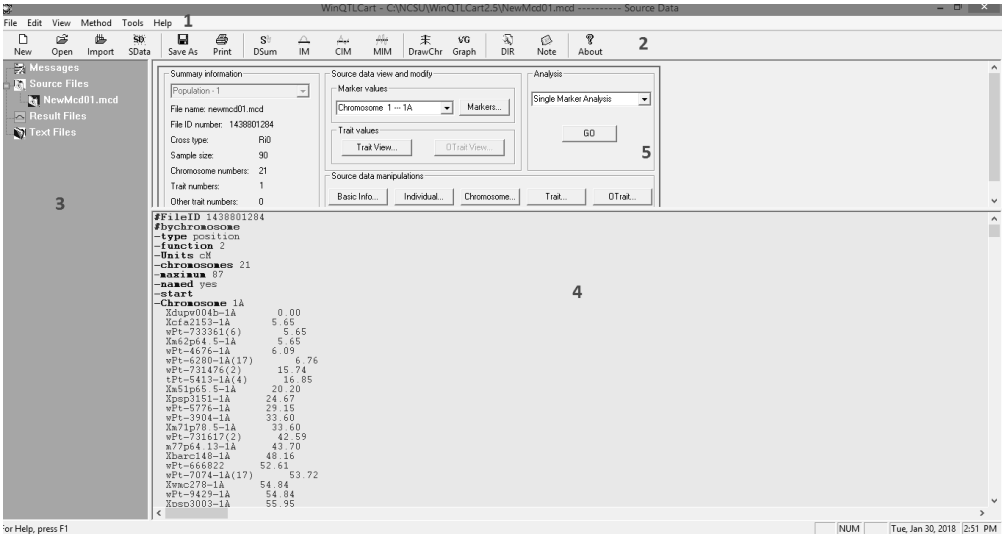


Fig. 10. Window WinQTLCart – Source Data

In this window, choose the method that we want to perform (in our case, Composite Interval Mapping to detect markers coupled with a feature) and click **GO** (Fig. 11).

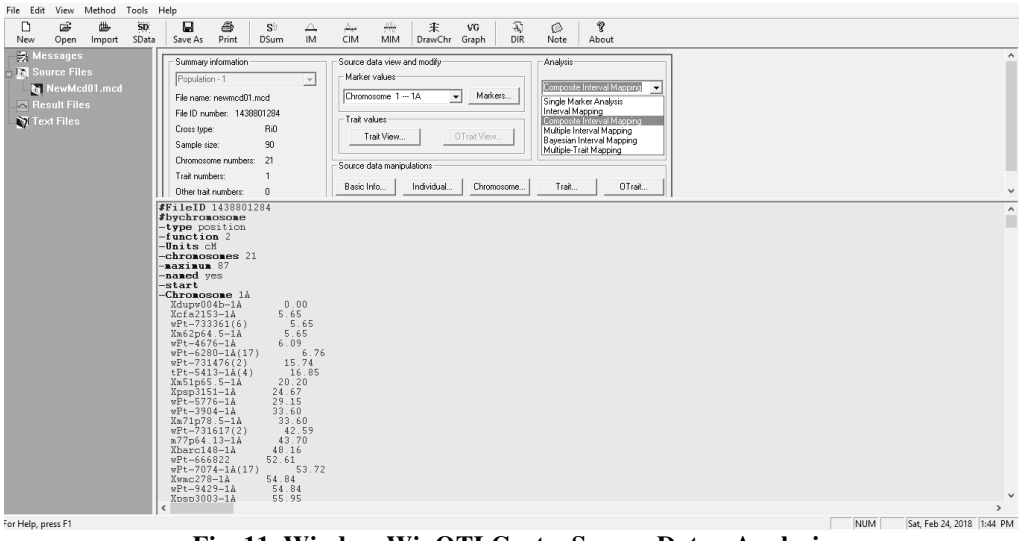


Fig. 11. Window WinQTLCart – Source Data - Analysis

Obtained results can also be presented graphically by clicking **Graphic**. A message appears storing information. Click **Save**.

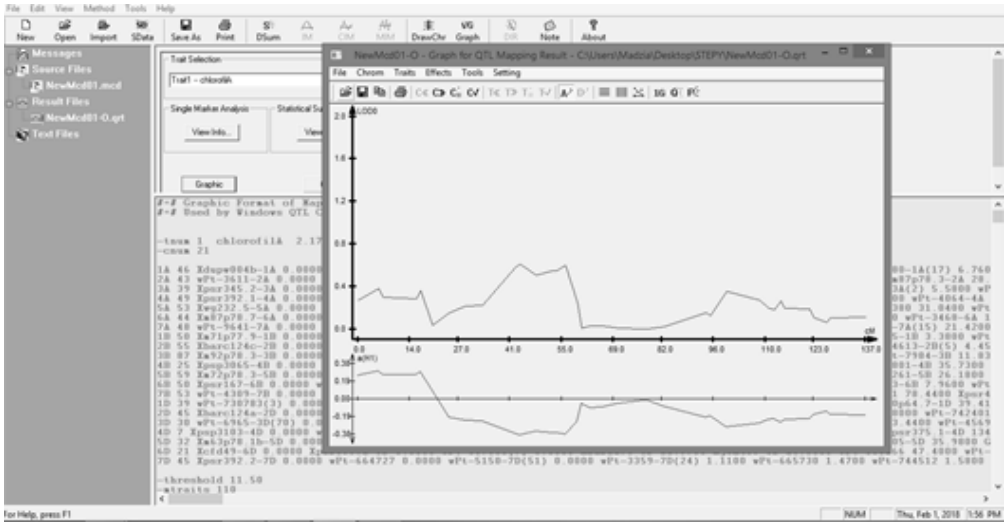
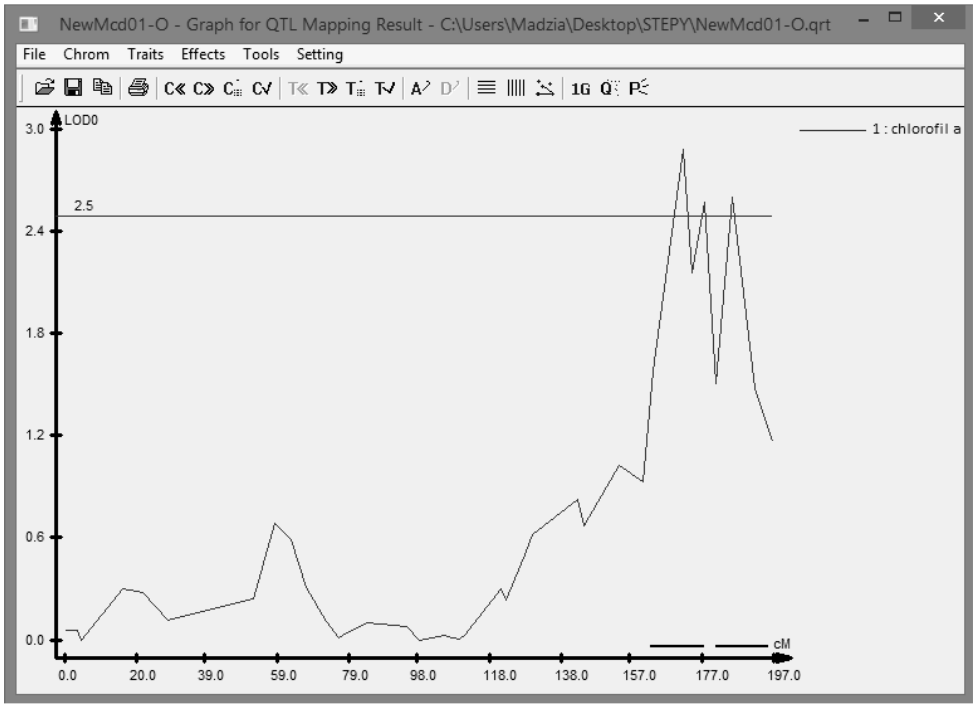


Fig. 12. Window showing the Graph for QTL Mapping Result

In the window thet appears (Fig. 12) on the Menu bar, click **Tools** > **Show QTL Information > Automatic location QTLs > OK**. We have here various options for graphic representation of results. We can present all or a selected (one) chromosome, present one or several features, etc.

The peak of the graph that exceeds the threshold Line is the place of QTL (Fig. 13).



RESULTS

In the next step, click **File > Save as EQTL File > Save**. After opening the saved file, we obtain accurate information on the obtained QTL (Fig. 14).

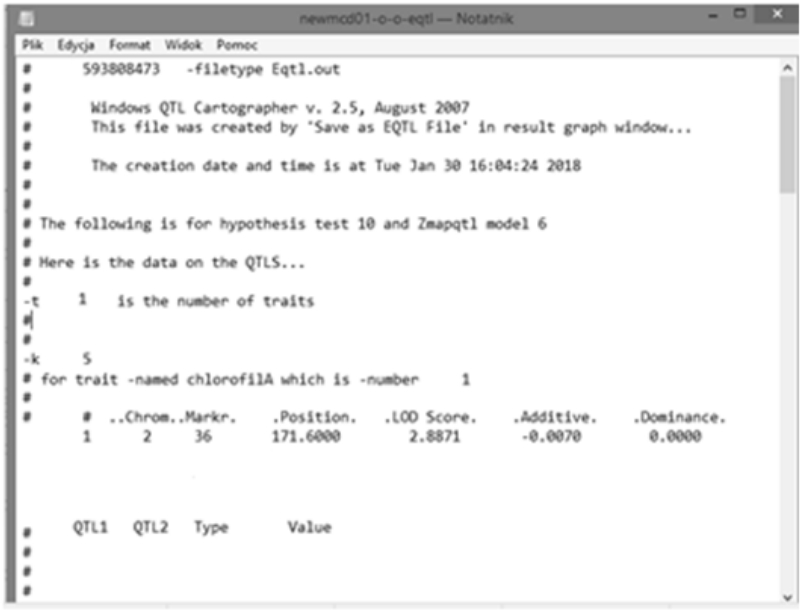


Fig. 14. Information on the obtained QTL (eQTL file)

With the other analyzes available in the program, eg. Single Marker Analysis (Fig. 10), we take the same steps.

In order to identify the obtained QTL, several parameters are used: the position of the most linked marker (cM), i.e. located closest to the maximum LOD curve peak, additive effect – a (determines by what value the allele decreases or increases the value of the trait) and the coefficient of determination (R^2), which determines the percentage of variation in the trait that remains under the control of the given *locus*. As a result of the CIM analysis, QTLs are detected – One chosen example of QTL analysis is presented in the Tab. 1 (Table 1). A LOD threshold above 2.5 indicates the localization of QTL.The QTLs is located on the chromosome 2A on the 171.568 cM position. The closets marker is wPt-1108, the LOD value is 2,8871. Additive effect can have positive or negative values. When the value is positive it means that allele from first parent (in our case CS) increases the value of the trait, when it is negative it means that allele from the second parent (in our case SQ) increase the value of the trait. In our example additive effect came from SQ. The determination factor is 12,4 % which means that this loci explains about 12 percent of the analyzed trait variation.

Tab. 1. Location of QTL chlorophyll ″a″ obtained by the CIM method.

Trait	Chromosome	Marker	QTL position [cM]	LOD value	a	R^2 (%)
Chlorophyll ″a″ content	2A	wPt-1108	171.568	2.8871	- 0.007	12.14

LOD – logarithm of odds, a – additive effects, R^2 - determination factor

CONCLUSION

In conclusion, after the QTL analysis with Win QTL Cartographer, it is possible to obtain QTLs connected with the tested trait for example with the chlorophyll content in common wheat. The localization of QTLs indicates potential places in the genome associated with trait analyzed .Nowadays, one of the goal of genetic research is looking for relationship between genetic information (e.g. markers, genes) and functional traits (e.g. yield, resistance to biotic and abiotic stress) QTL mapping brings the possibility to find markers associated with quantitative traits, that are difficult to introduce in lines or varieties by traditional breeding or transgenic strategies. After QTL analysis selected markers can be converted, if necessary, to low-time and low-cost consuming form and validated on breeding materials. Markers after conversion and validation can serve in marker assisted selection (MAS) as an excellent tool for breeders.

REFERENCES

1. Abdurakhmonov I. Y., Abdukarimov A. 2008. Application of Association Mapping to Understanding the Genetic Diversity of Plant Germplasm Resources. International Journal of Plant Genomics. 57 (4), 92-97.
2. Baer-Nawrocka A., Kiryluk-Dryjska E. 2015. Produkcja zbóż w wybranych krajach Unii Europejskiej - uwarunkowania strukturalne i polityczne. Journal of Agribusiness and Rural Development. 4, 38-46.
3. Bednarek P. T., Chwedorzewska K. 2001. Markery molekularne ich charakterystyka genetyczna oraz wybrane zastosowania w analizie genetycznej roślin. Biotechnologia. 1, 9-34.
4. Cacak-Pietrzak G., Gondek E. 2010. Właściwości przemiałowe ziarna orkiszu i pszenicy zwyczajnej. Acta Agrophysica. 16 (2), 263-273.
5. Collard B. C. Y., Jahufer M. Z. Z., Brouwer J. B., Pang E. C. K. 2005. An introduction to markers, quantitative trait loci (QTL) mapping and marker-assisted selection for crop improvement: the basic concepts. Euphytica. 142 (1-2), 169-196.
6. Czyczyło-Mysza I., Marcińska I., Skrzypek E., Cyganek K., Juzoń K., Karbarz M. 2014. QTL mapping for germination of seeds obtained from previous wheat generation under drought. Central European Journal of Biology. 9 (4), 374-382.
7. Czyczyło-Mysza I., Tyrka M., Marcińska I., Skrzypek E., Karbarz M., Dziurka M., Quarrie S. A. 2013. Quantitative trait loci for leaf chlorophyll fluorescence parameters, chlorophyll and carotenoid contents in relation to biomass and yield in bread wheat and their chromosome deletion bin assignments. Molecular breeding. 32 (1), 189-210.
8. Dresler S., Bednarek W., Tkaczyk P. 2010. Plonowanie pszenicy jarej w zależności od niektórych właściwości gleby i zabiegów agrotechnicznych. Acta Agrophysica. 16 (1), 15-24
9. Fan Y., Shabala S., Ma Y., Xu R., Zhou M. 2015. Using QTL mapping to investigate the relationships between abiotic stress tolerance (drought and salinity) and agronomic and physiological traits. BMC genomics. 16 (1), 43.
10. Gallai N., Salles J. M., Settele J., Vaissière B. E. 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological economics. 68 (3), 810-821.
11. Gołaś Z. 2017. Rentowność produkcji pszenicy zwyczajnej w UE. Zeszyty Naukowe SGGW w Warszawie. Problemy Rolnictwa Światowego. 17 (2), 29-40.
12. Gudyś K. 2017. Mapowanie genów i QTL związanych z reakcją na stres niedoboru wody z wykorzystaniem wysokorozdzielczej mapy genetycznej Hordeum vulgare L. (Doctoral dissertation).

13. Krajewski P., Bocianowski J., Gawłowska M., Kaczmarek Z., Pniewski T., Święcicki W., Wolko B. 2006. Identyfikacja i charakterystyka ekspresji genów determinujących cechy związane z plonowaniem w kombinacjach krzyżówkowych grochu. Biuletyn Instytutu Hodowli i Aklimatyzacji Roślin. 240, 271-278.
14. Lichtenthaler H. K., Buschmann C. 2001. Chlorophylls and carotenoids: Measurement and characterization by UV-VIS spectroscopy. Current protocols in food analytical chemistry.
15. Luciano Da Costa E. S., Wang S., Zeng Z. B. 2012. Composite interval mapping and multiple interval mapping: procedures and guidelines for using Windows QTL Cartographer. In Quantitative trait loci (QTL). (Humana Press), 75-119.
16. Rhoda R. 2018. Improving wheat grain yield by employing an integrated biotechnology approach (Doctoral dissertation, Stellenbosch University).
17. Shi X., Ling H. Q. 2017. Current advances in genome sequencing of common wheat and its ancestral species. The Crop Journal.
18. Szyp-Borowska I. 2005. Mapowanie loci cech ilościowych jako nowe narzędzie w hodowli selekcyjnej drzew leśnych. Leśne Prace Badawcze. (1), 99-107.
19. Wang K., Riaz B., Ye X. 2017. Wheat genome editing expedited by efficient transformation techniques: Progress and perspectives. The Crop Journal.
20. Zych J. 2005. Odmiany pszenicy ozimej-trudny wybór (Świat Zbóż). Biuletyn Informacyjny Krajowej Federacji Producentów Zbóż. (1), 17-24.

STRESZCZNIE

BADANIE ZWIĄZKÓW LIŚCI PSZENICY – PRZYKŁAD ANALIZY QTL

Podstawowym zbożem uprawianym w warunkach Polski jest pszenica. Zajmuje ona największą powierzchnię upraw, roczne zbiory sięgają 9 mln ton. Głównym gatunkiem jest pszenica zwyczajna *Triticum aestivum* ssp. vulgare, zwana też pszenicą miękką. Popularność uprawy tej rośliny w naszym kraju polega na szerokim zastosowaniu zebranego ziarna, dużych możliwościach produkcyjnych w warunkach klimatycznych i glebowych Polski oraz na tym, że jest ona zbożem towarowym. Obecnie, aby otrzymać najbardziej satysfakcjonujące plony, uprawa każdej rośliny rolniczej wymaga prowadzenia równoczesnej selekcji pod względem wielu cech. Identyfikacji loci cech ilościowych można dokonać przy użyciu odpowiednich markerów genetycznych za pomocą obliczania położenia QTL (*Quantitative Trait Loci* – locus cechy ilościowej). QTL to dające się zlokalizować markery genetyczne, które są ściśle sprzężone z genami kontrolującymi interesujące nas cechy. Jednym z ważniejszych celów badań genetycznych jest wyszukiwanie związku między informacją genetyczną, a cechą użytkową. Mapowanie QTL pozwala na znalezienie markerów związanych z cechami ilościowymi, które są trudne do wprowadzania w liniach lub odmianach poprzez zastosowanie tradycyjnych metod hodowlanych. Po identyfikacji markerów w regionach QTL dochodzi do identyfikacji genów, które są bezpośrednio zaangażowane w analizowany proces. Niniejsza praca opisuje zasadę metody statystyczno-genetycznej jaką jest analiza loci cech ilościowych QTL służącą do uwidocznienia powiązań między fenotypem a genotypem organizmów roślinnych. Metoda ta umożliwia określenie genetycznego podłoża cech ilościowych głównie u roślin uprawnych. Na wybranym przykładzie – analiza zawartości chlorofilu w liściach pszenicy zwyczajnej opisano kolejne kroki niezbędne do wykonania takiej analizy przy zastosowaniu jednego z ogólnodostępnych programów komputerowych – WinQTLCartographer 2,5. WinQTLCart jest kompatybilny z systemami Windows 95, 98, ME, NT, 2000, XP i Windows 7. Ze względu na to, że niektóre karty WinQTLCart są duże, sugerowana minimalna rozdzielczość powinna wynosić 1024x768. Na dysku zalecane jest

minimum 20MB wolnej przestrzeni i 512 MB RAM. Można importować dane z MapMaker/QTL, QTL Cartographer, i z Microsoft Excel. Do badań wykorzystano materiał roślinny – pszenicę zwyczajną (*Triticum aestivum* L.), którą stanowiła populacja podwojonych haploidów (DH) pochodząca z krzyżówki Chinese Spring (CS) x SQ1. Rośliny w fazie 11-13 BBCH ścięto nad koleoptylem, zliofilizowano i poddano badaniom na zawartość chlorofilu. Na podstawie obliczeń sporządzono histogram, statystykę opisową oraz przeprowadzono analizy wariancji jednoczynnikowej, w celu weryfikacji różnic pomiędzy analizowanymi liniami i w obrębie samych linii. Do przeprowadzenia analiz QTL , w celu wskazania lokalizacji QTL na chromosomach wykorzystano metodę mapowania kompozytowego (ang. Composite Interval Mapping – CIM) pozwalającą na wykrycie QTL z dużą precyzją.

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TREES SPECIES VARIETY AND THEIR TAXATION INVENTORY IN A RECREATION PARK IN TRUSKAVETSKA STREET, DROHOBYCH

Abstract. The recreation park situated in Truskavetska street, Drohobych is a landmark of local garden art. Its territory occupies 2 hectares.

Due to the increase in the city number and the development of manufacturing industry, the issue of environmental protection and creation of normal conditions for human being is becoming increasingly serious. In recent decades, the negative impact of a man on the environment, in particular on greenery, has increased [15].

The results of the analysis of the dendflora of the recreation park in Truskavetska street, Drohobych introduced in the article were found in the park on the basis of literature data and personal research.

Deciduous trees are ascertained to be the prevailing in the park. Their quantity is 92.8 % of the total number of all trees. The rest 7.2% belong to evergreens. We have found that most of the trees in terms of phytosanitary characteristics are characterized by a good and satisfactory condition. There was investigated that the estimation of the relative total tree density indicates that the vital condition of the park is weakened.

Key words: inventory, green plantations, landscaping, species and quantitative composition of green plantations, dendroflora, urboecosystem, phytoncide properties.

INTRODUCTION

The problem of preservation and protection of biodiversity as an integral component of the natural environment has become urgent nowadays. Due to a variety of reasons, this problem become particularly severe for Ukraine that is caused by anthropogenic transformation threatening to health and life [4; 5].

Modern city embodies an urban ecosystem an integral component of which are green plantations. They meet the growing need of people in communicating with nature and are the means of preserving the natural environment in urban cities. Green plantations are very important, as they create favourable conditions for life in the urban ecosystem.

Green plantations play an important role in weakening as well as in neutralization of the negative impact of the industrial areas on urban residents and environment components. They provide reduction in sound waves intensity, regulation of wind, dust, wind, and gas streams, improvement of the atmospheric basin by minimizing the concentration of dust and toxic substances in the air, formation of a comfortable microclimate, etc.

Taking into consideration a great role of green plantations in the urban environment, it is necessary to study dendroflora in a comprehensive manner, to inventory and assess the condition of the plants in the city parks in order to elaborate recommendations for their care and reconstruction. Inventory of objects of the green industry, which is aimed at protecting and preserving green plantations in urban cities and towns in a healthy and regulated condition, makes it possible to determine the biological and phytosanitary condition of tree plants, to assess the impact of anthropogenic factors on the stage of green plants, and to understand changes in the landscape object [3; 6; 13].

The purpose of our research was to study the species diversity and carry out tax inventory of the trees of the recreation park in Truskavetska street, Drohobych.

PURPOSE OF THE RESEARCH

Inventory of plantings was carried out during full-scale inspections and field explorations. The inventory was carried out in accordance with the requirements of the "Instructions for the technical inventory of green plantations in urban cities and towns of Ukraine" [17]. During the survey, the following indicators were analysed: species composition, diameter of the barrel, estimated age [9], phytosanitary condition.

When carrying out the tax inventory, we have investigated the general stand of the green plantations.

The following formula was used to calculate the stand condition:

$$L_n = (100\ n_1 + 70\ n_2 + 40\ n_3 + 5\ n_4) / N,$$

where L_n is relative state of the the stand, calculated by the number of trees; n_1 is a number of healthy trees, n_2 are weakened trees, n_3 are extremely weakened, n_4 are dying trees of the territory; N is a total number of trees (including dry) territories [19].

Field explorations were used to determine the species composition of tree plants (a detailed route of inspections was drawn up); the definition of green plantings according to plant determinants has been carried out. The diameter of the barrel was determined with the help of a forest metric fork at 1.3 m altitude in field conditions.

RESEARCHES RESULTS AND THEIR DISCUSSION

There are 251 specimens belonging to 17 species, 15 genera and 11 families according to the results of the research of the park dendroflora. The found species of the tree are as the following: 1.

Table 1. Specific and quantitative composition of the recreation park dendroflora in Truskavetska Street, Drohobych

№ s/n	Species name		Plants quantity, unit.
	English	Latin	
1	Silver birch	*(Betula pendula)*	44
2	Weeping birch	*(Salix babylonica)*	5
3	Wych elm	*(Ulmus glabra)*	5
4	Horse-chestnut	*(Aesculus hippocastanum)*	18
5	Common hornbeam	*(Carpinus betulus)*	59
6	Single-seeded hawthorn	*(Crataegus monogyna)*	3
7	Common oak	*(Qurcus robur)*	5
8	Northern red oak	*(Quercus rubra)*	2
9	Sycamore	*(Acer pseudoplatanus)*	6
10	Box elder	*(Acer negundo)*	7
11	Small-leaved lime	(*Tilia cordata*)	50
12	European larch	*(Larix decidua)*	1
13	Black locust	*(Robinia pseudoacacia)*	1
14	Black poplar	(*Populus nigra)*	20
15	Northern white-cedar	(*Thuja occidentalis*)	4
16	Norway spruce	*Norway spruce*	13
17	European ash	*(Fraxinus excelsior)*	8
Total number:			**251**

You can see from the table that in the park predominate: Common hornbeam (59 exemplar, 23,5%), Small-leaved lime (50 exemplar, 20%), Silver birch (44 exemplar, 17,5%). Three species are represented by the number of plants from 11 to 20 specimens, three species have from 6 to 10 specimens, eight species have from 1 to 5 specimens. The most common in the park are deciduous trees, which make up 92.8% of the total number of all trees, 7.2% belongs to evergreens, among which the dominant representative is Norway spruce - 5.2%. Researches show that the proportion of conifer trees is very low, but the expansion of the assortment of evergreen trees would provide high decorative function and air saturation with phytoncides at any time of the year.

11 families form the leading part of the family spectrum in the number of species. Quantitative composition of species in families is given in fig. 1.

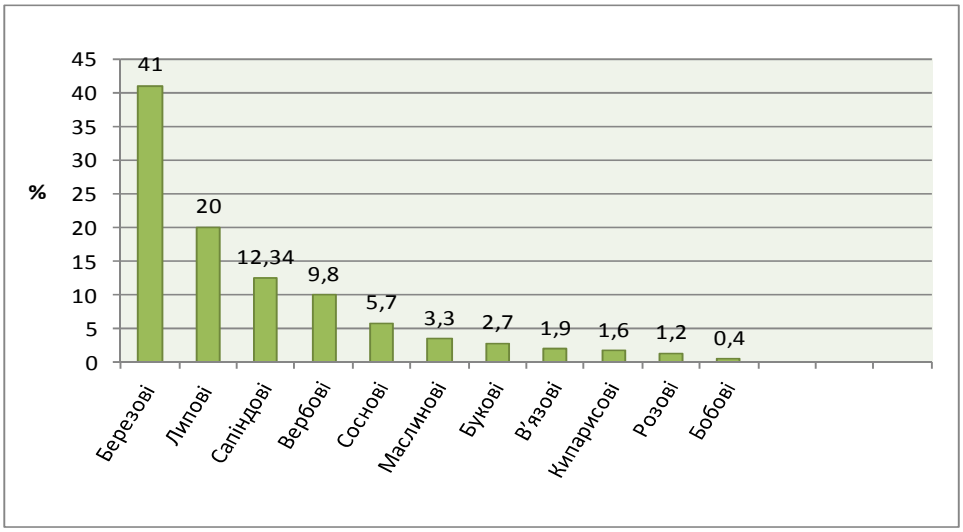

Fig. 1. Quantitative composition of species in families

We made a tax inventory [17] and measured: diameter, approximate age [9; 10] and the condition of green plantations in the park. Based on these data there was studied the condition of each tree and there were developed measures to improve them. Materials of taxation inventory of park trees are presented in Table 2.

Table 2. Taxation indicators of green areas of the recreational park territory in Truskavetska street, Drohobych

№ s/n	Species (English, Latin)	Diameter, cm	Approximate age, years	Condition	Improvement measures
1	**2**	**3**	**4**	**5**	**6**
1	Common oak *(Qurcus robur)*	102	150	satisfactory	
2	Box elder *(Acer negundo)*	46	30	unsatisfactory (emergency)	Cutting down
3	Common oak *(Qurcus robur)*	76	130	good	
4	Black locust *(Robnia pseudoaccia)*	66	90	unsatisfactory	Cutting down
5	European ash (*Fraxinus excelsior)*	26	80	satisfactory	
6	Common hornbeam *(Carpinus betulus)*	44	75	satisfactory	
7	Common hornbeam *(Carpinus betulus)*	28	80	satisfactory	

8	Small-leaved lime (*Tilia cordata*)	36	100	good	
9	Small-leaved lime (*Tilia cordata*)	44	110	good	
10	Common hornbeam (Carpinus betulus)	36	30	good	
11	Common hornbeam *(Carpinus betulus)*	56	80	good	
12	Silver birch (*Betula pendula)*	50	120	unsatisfactory	Cutting down
13	Norway spruce (Picea abies)	36	130	unsatisfactory (extinct)	Cut down
14	Silver birch (*Betula pendula)*	46	115	unsatisfactory	Cutting down
15	Silver birch (*Betula pendula)*	42	110	unsatisfactory	Cutting down
16	Small-leaved lime (*Tilia cordata*)	20	60	good	
17	Small-leaved lime (*Tilia cordata*)	26	60	good	
18	European ash (*Fraxinus excelsior)*	36	100	good	
19	Silver birch (*Betula pendula)*	38	98	unsatisfactory	Cutting down
20	Small-leaved lime (*Tilia cordata*)	32	96	good	
21	Silver birch (*Betula pendula)*	26	86	unsatisfactory (emergency)	Cutting down
22	Small-leaved lime (*Tilia cordata*)	50	120	good	
23	Silver birch (*Betula pendula)*	56	120	unsatisfactory	Cutting down
24	Small-leaved lime (*Tilia cordata*)	40	100	good	
25	European ash (*Fraxinus excelsior)*	72	120	good	
26	European ash (*Fraxinus excelsior)*	70	120	good	
27	Box elder *(Acer negundo)*	36	98	unsatisfactory	pruning
28	Box elder (*Acer negundo*)	50	110	good	
29	Silver birch (*Betula pendula)*	46	110	unsatisfactory	Cutting down
30	Box elder (*Acer negundo*)	84	130	satisfactory	
31	Silver birch (*Betula pendula)*	42	110	unsatisfactory	Cutting down
32	Small-leaved lime (*Tilia cordata*)	34	100	good	
33	Small-leaved lime (*Tilia cordata*)	30	100	good	
34	Small-leaved lime (*Tilia cordata*)	34	100	satisfactory	
35	Norway spruce (Picea abies)	24	80	good	
36	Box elder (*Acer negundo*)	52	110	satisfactory	
37	Norway spruce (Picea abies)	26	120	good	
38	Small-leaved lime (*Tilia cordata*)	66	120	good	

39	Horse-chestnut (*Aesculus hippocastanum*)	78	100	good	
40	Sycamore (*Acer pseudoplatanus)*	62	100	satisfactory	
41	Horse-chestnut (*Aesculus hippocastanum*)	62	96	good	
42	Small-leaved lime (*Tilia cordata*)	56	120	satisfactory	
43	Small-leaved lime (*Tilia cordata*)	32	98	satisfactory	
44	Small-leaved lime (*Tilia cordata*)	34	100	unsatisfactory	arboriculture
45	Small-leaved lime (*Tilia cordata*)	46	110	unsatisfactory	pruning
46	Common hornbeam *(Carpinus betulus)*	48	90	good	
47	Black poplar (*Populus nigra)*	98	120	good	
48	Weeping birch (***Salix babylonica*)**	44	56	unsatisfactory	pruning
49	Silver birch (*Betula pendula)*	40	110	unsatisfactory (emergency)	Cutting down
50	Silver birch (*Betula pendula)*	34	98	unsatisfactory (emergency)	Cutting down
51	Silver birch (*Betula pendula)*	36	98	unsatisfactory	Cutting down
52	Silver birch (*Betula pendula)*	32	94	unsatisfactory (emergency)	Cutting down
53	Silver birch (*Betula pendula)*	34	94	unsatisfactory	Cutting down
54	Silver birch (*Betula pendula)*	26	86	unsatisfactory	Cutting down
55	Silver birch (*Betula pendula)*	30	92	Good	
56	Silver birch (*Betula pendula)*	20	70	Good	
57	Silver birch (*Betula pendula)*	46	115	satisfactory	
58	Silver birch (*Betula pendula)*	36	94	Good	
59	Silver birch (*Betula pendula)*	26	86	satisfactory	
60	Weeping birch (***Salix babylonica*)**	90	110	unsatisfactory	pruning
61	Small-leaved lime (*Tilia cordata*)	36	100	unsatisfactory	Cutting down
62	Small-leaved lime (*Tilia cordata*)	28	90	unsatisfactory (emergency)	Cutting down
63	Common hornbeam *(Carpinus betulus)*	38	80	Good	
64	Common hornbeam *(Carpinus betulus)*	30	75	unsatisfactory	pruning
65	Black poplar (*Populus nigra)*	102	122	Good	
66	Small-leaved lime (*Tilia cordata*)	26	90	Good	
67	Small-leaved lime (*Tilia cordata*)	30	94	Good	
68	Common hornbeam *(Carpinus betulus)*	38	80	satisfactory	
69	Wych elm (*Ulmus glabra)*	28	90	Good	
70	Common hornbeam *(Carpinus betulus)*	48	90	satisfactory	

71	Common hornbeam *(Carpinus betulus)*	62	96	Good	
72	Small-leaved lime (*Tilia cordata*)	36	98	unsatisfactory	pruning
73	Common hornbeam *(Carpinus betulus)*	70	98	Good	
74	Common hornbeam *(Carpinus betulus)*	56	92	Good	
75	Small-leaved lime (*Tilia cordata*)	48	110	Good	
76	Wych elm (*Ulmus glabra)*	24	90	satisfactory	
77	European ash (*Fraxinus excelsior)*	46	110	satisfactory	
78	Small-leaved lime (*Tilia cordata*)	40	110	unsatisfactory	pruning
79	Small-leaved lime (*Tilia cordata*)	28	80	unsatisfactory	arboriculture
80	European ash (*Fraxinus excelsior)*	34	90	unsatisfactory	Cutting down
81	Small-leaved lime (*Tilia cordata*)	34	98	satisfactory	
82	Horse-chestnut (*Aesculus hippocastanum*)	48	88	satisfactory	
83	Wych elm (*Ulmus glabra)*	34	96	unsatisfactory	pruning
84	Small-leaved lime (*Tilia cordata*)	50	120	unsatisfactory	pruning
85	Small-leaved lime (*Tilia cordata*)	32	90	Good	
86	Common hornbeam *(Carpinus betulus)*	40	90	Good	
87	Common hornbeam *(Carpinus betulus)*	28	80	Good	
88	Small-leaved lime (*Tilia cordata*)	28	85	unsatisfactory (extinct)	Cutting down
89	Common hornbeam *(Carpinus betulus)*	30	80	unsatisfactory	Cutting down
90	Small-leaved lime (*Tilia cordata*)	32	86	unsatisfactory	pruning
91	Small-leaved lime (*Tilia cordata*)	22	70	satisfactory	
92	Norway spruce (Picea abies)	32	115	satisfactory	
93	Small-leaved lime (*Tilia cordata*)	26	70	satisfactory	
94	Small-leaved lime (*Tilia cordata*)	36	100	unsatisfactory	pruning
95	Small-leaved lime (*Tilia cordata*)	46	110	unsatisfactory	pruning
96	Common hornbeam *(Carpinus betulus)*	82	120	satisfactory	
97	Box elder *(Acer negundo)*	28	80	Good	
98	Common hornbeam *(Carpinus betulus)*	28	80	unsatisfactory	pruning
99	Common hornbeam *(Carpinus betulus)*	40	90	satisfactory	
100	Small-leaved lime (*Tilia cordata*)	22	70	unsatisfactory	pruning
101	Small-leaved lime(*Tilia cordata*)	28	70	Good	
102	Small-leaved lime (*Tilia cordata*)	42	110	Good	
103	Single-seeded hawthorn (*Crataegus monogyna)*	34	40	Good	
104	Northern red oak *(Quercus rubra)*	36	100	Good	
105	Northern red oak *(Quercus rubra)*	36	100	Good	
106	Common oak *(Quercus rubur)*	28	80	Good	
107	Northern white-cedar *(Quercus rubur)*	8	30	unsatisfactory	Cutting down
108	Common oak *(Qurcus robur)*	32	94	Good	
109	Small-leaved lime (*Tilia cordata*)	26	70	Good	
110	Small-leaved lime (*Tilia cordata*)	28	70	Good	
111	Small-leaved lime (*Tilia cordata*)	40	110	unsatisfactory (extinct)	Cutting down
112	Small-leaved lime (*Tilia cordata*)	46	110	Good	
113	Box elder *(Acer negundo)*	28	80	satisfactory	

114	Single-seeded hawthorn (*Crataegus monogyna)*	28	35	satisfactory	
115	Single-seeded hawthorn (*Crataegus monogyna)*	26	35	satisfactory	
116	Common oak *(Qurcus robur)*	84	110	Good	
117	Common hornbeam *(Carpinus betulus)*	56	94	Good	
118	Common hornbeam *(Carpinus betulus)*	56	94	Good	
119	Silver birch (*Betula pendula)*	58	120	satisfactory	
120	Norway spruce (Picea abies)	48	140	Good	
121	Norway spruce (Picea abies)	48	140	satisfactory	
122	Silver birch (*Betula pendula)*	46	115	satisfactory	
123	Silver birch (*Betula pendula)*	50	120	unsatisfactory	Cutting down
124	Silver birch (*Betula pendula)*	34	98	satisfactory	
125	Northern white-cedar *(Quercus rubur)*	24		satisfactory	

Quantitative characteristics of tree plants by categories of phytosanitary condition of plantations gave the following results (fig. 2)

Picture 2. Distribution of dendroflora according to phytosanitary condition

There are 102 trees (41%) of the total number of plants that do not show signs of weakening. 78 trees (31%) are characterised by the satisfactory condition. 71 trees (28%) are characterised by the unsatisfactory condition. The following characteristics are common for them: weakness, distorted trunks, poorly developed crowns; there are dry and damaged branches, damaged trunks, hollows, small quantity of the leaves on the branches [2; 17].

According to the calculation of the stand condition [19], the index of the relative living condition of the park stand is 71.8%, which can be assessed as "weakened".

The species variety of the park trees is poor, therefore, it needs to be complemented by a range of interesting trees (Ginkgo tree (*Ginkgo biloba*), Douglas-fir *(Pseudotsuga Menziesii*), Saucer magnolia (*Magnolia Soulangeana*)). The following types of trees are proposed when performing protective landscaping:

- for noise protection – Norway maple, Redhaw hawthorn, Siberian peashrub;
- for gas protection – Striped maple, Honey locust, White mulberry;
- for dust protection – Chinese elm, White willow, Silver maple, Ash, White mulberry.

CONCLUSIONS

During the dendroflora research in recreation park in Truskavetska Street, Drohobych, the following conclusions are made:

The park dendroflora is characterized by a poor species variety of 251 specimens of tree plants growing on its territory,

Which are of 17 species, 15 genera and 11 families. Common hornbeam *(Carpinus betulus)*, Small-leaved lime (*Tilia cordata*), Silver birch (*Betula pendula)* are the dominant species. The most numerous are Birch family *(Betulaceae)* - 103 exemplar*s,* Tiliaceae family *(Tiliaceae)* – 50 exemplars, Soapberry family *(Sapindaceae)* - 31 exemplars, Sallows *(Salicaceae)* – 25 exemplars.

The most common in the park are deciduous trees, which make up 92.8% of the total number of all trees. 7.2% belong to evergreens, among which the main representative is Norway spruce – 5.2%.

Green plantations play an important role in the system of external improvement of cities; they create highly artistic architectural and landscape complexes that play an important aesthetic function. In addition to this, they reduce the quantity of dust and smoke in the city air, as a peculiar filter, affecting the formation of a comfortable microclimate.

On the phytosanitary basis, most of the trees are characterized by a good and satisfactory condition. Nearly 20 trees are dry stands of the past years, which require to be cut down and replaced.

The assessment of the relative total stands indicates that the vital condition of the park is weakened.

On the basis of the condition analysis of the recreation park tree plantations in Truskavetska street, Drohobych, the following recommendations were elaborated:

- to diversify the species variety of the tree plants, especially representatives of gymnosperms;
- to rejuvenate old and dying plantations;
- keep to the rules and techniques of tree care.

REFERENCES

1. Астахова Е., 2009. Ландшафтный дизайн. Харьков: Клуб семейного досуга, 320.
2. Боговая И. О., 1990. Озеленение населенных мест: Учеб. пособие для вузов. М.: «Агропромиздат», 239.
3. Велихов Л. А., 1996. Основи міського господарства. М: «Наука», 470.
4. Горохов В. А., 1991. Городское зеленое строительство: учеб. пособ. М.: «Стрйиздат», 120.
5. Заячук В.Я., 2008. Дендрологія: підручник [для студ. ВНЗ]. Львів: «Апріорі», 246.
6. Іванченко А. І., 2001. Словник таксономічних назв рослин. Львів: «Світ», 148.
7. Кашпор С. М., 2013. Лісотаксаційний довідник. К.: Видавничий дім «Вініченко», 496.
8. Кучерявий В. П., 2005. Озеленення населених місць. Львів: «Світ», 456.
9. Наказ Державного комітету будівництва, архітектури та житлової політики «Інструкція з технічної інвентаризації зелених насаджень у містах та інших населених пунктах України» № 226 від 24.12.2001 р.
10. Ходько Н.С., 2012. Профіль міста Дрогобич. Проект РЕОП, 6-9.
11. Chirici G., 2012. National Forest Inventory Contributions to Forest Biodiversity Monitoring. Forest Sciense, Vol. 58 (3), 257-268.
12. Commarmot B., Brandli U.-B., Hamor F., 2013. Inventory of the Largest Primeval Beech Forest in Europe. A Swiss-Ukrainian Scientific Adventure. Birmensdorf , WSL; Lviv, UNFU, Rakhiv, CBR, 69.
13. Matti Katila Erkki Tomppo, 2001. Selecting estimation parameters for the Finnish multisource National Forest Inventory. Remote Sensing of Environment, Vol. 76, Issue 1, 16-32.
14. Oliva J., Stenlid J., Grönkvist-Wichmann L., Wahlström K., Jonsson M., Drobyshev I., Stenström E.., 2016. Pathogen-induced defoliation of Pinus sylvestris leads to tree

decline and death from secondary biotic factors. *Forest Ecology and Management,* 379, 273-280.
Seppo Nevalainen, Hannu Yli-Kojola, 2000. Extent of abiotic damage and its relation to defoliation of conifers in Finland. *Forest Ecology and Management* 135:1-3, 229-235.
15. Seppo Nevalainen, 1999. Gremmeniella abietina in Finnish Pinus sylvestris Stands in 1986-1992: A Study Based on the National Forest Inventory. Scandinavian Journal of Forest Research, vol. 14, Issue 2, 111-120
16. Thomas Wutzler, Ingolf Profft, Martina Mund, 2011. Quantifying tree biomass carbon stocks, their changes and uncertainties using routine stand taxation inventory data. Silva Fennica 45(3), 2011, 359-377.

АНОТАЦІЯ

ВИДОВА РІЗНОМАНІТНІСТЬ І ТАКСАЦІЙНА ІНВЕНТАРИЗАЦІЯ ДЕРЕВ ПАРКУ ВІДПОЧИНКУ НА ВУЛИЦІ ТРУСКАВЕЦЬКІЙ М. ДРОГОБИЧ

Проблема збереження та охорони біорізноманіття як невід'ємного компонента природного середовища набула сьогодні невідкладної актуальності. Із різних причин особливо гострою ця проблема стала для України, що обумовлено загрозливими для здоров'я і життя масштабами антропогенної трансформації [4; 5].

Сучасне місто – це урбоекосистема, невідємним компонентом якої є зелені насадження. Вони є засобами збереження природного середовища в урбанізованих містах і відповідають зростаючій потребі людей в спілкуванні з природою. Зелені насадження – є дуже важливі, оскільки створюють сприятливі умови для життєдіяльності в міській екосистемі.

Парк відпочинку на вул. Трускавецькій м. Дрогобич − є пам'яткою садово-паркового мистецтва місцевого значення, територія якого становить 2 га. Із зростанням чисельності міст, розвитком промисловості, стає все більш складною проблема охорони навколишнього середовища, створення нормальних умов для життя і діяльності людини. В останні десятиліття посилився негативний вплив людини на навколишнє середовище і, зокрема, на зелені насадження.

Дендрофлора парку характеризується бідним видовим складом, на території якого зростає 251 екземпляр
деревних рослин, які відносяться до 17 видів, 15 родів, 11 родин. Домінуючими видами є Граб звичайний *(Carpinus betulus),* Липа серцелиста (*Tilia cordata*) та Береза повисла (*Betula pendula)*. Найчисельнішими є родини Березові *(Betulaceae)* − 103 екземпляри, Липові *(Tiliaceae)* – 50 екземплярів, Сапіндові *(Sapindaceae)* – 31 екземпляр, Вербові *(Salicaceae)* – 25 екземпляр.

У парку найбільш поширеними є листопадні дерева, що складають 92,8% від загальної кількості всіх дерев. 7,2% припадає на вічнозелених рослин, серед яких переважаючим представником є Ялина звичайна – 5,2%.

Зелені насадження відіграють важливу роль у системі зовнішнього благоустрою міст, вони створюють
як високохудожні архітектурно-ландшафтні комплекси, які відіграють важливу естетичну функцію. Крім цього вони також зменшують наявність пилу й диму в повітрі міста, відіграючи роль своєрідного фільтру, впливають на формування комфортного мікроклімату.

Більшість дерев за фітосанітарним ознаками характеризуються добрим та задовільним станом. Близько 20 дерев є сухостоєм минулих років, які потребують вирубки і їх заміни.

Оцінка відносного загального деревостану, вказує на те, що життєвий стан парку – ослаблений.

На основі проведеного аналізу стану деревних насаджень парку відпочинку на вул. Трускавецькій м Дрогобич нами розроблено такі рекомендації:

− урізноманітнити видовий склад деревних рослин, особливо представників голонасінних;

− провести омолодження старих і відмираючих насаджень;

− дотримуватись правил та прийомів догляду дерев.

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CRYO-LASEROTHERAPY AT THE HEALTH RESORT STAGE OF REHABILITATION OF PATIENTS WITH GONARTHROSIS

Abstract. The article presents data about the use of air cryotherapy in the combination with laser therapy for degenerative-dystrophic lesions of the knee joints. The combination of cryo and laser therapy shows that they have a higher effect on the clinical course of the disease than with their isolated use. Such a combination increases the effectiveness of patients' rehabilitation with gonarthrosis. The dynamics of the total evaluation of the pathological process activity in the Leken's algoprofunctional index revealed a decrease in the number of points in the main group from 8.6 to 5.3, and in control groups from 8.3 to 6.2 and from 8.5 to 7.1. The comparative analysis of the effectiveness of combined cryo and laser therapy in the complex health resort rehabilitation of patients with deforming osteoarthrosis of knee joints in the main group was 91%, and in the first and second control groups was 79% and 68%.

Keywords: cryo therapy, laser therapy, gonarthrosis, health resort rehabilitation, arthralgia.

INTRODUCTION

Degenerative-dystrophic lesions of the knee joints are one of the most common musculoskeletal system diseases, which leads not only to the decline of the life quality and sometimes leads to disability of working age patients [1, 4, 8, 9]. A significant place among musculoskeletal system diseases of degenerative-dystrophic type takes the knee joints and according to the Ministry of Health of Ukraine their pathology leads to disability except the decline of the life quality in 15-31% of working-age patients [4]. All this testifies not only to the medical but also to the socio-economic importance of the problem of treatment and rehabilitation of patients with osteoarthrosis of knee joints. Despite the positive results of medical therapy, and taking into account the complexity of the mechanism of disease development, there is the further search of methods and means, in particular, physical therapeutic factors with a diverse influence on the pathological process in the articular apparatus which will increase the efficiency of the patients rehabilitation with this pathology [3–7, 10]. In recent years, attention has been paid to the use of cryotherapy with this pathology [3, 21, 22]. However, at present there is not enough data on the combination of cryotherapy with other physical therapeutic factors [7, 14, 16, 20], which became the subject of the choice of the topic of this study.

The aim of this work was to evaluate the effectiveness of the combined method of cryo and laser therapy in patients rehabilitation with arthrosis of knee joints in the background of the use of treatment factors at the Skhidnytsya resort. The combined method of cryo and laser therapy unlike the isolated use of cryo and laser therapy increases the effectiveness of patients rehabilitation with dystrophic lesion of the knee joints and prevents the progression of the patients' disease with degenerative lesion of the knee joints.

METHODS AND RESULTS OF THE RESEARCH

Under our supervision in the conditions of the Medical and Rehabilitation Center "Prykarpattya" PJSC "Atomprofozdorovnytsia"of Skhidnytsia resort there were 19 patients

with gastroenterological and urological profile (11 women and 8 men) aged from 48 to 63 with an accompanying diagnosis of knee joints osteoarthrosis of stage II with functional deficiency of joints (FDJ) degree I, which was established according to X-ray and ultrasound examination at the place of permanent residence. Duration of osteoarthrosis was 8.6 ± 1, 5 years. From the total number of examined patients 5 patients (4 women and 1 man) according to the history of their disease had a lesion of two knee joints, which was taken into account by us when we drew a plan for the appointment of cryo and laser therapy.

Clinical examinations included: complaints of patients, data of an objective examination of the articular system by palpation of the knee joints, determination of the joints size and their motor functions. The assessment of changes in the severity of the patients articular apparatus in the process of rehabilitation was carried out on the merit point system using the Leken's algofunctional index in the dynamics at the beginning of rehabilitation, after the first physiotherapeutic procedures and at the completion of the treatment course (Table 1.) [2].

The size of the joints was determined by measuring their circumference with a centimeter tape at the level of the articular cavity with an accuracy to 0.5 cm, and the motor function of the joints was determined by the using of the universal medical goniometer UMG-3, the movement in the joints was determined in the sagital plane during active bending and stretching of joints at the level of the articular cavity in the patient's position lying on the abdomen with the location of the lower jaw of the goniometer, laterally and in parallel to the axis of the leg, with an accuracy from 0.5 to 1.0 °.

Table 1. Total Leken's Index (height index for gonarthrosis)

1. Pain or discomfort	**Points**
Pain at night:	
– absent	**0**
– only when moving and in certain positions	**1**
– even without movement	**2**
Morning woodiness or pain after getting up	
– Absent or less than 1 minute	**0**
– less 15 minutes	**1**
– 15 minutes or more	**2**
Strengthen the pain after standing on the legs for 30 minutes	
– absent	**0**
– present	**1**
Pain when walking	
– doesn’t occur	**0**
– occures only after passing a certain distance	**1**
– occures from the beginning and then increases	**2**
Pain or discomfort when standing up without the help of hands from sitting position:	
– absent	**0**
– present	**1**
2. Maximum distance during walking without pain:	
– no limitation	**0**
– more than 1 km, but there is a difficulty	**1**

– about 1 km	**2**
– from 500 to 900 m	**3**
– from 300 to 500 m	**4**
– from 100 to 300 m	**5**
– less than 100 m	**6**
– with one walking stick or crutch	**+1**
– with two walking sticks or crutches	**+2**
3. Functional activity (by gradation of responses)	
Can you go up one step on the stairs?	**0-2**
Can you go down one step on the stairs?	**0-2**
Can you tidy the lower cabinet shelf, kneeling?	**0-2**
Can you walk on a rough road?	**0-2**
Do you feel stinging pain or the sudden feeling of losing crutch in the lesioned limb?	**0-2**
– sometimes	**1**
– often	**2**
The severity of gonarthrosis: 1 - 4 points - weak, 5-7 points - average, 8 - 10 points - expressive, more than 10 points - sharply expressed.	

Assessment of locomotoric function of patients was determined by passing the 30-meter distance on a flat area and ascending and descending stairs (10 steps).

Cryotherapy procedures were carried out by using the physiotherapeutic mechanism Criotur-600 (Germany), which works on contact (conductive) transfer of cold to a specific area of the body and creates a cold load with the help of thermoelectric Peltier elements provided by the therapeutic head and cuff that are added to the device.

The beginning of each cryotherapy procedure was carried out by using a thermal head, which cooled down to a certain selected temperature in the range from 1.0 ° C to -10 ° C, which was displayed on the screen of the device, taking into account the individual sensitivity of the patient to cold load in the joint area. After finding out the individual sensitivity of the patient to the cooling, the thermal head changed to a thermal cuff with the help of which the procedures were carried out in the patient's lying position, at a given temperature. At the temperature of the thermal cuff, the duration of the procedure was to -5ºC from 5 to10 minutes, and to-10ºC from 3 to 5 minutes. The course of treatment is carried out every other day, it requires 8 procedures.

The procedures of laser therapy were performed using serial device Medyk-2K of the firm NMC "Medintekh", which generates laser radiation of the red and infrared wavelengths of 0.78-0.85 mKm. We used a distant labile technique with a ray of radiation on a projection section of the articular cavity biliary within 1-3 minutes.

The statistical processing of the obtained research results was carried out using Microsoft Windows Excel and Statistics. The level of reliability was set at P = 0.05, which was determined by the Student's t-test.

The complex sanatorium-resort rehabilitation for the term of 21 days included medical nutrition, drinking regime of mineral waters according to the nosological forms of the main disease, the use of therapeutic physical culture in the form of morning hygienic gymnastics (RGG), medical gymnastics (LH) by group method, observing all pedagogical principles during classes (starting positions, movements amplitude, number of repetitions, etc.). The duration of the lesson is 20-30 minutes of the therapeutic walking (TW), which included

walking from the sanatorium to the pump room of mineral waters 2-3 times a day, therapeutic massage (segmental reflex or general), mineral baths with a concentration of sodium chloride (NaCl) up to 15 g / l with a 37 ° C temperature, and with an exposure to 10 minutes for the course of treatment from 10 to 12 baths and ozocerite applications on the lumbar area or the right hypochondriac, depending on the nosological form of the main disease and on knee joints at a temperature from 42 to 45ºC with an exposure from 30 to 40 minutes. The course of treatment requires from 8 to 10 procedures.

RESULTS OF THE RESEARCH AND ITS DISCUSSION

In the primary anamnestic and objective examination, 17 patients (89.3%) complained about joints pain of varying intensity and duration when walking on a flat area and also about ascending and descending stairs, except the joints pain 10 patients (57%) complained about the severity of knee joints during prolonged stay in a standing position also except the joint pain, 7 patients (37%) complained about slight joints stiffness in the morning, after night sleep, and 5 patients (24%) complained about the crapitation in the knee joints.

In order to assess the effectiveness of cryo- and laser therapy for pain syndrome and locomotoric function with gonarthrosis, the patients were divided into three groups: the main group (9 patients) and two control groups (5 patients in each group). Patients in the main group passed a combination of cryo and laser therapy procedures every other day for a course of treatment for 8 procedures every other day. Patients of the 1st control group passed the procedure of cryotherapy, patients of the 2nd control group received procedures for laser therapy for the course of treatment for 8 procedures per day. During physiotherapeutic procedures patients showed no negative reactions and its poor tolerability.

As a result of the rehabilitation, its positive dynamics was noted in all groups of examined patients, however, in the main group, the reduction of pain syndrome during physical activity was noted on 5 ± 2 day from the beginning of rehabilitation; in the 1st control group on 8 ± 3 day and in the 2nd control group on 16±2, respectively. 2 patients in the main group had complete disappearance of pain in the knee joints, with physical activity on the 3rd day after begining of rehabilitation. We associate a more pronounced analgesic effect of reducing arthralgia and reducing the duration of pain in the main group with a combined analgesic effect of cryo- and laser therapy, and in the 1st control group we associate it with the isolated effect of cryotherapy. Except the positive dynamics of the pain syndrome, also there were improved the indexes of the articular apparatus' functional state in the examined patients of all groups (Table 2.), however, the improvement of the articular apparatus' functional state in the main group was observed on the 16 ± 3rd day from the beginning of rehabilitation, and in the 1 st and in the 2nd control groups the improvement was observed on the 18 ± 3rd day. It should be emphasized that the improvement of joint functions was assosiated not only with the analgesic and anti-inflammatory effects of cryotherapy and laser therapy, but also with their beneficial effect on the muscles that are anatomically and functionally associated with the lesioned joint.

During the study of the movement amplitude in the joints at the end of rehabilitation there was observed its significant increase in the main group that was +6.5° in comparison with the 1st and 2nd control groups +3.2°, +1.9° in our opinion which was related with more pronounced elimination of soft tissue edema in the joint area as a result of improved tissue metabolism in the joints, which was revealed by a decrease in their size in the process of patients rehabilitation in the main group 3.9 ± 0.04 cm, in comparison with the 1st and 2nd control groups, respectively, 2,6 ± 0,23 and 2,1 ± 0,3 cm.

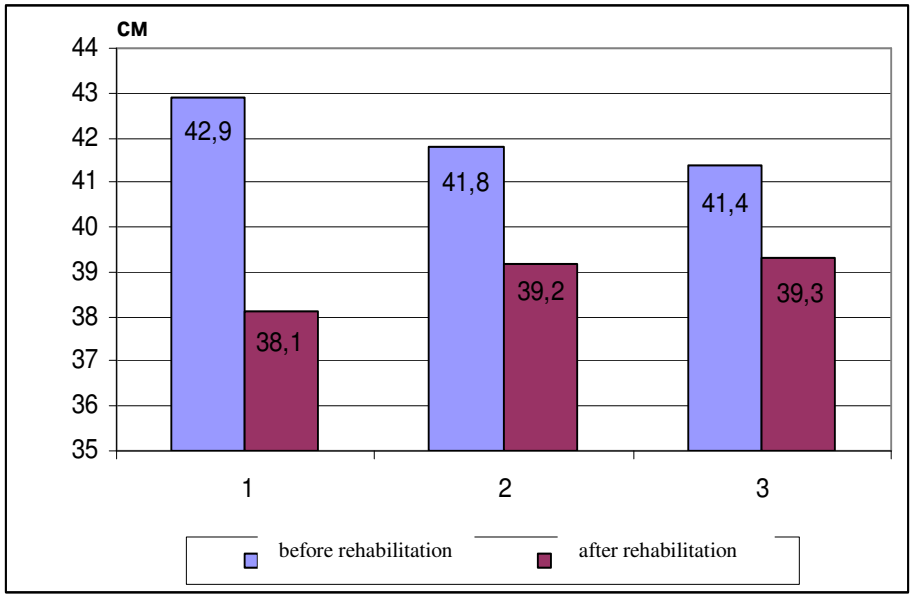
Table 2. Dynamics of clinical indicators of patients in the process of rehabilitation

Indicators	Groups of patients		
	Main group n = 9	The first control group n = 5	Second control group n = 5
Leken's algofunctional index (points)	8.6 ± 1.3 5.3 ± 0.07	8.3 ± 1.01 6.2 ± 0.09	8.5 ± 0.09 7.1 ± 0.06
Knee joint volume (cm)	42.9 ± 0.63 38.1 ± 0.59	41.8 ± 0.65 39.2 ± 0.22	41.4 ± 0.61 39.3 ± 0.31
The amplitude of knee movements joint (degrees)	133.0 ± 3.2 139.5 ± 2.6	132.9 ± 3.1 135.1 ± 2.9	131.3 ± 2.1 133.2 ± 3.0
Time to go up stairs (10 steps) (sec)	18.3 ± 0.96 11.0 ± 0.38	18.31 ± 0.4 13.1 ± 0.8	18.2 ± 0.71 13.4 ± 0.9
Time to go down stairs (10 steps) (sec)	12.15 ± 0.32 8.62 ± 0.36	12.5 ± 0.18 10.0 ± 0.15	12.3 ± 0.17 10.1 ± 0.07
Time to pass 30-meter distance (sec)	32.2 ± 0.6 26.3 ± 0.5	32.1 ± 0.4 27.4 ± 0.5	32.3 ± 0.3 28.1 ± 0.5

Note: in the numerator there are indicators at the beginning of rehabilitation,
in the denominator there are indicators after rehabilitation
(P) is the index of change before and after rehabilitation - P <0.05 - 0. 001

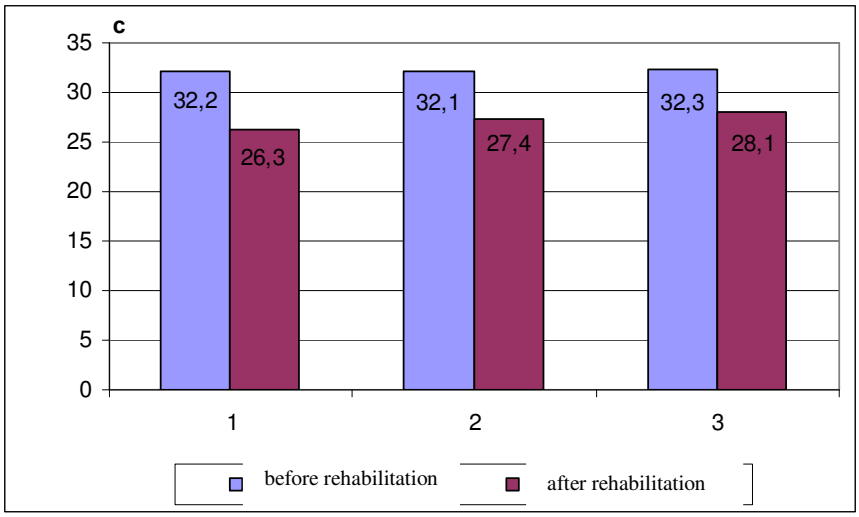
In parallel with the improvement of the movements amplitude the use of physiotherapeutic factors had a positive effect on locomotor indexes of the articular and muscle apparatus of patients in the form of reduced time to overcome the 30-meter distance, as well as going up and down stairs.

Dynamics of changes in the knee joints size is shown in Picture 1.



Picture. 1 Dynamics of changes in the knee joints size (cm)
1 – the main group, 2 – the first control group, 3 – the second control group

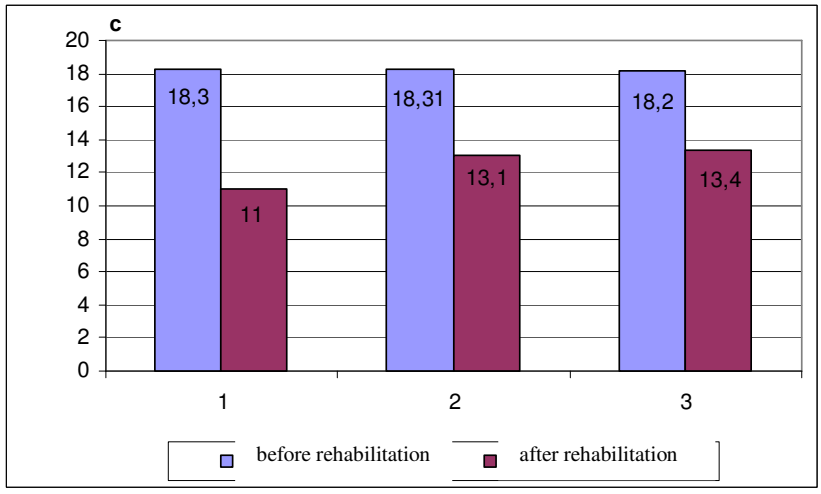
Dynamics of changes in the passage time of the 30-meter distance is shown in Picture 2.



Picture 2. Changes in the passage time of a 30-meter distance (sec)
1 – the main group, 2 – the first control group, 3 – the second control group

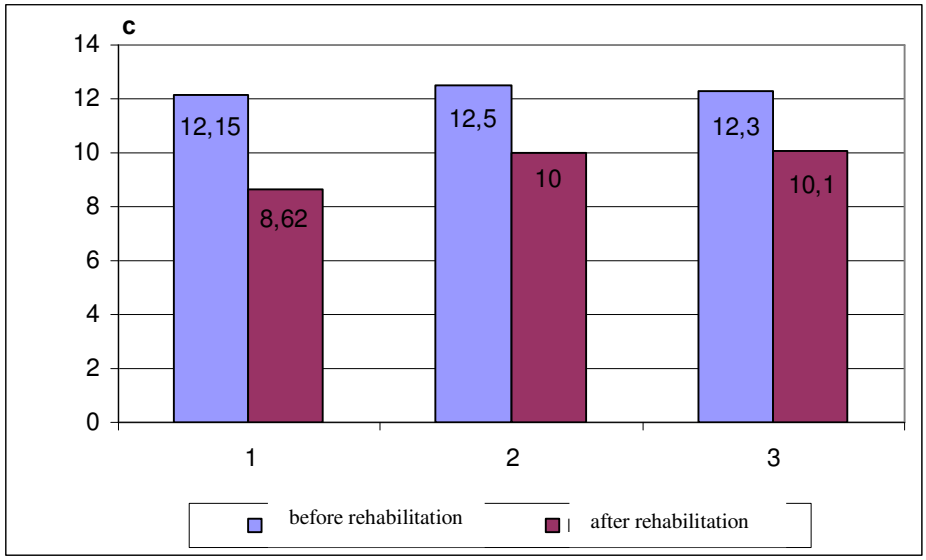
However, the passage time of the 30-meter distance of patients in the main group decreased on 5.9 ± 0.1 seconds. The passage time of the 30-meter distance of patients in the 1st control group decreased on 4.7 ± 0.1 seconds, and in the 2nd control group decreased on 4.2 ± 0.2 seconds.

Changes in time when going up stairs are shown in Picture 3 - 4.



Picture 3. Changes in time when going up stairs (sec)
1 – the main group, 2 – the first control group, 3 – the second control group

The time to go down stairs in the main group decreased on 3.53 ± 0.04 sec, in the 1st group decreased on 2.5 ± 0.03 sec and in the 2nd group decreased on 2.2 ± 0.1 sec.



Picture 4. Changes in time when going down stairs (sec)
1 – the main group, 2 – the first control group, 3 – the second control group

Accordingly, our study with the use of cryo and laser therapy combination shows that they have a higher effect on the clinical course of the disease than in their isolated use, which is related to the complex and balanced therapeutic effect on the pathogenetic mechanisms of the disease and thus increase the effectiveness of patients rehabilitation with this pathology.

The dynamics of the total evaluation of the activity of the pathological process in the Leken's algoprofunctional index revealed a decrease in the number of points in the main group from 8.6 to 5.3, and in control groups from 8.3 to 6.2 and from 8.5 to 7.1.

The comparative analysis of the effectiveness of combined cryo and laser therapy in the complex health resort rehabilitation of patients with deforming osteoarthrosis of knee joints in the main group was 91%, and in the 1st and 2nd control groups was 79% and 68%.

CONCLUSIONS

1. The results of our study show that the treatment of cryo and laser therapy complex in the patients main group significantly affects on the reduction of the pain syndrome duration on the 8 ± 2nd day from the beginning of rehabilitation in comparison with the 1st and 2nd control groups on 16 ± 2 day, and also affects on the increase of joints amplitude in the patients main group on 6,5° at the end of rehabilitation in comparison with the patients 1st and 2nd control groups on 3.2 and 1.9 °, and on the increase of locomotor activity of the articular apparatus as pointed walking speed on flat area, as well as going up and down stairs

2. Positive results of the influence of combined cryo and laser therapy on functional parameters of the articular apparatus and patients good tolerability of this complex allow to include it to the complex of health resort rehabilitation at deforming arthrosis of knee joints.

REFERENCES

1. Бабов К. Д., Пеклина Г. П., Леонова Н. Н. 2001. Проблемы восстановительного лечения больных с дегенеративно-дистрофическими заболеваниями опорно-двигательного апарата на современном этапе. Мед.реабилтац.в курортол.и физиотерапия. № 1. С. 43 – 47.
2. Белова Н. А., Щепетова О. Н. 2002. Шкалы, тесты и опросники в медицинской реабилитации. Руководство для врачей и научных работников. Москва. Антидор. 439 с.
3. Бур'янов О. А., Соболевський Ю. Л. 2007. Сучасні підходи до патогенезу, класифікації та лікування ранніх стадій остеоартрозу колінного суглобу. Науковий вісник Ужгородського національного університету. Серія «Медицина». Вип. 32. Ужгород: Поліграфцентр «Ліра». С. 23 – 26.
4. Герцен Г. І., Остапчук Н. П., Буштрук А. Н. 2003. Деформуючий артроз колінних суглобів. Укр.мед.часопис. IX–X. № 5. С. 55 – 60.
5. Григорьева В. Д., Федорова Н. Е. 1998. Новые аспекты применения криотерапии, ультразвука, магнитотерапии и лечебной гимнастики в реабилитации больных гоноартрозом. Вопр. курортол. № 2. С. 26 – 28.
6. Дашина Т. А. 2001. Применение крио- и крио-СМТ терапии у больных гонартрозом. Вопр. курортол. № 4. С. 21 – 24.
7. Дубровина О. С., Золотов К. Б. 2006. Применение лазеромагнитотерапии при деформирующих артрозах коленных суставов. Тезисы докладов VI Всероссийского Съезда физиотерапевтов. СПб. С. 199.
8. Комарова Л. А., Радченко Г. В. 2000. Лазерная терапия больных деформирующим остеоартрозом коленнях и тазобедренных суставов. Вокр.курортол. № 6. С. 45 – 46.
9. Миронов С. П., Омельченко М. П., Орлецкий В. К., Марков Ю. А., Карпов И. Н. 2001. Остеоартроз: современное состояние проблемы (аналитический обзор). Вестник травматол., и ортопедии им. Н. И. Пирогова. № 2. С. 96 – 99.
10. Нейко Е. Н., Головач И. Ю. 2000. Сучасні уявлення про патогенез деформуючого остеоартрозу. Укр. ревматол. Журнал. № 1. С. 9 – 12.
11. Поливода Л. Н., Вишневский В. А. 2003. Современные подходы к комплексному использованию физических факторов и других лечебных средств в восстановительном лечении больных остеоартрозом. Мед. реабил. курортол. Физиотер. № 4. С. 35 – 38.
12. Синяченко О. В. 1998. Исследование суставов. Донецк: Донеччина, 1998. 208 с.
13. Ушаков А. А. 1996. Руководство по практической физиотерапии. Москва АНМИ. 271 с.
14. Частная физиотерапия. 2005. Под ред. Г. Н. Пономаренко. М.: ОАО «Издательство Медицина». 742 с.
15. Callies R., Shretber U., Schmolenski U., Steinberg R. 1992. Dosisparametren einer localen Kaltluftapplication. Phis Rehab. Kur. Med. S. 190 – 193.
16. Caramer P., Hohberg Vc. 1997. Osteoarthritis. Lancet. V. 35. № 5. P. 503 – 508.
17. Hag J., Murphy E., Dacre J. 2003. Osteoarthritis. Postrag. Med. J. V.79. P. 377. S. 283.
18. Howell D. S. Pathogenesis of osteoarthritis. American J. Med. 1998. V. 80. P. 24 – 30.
19. Kraus V. B. 1997. Pathogenesis and treatment of osteoarthritis. Med. Clin. North. Am. V. 81, № 1. P. 85 – 112.
20. Maheu E. 2000. Загальні принципи лікування артрозів. Мед. світу. Том VIII. число 1. С. 17, число 2. С. 68 – 73.
21. Shesterton L.S., Foster N. E., Ross L. 2002. Skin temperature reponse to cryotherapy. Archives of physical medicine and repabilitation. 83: P. 543 – 548.

22. Raulin C., Greve B., Hammes S. 2000. Cold air in laser therapy: first experiences with a new cooling system; Laser Surg Med. 27 (V.5): P. 404 – 410.

ABSTRACT

КРІО-ЛАЗЕРОТЕРАПІЯ НА САНАТОРНО-КУРОРТНОМУ ЕТАПІ РЕАБІЛІТАЦІЇ ХВОРИХ ГОНОАРТРОЗОМ

Дегенеративно-дистрофічні ураження колінних суглобів складають одну із найбільш розповсюджених захворювань опорно-рухового апарату, що призводить не тільки до погіршення якості життя хворих, а і до виникнення інвалідності, що вимагає впровадження ефективних методів відновного лікування даного захворювання.

Застосування поєднання кріо- та лазеротерапії значно підвищує ефективність реабілітації пацієнтів з артрозом колінних суглобів, спричинює більш виразні сприятливі зміни у стані суглобового апарата на відміну їх ізольованого використання і обґрунтовує застосування цього комплексу у реабілітації хворих з даною патологією.

Універсальним механізмом патогенезу захворювання є порушення рівноваги між механізмами синтезу і дегенерації хондроцитів суглобового хряща у бік зменшення їх синтезу. Внаслідок цього змінюються механічні властивості хряща, які залежать від нормального співвідношення в його тканині колагену, протеогліканів і води, тому що суглобовий хрящ не має власної судинної стінки, а його живлення здійснюється осмотичним шляхом з кістки і синовіальною рідиною. Ключова роль у нормальному співвідношенні компонентів, які забезпечують нормальний стан суглобового хряща належить хондроцитам і при порушенні їх синтезу гіаліновий хрящ втрачає свою амортизаційну властивість.

Одним із важливих напрямків у сучасних методах реабілітації є пошук і впровадження в практику новітніх технологій зокрема у фізіотерапії, спрямованих на підвищення ефективності відновного лікування хворих та інвалідів і профілактику захворювань. На даний час у використанні фізіотерапевтичних чинників все більшого значення набуває кріотерапія – сукупність фізичних методів лікування, реабілітації та профілактики різних нозологічних форм захворювань, заснованих на використанні холодового фактора, який створюється різними за природою і формою кріоагентами, що забезпечують відведення тепла від тканин, органів або всього тіла людини.

В результаті проведеної поєднаної реабілітації її позитивна динаміка була відмічена у всіх досліджуваних групах, проте в основній групі зменшення больового синдрому при фізичному навантаженні відмічалось на 5±2-й день від початку реабілітації; у 1-й контрольній група на 8±3-й день, а у 2-й контрольній групі на 16±2-й день відповідно. У 2-х хворих основної групи було відмічено повне зникнення болі у колінних суглобах, при фізичних навантаженнях – на 3-й день після початку реабілітації. Більш виражений знеболюючий ефект у вигляді зменшення артралгії та скорочення термінів больового синдрому в основній групі ми пов'язуємо з поєднаним аналгетичним впливом кріо-лазеротерапії, а в 1-й контрольній групі – ізольованим впливом кріотерапії. Крім позитивної динаміки больового синдрому покращились показники функціонального стану суглобового апарата у досліджуваних хворих, проте покращення функціонального стану суглобового апарата в основній групі спостерігалося на 16±3-й день від початку реабілітації, в 1-й контрольній групі та в 2-й контрольній групі – на 18±3-й день. При дослідженні амплітуди рухової активності суглобів наприкінці реабілітації суттєве їх підвищення спостерігалось в основній групі і складала + 6,5º у порівнянні з 1-ю та 2-ю контрольними групами +3,2º, +1,9º відповідно, що було пов'язано з більш вираженим усуненням набряку м'яких тканин в ділянці суглоба, покращенням метаболізму у

суглобах, що проявилось зменшенням їх об'єму у хворих основної групи на 3,9±0,04 см, у порівнянні з 1-ю та 2-ю контрольною крупами відповідно 2,6 ±0,23 і 2, 1±0,3 см.

Застосування поєднання кріо- та лазеротерапії значно підвищує ефективність реабілітації пацієнтів з артрозом колінних суглобів, спричинює більш виразні сприятливі зміни у стані суглобового апарата на відміну їх ізольованого використання і обґрунтовує застосування цього комплексу у реабілітації хворих з даною патологією.

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DIOXINS - MODERN PRIORITY ORGANIC ENVIRONMENTAL POLLUTANTS

One of the important problems encountered at the present stage of human society development is the problem of improving ecological and analytical monitoring and providing real data on DLC in the objects of the natural environment of Ukraine in accordance with the requirements of the Stockholm Convention on Persistent Organic Pollutants for Effective Health Protection of People and the environment from the harmful effects of ecotoxicants of the 21st century - dioxins. Modern scientific notions about dioxins as persistent organic environmental pollutants are generalized and systematized; the main types of dioxins, sources of their occurrence and inflow into natural objects, methods of detecting dioxins are characterized; the effect of dioxins on living organisms is shown. The highest toxicity in relation to the most sensitive species - guinea pigs - detects 2,3,7,8-TCDD, and the smallest - 2,3,7,8-tetrahloronapthalene, and, reducing or increasing the number of halogen atoms in PCDD molecules dramatically reduces their toxic properties.

Keywords: environmental quality, persistent organic environmental pollutants, dioxins, dioxin background.

INTRODUCTION

Current issues of the present day are the problem of preserving the environment, the which quality defines the life and health of people. In the process of economic activity, more than 120 thousand chemicals are used, 70% of which have uncertain toxicity. According to the scientific research results, the organism of modern man contains more than 500 chemical compounds - potential poisons unknown at the beginning of the twentieth century [10].

A large number of alien compounds for humans and animals - xenobiotics - mostly of organic origin, is involved in circulation and circulates in the biosphere.

Priority organic pollutants include poisonous substances of instantaneous action (synthetic poisons, rocket fuel components) and prolonged action (polycyclic aromatic hydrocarbons, phthalates, persistent organic pollutants), which present the greatest danger both today and in the future. Persistent organic environmental pollutants include dioxins [11].

Dioxins are modern superecotoxicants, which belong to the substances of the (highest) class of toxicity. They are not biotransformed in the body, nature does not have enzymes that would expose them, because by 1930 they did not exist in nature at all. Dioxins are not found in the tissues of Egyptian or Indian mummies, but now they are found everywhere, including Antarctic ice. They are in all food without exception, especially many of them are in dairy and meat products. In this regard, the concept of "dioxin background" was introduced, which came close to the maximum permissible level in some countries at which chronic poisoning begins. Monitoring of dioxin contamination requires high financial costs (the cost of one study reaches 2 to 3 thousand USD). There are only 40 laboratories conducting such studies in the world [16].

Given the long-term and severe effects of dioxin contamination, periods of intensive farming using DDT, herbicides, insecticides, and backward industrial technologies, we can assume that the dioxin problem is extremely relevant for our country.

The aim of the work is to synthesize and systematize modern scientific ideas about dioxin-like compounds in the structure of persistent organic environmental pollutants; analysis of the dioxins characteristics, their types, chemical composition and properties, the main sources of

dioxin entering the environment and methods for their detection; studying the pathways of dioxins to living organisms and their effects on living organisms.

STABLE ORGANIC ENVIRONMENTAL POLLUTANTS AND DIOXINS IN THEIR STRUCTURE

Highly polluted organochlorinated organic compounds belonging to persistent organic pollutants (POPs) are a major problem for human health and the environment. These substances belong to different classes of chemical compounds, but, despite numerous differences and different degrees of danger, there are four common properties for the POPs [16]:

1) high toxicity, even in small quantities, and even greater toxicity of the products resulting from their decomposition;

2) decomposition stability (they are hard to break down and remain unchanged in the environment for many years after use);

3) the ability to concentrate in the fatty tissues of humans and animals representing the upper levels in the food chain;

4) the ability to overcome significant distances by air, waterways and migration of birds, animals and fish.

Consequences of POPs negative effects on animals are documented: congenital defects, risk of cancer, immune and reproductive systems impairment. For example, the effect of POPs is associated with a sharp decline in the population of seals, guinea pigs, dolphins, etc.

Scientists point at strong evidence of the health risks related to POPs. The harmful effects are similar to those found in animals: cancer, developmental defects, fertility problems, immunity decline, and decreased mental abilities in some cases. Studies in Sweden, Canada, the United States, Mexico, and other countries in the world have found that the use of foods with very low levels of POPs causes imbalances in the immune system in adults, and children have serious problems with coordination of movements and mental activity [17].

Of course, there is a need for further study of the negative effects of POPs on human health and the environment, but the threat of POPs for the planet is so significant that its disappointing perspectives require urgent action by humankind. The risks are too high to delay. Measures to eliminate the effects of POPs should be immediate and adequate.

In 1994, meetings of the United States, Canada, Japan and a number of European countries representatives repeatedly raised the issue of the inadmissibility for the further spread of POPs. To this end, a list of twelve substances has been compiled, for which there is a need to take immediate measures. The list, immediately dubbed "dirty dozen", consists of three groups of POPs constituting a significant threat for the human health and the environment [16, 18].

The first group of POPs is highly toxic chlorinated pesticides (dichlorodiphenyl trichlorethane (DDT), dildrin, aldrin, heptachlor, mirex, toxaphene, endrin, chlorodan, hexachlorobenzene (HCB)).

The second group of POPs is industrial products (polychlorinated biphenyls – PCBs).

The third group of POPs is represented by so-called dioxins – a group of compounds formed as by-products in some industries. Dioxins are found in a small amount in any production where chlorine is used, especially at high temperature processes.

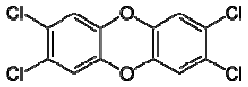
In Ukraine, the extent of environmental pollution for the POPs (including DLC) was not been reliably evaluated for a long time due to the lack of material and technical basis necessary for scientific research on the dioxins determination in all living objects and inanimate nature. The first preliminary determination of dioxin emissions was carried out by experts from the Task Force on Emission Factors Assessment of the GEF/UNEP Project "Providing Measures for the Development of a National Plan for the Implementation of the Stockholm Convention on Persistent Organic Pollutants in Ukraine" (2003-2006) [16]. They show that ferrous and non-ferrous metallurgy and electricity and heat production in Ukraine – these categories of sources

make the main contribution to the total emissions of PCDD/PCDF (95%). Up to 99% of emissions are released into the air and waste.

On May 23, 2001 Ukraine signed the Stockholm Convention on POPs, and its ratification process took place in the summer of 2007. Our country has become a Party to the Stockholm Convention on POPs, which, on the one hand, grants it particular rights and, at the same time, particular obligations related to the entire complex of tasks for the destruction of the twelve POPs provided by the Convention [14].

Concepts about dioxins and their main types

In ecology, dioxins are often treated as polychlorinated tricyclic aromatic compounds containing oxygen atoms:



1,4- dioxin

This is an unstable and easily polymerized compound [8].

A large group of chlorinated hydrocarbons, which are called dioxins, contains 75 proper dioxins (polychlorinated dibenzodioxins, PCDDs), 135 different furans (polychlorinated dibenzofurans, PCDF) and 209 polychlorinated biphenyls (PCBs). Only 7 dioxins, 10 furans and 12 PCBs are extremely toxic to all living objects – from bacteria to mammals. These 29 compounds have similar biological activity, which is due to a common mechanism of action. Representatives of the three above-mentioned classes are more correctly called dioxin-like compounds - DLC. However, in practice, the term "dioxins" is most frequently used [5, 6, 7].

Among the most studied chemical, physical and toxic properties of dioxin-like compounds (DLC), polychlorinated dibenzo-para dioxins (PDBs) and polychlorinated dibenzofurans (PCDFs), commonly referred to as dioxins. Polibrominated and polyfluorated dibenzodioxins and dibenzofurans, as well as compounds of a similar structure, which contain chlorine, bromine and fluorus atoms at the same time [11], are studied to a lesser degree.

It was established that during the last decades, the objects of scientific research were polyhalogenated xanthians, xanthones and biphenylenes. The latter can be oxidized to traditional xenobiotics of PCDD and PCDF.

Although all DLC are dangerous, there are compounds with different levels of toxicity among them. Among them 2,3,7,8-tetrachlorodibenzo-n-dioxin (TCDD) - the most toxic and most studied. Therefore, its toxicity is taken as "1", and each DLC has its toxicity factor relative to TCDD. TCDD toxicity is such that its maximum allowable concentration is negligible: 10-12 g per kilogram of substance or liter of fluid! [16].

DLC have a high melting point, non-volatile, poorly soluble in water and, better, in organic solvents. These compounds are characterized by high thermal stability, their decomposition begins at a temperature of 750-1000 °C. They do not react with acids and alkalis, even when boiling. In the characteristic aromatic compounds, the reaction of DLC come only under harsh conditions in the presence of catalysts [8].

Using the example of TCDD (2,3,7,8-tetrachlorodibenzo-n-dioxin), we will consider more detailed physical and chemical properties of such substances. TCDD is a colorless crystalline substance with a high melting point (305 °C) and very low volatility. It is almost insoluble in water, but is better soluble in organic solvents. Thermally stable (decomposes at 700-750 °C). It is chemically inert, not decomposed by acids or alkalis. Being a hydrophobic substance and capable of donor-acceptor interactions, it forms complex compounds with substances of different structure. Dioxin easily forms a radical cation.

Getting into the body, dioxin almost does not enter into metabolic processes, slowly decomposes and very slowly eliminated from it. The biological activity of dioxins is usually

expressed by the concentration of the substrate, which causes a 50% increase in the activity of cytochrome P-448 from the maximum possible.

Dioxin affects the genetic apparatus, and has a mutagenic effect. Toxicity of dioxin changes as follows: the most potent properties are manifested when the substituent plays the role of a chlorine atom: dibezono-n-dioxin ➢ dibenzofuran ➢ the biphenyl ➢ naphthalene.

The dioxin molecule is flat and differs in high symmetry. The distribution of the electronic density in it is such that the maximum is located in the zone of oxygen and chlorine atoms, and the least is in the centers of benzene rings. These features of the structure and the electronic state make it necessary to study the extreme properties of the dioxin molecule.

Dioxin is a chemically inert substance. Acids and alkalis do not decompose it, as it was already noted, even during boiling. In the characteristic aromatic compounds of the reaction, it interacts only under very harsh conditions and in the presence of catalysts. The replacement of chlorine atoms with other atoms or groups of atoms can occur only in terms of free radical reactions. Some of these transformations, for example, interaction with sodium-naphthalene and regenerative dechlorination with ultraviolet radiation, are used to destroy a small amount of dioxin. When oxidized in anhydrous conditions, dioxin releases one electron easily and turns into a stable cationic radical, which, however, is easily recovered in dioxin by water with the release of a very active cation-radical HO+. Characteristic to dioxin is its ability to form strong complexes with many natural and synthetic polycyclic compounds [11].

The solution of practical issues of organic dioxin xenobiotics analysis and toxicology is considerably complicated due to their structural diversity - the complexity of the isomeric and homologous structure. There are only 209 homogeneously substituted polychlorinated biphenyls (PCBs). The same compounds are a part of a number of polibromobiphenyls (PBBs), as well as to the series of homogeneously substituted halogenated azobenzenes and their azoanalogs. The number of homologues and isomers in a number of halogenated naphthalenes coincides with that in the actual dioxins [7].

Mainly tetra-, penta-, hepta- and octo-substituted dioxins, which include halogens atoms in the lateral positions of 2,3,7,8, are especially dangerous for man and nature. In a number of polyhalogenated dibenzo-n-dioxins and dibenzofurans, the number of homologues and isomers increases to 1018. Despite not all of these most dangerous substances actually get into the human environment, only their numbers indicate the scale of the difficulties arising in connection with the need to identify in the various living objects and inanimate nature the most dangerous tens and hundreds of dioxins among thousands of substances similar to them.

Additional difficulties can be attributed to the presence in the microvillas of existing technologies of functionally substituted dioxins containing the NO2, NH2, Alk, etc group instead of the halogen atom. In a few cases, it turned out to be extremely dangerous substances. However, there are also competitive antagonists of highly toxic dioxin among them, which reduce the effect of the latter. It can also lead to an increase in the amount of analytical work, its complication due to the background expansion and restrictions in the use of biological methods of analysis [16].

SOURCES OF DIOXINS

Dioxins are artificial compounds, although nobody has ever deliberately created these poisons. Their appearance in the environment is due to the development of various technologies, mainly in the postwar period, and is mainly associated with the production and use of organochlorine compounds and the disposal of their waste [13]. All DLC can safely be called "ecological dirt", which is formed:

- due to the combustion of chlorinated compounds;
- when producing pesticides, herbicides and defoliations as a by-product (admixture): the most significant levels of contamination with dioxins (mainly TCDD) are herbicides based

on 2,4-dihydrochloric acid and 2,4,5-trichlorophenoxyacetic acids (2,4-D and 2,4,5-T); fungicides, insecticides, antiseptics and disinfectants, a bactericidal preparation of hexachlorophen, synthesized from chlorodiphenyl ethers of herbicides, hexachlorobenzene, PCB;

• in electrolytic processes for the production of nickel and magnesium from their chlorides, casting of steel and copper, smelting of scrap iron, as well as during the production of aluminum. When obtaining steel in open-hearth furnaces, scrap metal is not separated from garbage, plastic and other organic matter, which leads to the formation of dioxins;

• during the production of cellulose in the bleaching process, which involves chlorination: dioxins are found in pulp, filtrate, sewage, solid waste, finished products;

• due to the burning of car oil and gasoline, in exhaust gases of cars, working on gasoline containing lead additives. The appearance of dioxins in this case is due to the fact that an increase in the octane number of gasoline is usually achieved by introducing toxic tetraethyl- and tetramethyl lead into them, simultaneously requiring an appropriate technological antidote. For this purpose, dichloro- and dibromethanes and other bromorganic compounds (soap-extractors) are added. Under those conditions arising in the process of fuel combustion, the latter, providing a solution to the direct problem, simultaneously prove to be the precursors for a whole range of very toxic substances, including dioxins;

• in the oil refining processes;

• in case of fire and breakage of electrical equipment, where PCB is used as a transformer fluid;

• when using chemical substances in military conflicts;

• in violation of the rules for the industrial waste disposal.

It has been established that polychlorinated dioxins are formed during the oxidation of organic compounds, even as a result of ordinary combustion (750-900 °C), provided that chlorine compounds are present.

Among the products used in everyday life, the paper belongs to one that is not a source, but only a carrier of dioxins [5, 6]. Dioxin at the MPC level is found in filtering (in particular, in filters for coffee and tea) and packaging paper, paper napkins, baby nappies, cosmetic fabrics, etc., especially high content of PCDD and PCDF is in recycled paper.

A powerful source of dioxin released to the atmosphere are incinerators (CWS). Therefore, the countries of the European Union adopted a "Strategy for waste management" in 1990, which the main principles can be expressed the following provisions:

• to use all possibilities to prevent the formation of waste;

• everything useful in waste should be reused;

• those that can not be used as secondary resources should either be buried or burned in strict compliance with environmental safety requirements in both the first and second cases.

It is important to take into account that waste from production and consumption is a secondary resource itself, a raw material for useful products, and burning is an anti-ecological approach to the problem, since it permanently removes these secondary resources from circulation [15].

The danger of waste incineration plants from the point of view of environmental pollution by DLC is due to their technological features. So, with the efficiency of PCB destruction at 99.999% (according to the requirements of the European Union), 0.001% of these compounds still gets into the air. And this means that 1 mg per burnt kg of PCB will enter the air environment. In addition, it has been established that dioxins are formed in the so-called cooling zone and in the filters in existing combustion technologies.

According to the experts of the Center for Independent Expertise:

1) incinerators is the main source of dioxin release in the environment;

2) there are no technologies and technical solutions for the burning of unsorted garbage today completely excluding the introduction of dioxins into the environment;

3) according to the norms adopted in the USSR, even when the dioxin problem "did not exist", the GCC at that time were classified in the 2nd category of the danger for industrial enterprises;

4) the design, construction and functioning of the GCC complying with the requirements of the European Union is economically unacceptable;

5) the destruction of unsorted waste by combustion, even in the most technologically advanced GCC, is anti-ecological by its very nature and is not consistent with the concept of sustainable development, according to which actions posing a threat to future generations are unlawful and should be excluded.

The problem of waste utilization is acutely facing both Ukraine and the whole world. But which way to solve it? Are there generally environmental friendly technologies for waste disposal and, in particular, organochlorine compounds? Humanity is looking for answers to these questions. It is important that decisions on the construction of new SRS be subject to the necessary environmental expertise for mandatory participation of the public [2, 12].

Ways of penetration and accumulation of dioxins in natural objects

Dioxins are the most dangerous for humans. After all, to defeat the human body a very small dose is required and dioxins deduced from the body very slowly.

Living organisms are exposed to dioxins through air (aerosols), water, food. High adhesion of DLC to soil particles, ash and bottom sediments causes their accumulation and migration in surface waters in the form of suspensions and complexes with organic substances. From the water phase dioxins, due to adhesion, are concentrated on particles of various suspensions and microorganisms. High concentrations of dioxins in the air are due to the effective sorption on aerosol particles [11].

In inanimate nature, dioxins evaporate from surfaces very slowly. At the same time, they gradually move into the organic phase of soil or water, migrating further in the form of complexes with organic substances (humic and fulvic acids), entering into air, reservoirs, are included in food chains. Getting into living organisms, dioxins are accumulate (bioconcentrated) and then modify biochemical processes [9].

Thus, with regard to the ways of penetration and accumulation of dioxins, there are three sources: food, air and by the use of chlorinated water.

In the air dwellings, dioxins come from burning wood, coal, fuel oil, and especially combustion of polyvinyl chloride and plastic (for example, in landfills) in the home furnaces. An additional source of indoor air pollution by dioxins is wood products pre-treated with polychlorinated biphenyls [7].

Dioxins can get into food, and with them and to the human body, in several ways:

- through soil (vegetables), because the soil is the main depot of dioxin in nature (dioxins are extremely stable in the soil and are stored mainly in the upper layers - at a depth of 2 to 5 cm. It almost does not migrate and does not enter the groundwater);
- with food (meat from animals contaminated with dioxin products).

Soil is the main depot of dioxins in nature [3, 5, 6]. Dioxins are extremely stable in the soil and stored, as it was noted above, mainly in the upper layers - at a depth of 2 to 5 cm. They practically do not migrate. However, it should be noted that their migration in the soil depends on concomitant pollutants and biomass affecting not only the penetration depth, but also the binding of the DLC to the soil components. From the soil, these compounds are absorbed by plants and soil organisms, and then with vegetables and fruits, as well as through other links of food chains - the organisms of birds and animals - get into the human body. Consequently, concentrated dairy products (butter, cheese), bovine meat, eggs and poultry meat may contain high concentrations of DLC.

In an organism of farm animals, dioxins get from contaminated water and fodder, saturated with pesticides and herbicides [4]. American scientists believe that a person can get with cattle meat up to 37 pg TE/day, with pork and chicken - 12-13, milk can "provide" 17, and

other milk products - 24 pg TE/day (pg - picogram, 10^{-12} g; TE - toxic equivalent - the standard unit adopted for the assessment of contamination by dioxin-like compounds; the toxicity of 2,3,7,8-TCDD is taken as a unit and each DLC has its toxicity factor relative to TCDD).

In countries with excellent culinary preferences, there are other ways to get DLC in the body. Especially heavily contaminated seafood, in particular fish. Scientists estimate that the inhabitants of Finland get 63% of PCDD and 42% of PCDF through fish products. As for the river fishes, the bottom line is a particular danger [4; 11].

Dioxins can also be found in products through the paper that they wrap with. As it was stated above, dioxins are also contained in paper as a result of processing. Therefore, when contacting the product in paper, the conditions for the receipt of dioxins to these products are created. Another example of exposure to dioxins into a human body is the use of paper with dioxin in the manufacture of nasal tissues, since nasal-mucous canals can very well filter out dioxin substances [8].

It was established that in each cigar smoked by a smoker contains 0.08-0.15 pg of TE-dioxins. Smoking 20 cigarettes, the smoker additionally receives 1.6-3 pg of TE-dioxins [11].

Dioxins are insoluble in water. Occurring in the form of industrial emissions in the river, they settle down in the mules and soils, they accumulate from the sea water in the tissues of hydrobionts, where their concentration is tens and hundreds of thousands of times higher than in water. The feature of DLC is their ability to bioaccumulate. In model experiments with the introduction of radio-labeled TCDD, it has been shown that its concentration in mosquito larvae is 9000 times higher than in water. The next link of the food chain consumes mosquito larvae - a fish or waterfowl - "purposefully" increases the concentration of poisons in the fatty tissues of your body, where it is practically not displayed. The consumer of such fish receives concentrations of TCDD, which can tens of thousands times exceed its levels in the environment [6].

As it was already noted, DLC is chemically stable compounds. Therefore, their half-life in the environment is very long: for PCDD it ranges from 102 to 139 years, for PCDF it is 29-79 years [5, 6].

The main route of exposure to dioxins in the body is the food chain., the body gets 98% of total dioxin supply with food, with air - 2%, with drinking water - less than 0.01%. A person who weighs 70 kg receives TCDD (in pg/kg) with food - 0,35 during the day, with air - 0,006 and consumer goods - 0,001. According to the US Environmental Protection Agency, daily intake of dioxins is 1 pg/kg. According to other sources, the average intake of dioxins in the human body varies from 0.03 to 0.05 ng/day. In the samples of urban air in Hamburg, 0.02 pg/m3 TCDD was detected. If a person inhales 20 m^3 of such air in one day, it is 0.006 pg of TCDD [16].

Water, as a product that people widely use for a variety of purposes, can also be polluted with dioxins. There is an evidence that, under certain conditions, the chlorinated tap water may be a potential source of dioxins. Back in 1980, scientists warned that a serious source of dioxin formation in water utilities could be the process of disinfecting drinking water by treating it with molecular chlorine. At the same time, it was demonstrated how compounds that can be transformed into dioxin are formed in the process of drinking water chlorination. As it turned out, humic and fulvic acids contained in water - natural sources of phenolic substances - in the process of chlorination, converted into 2,4,5-TPHF, PCF and other chlorophenols. The danger to people is sharply increasing in those settlements where, besides natural ones, there are also man-made sources of phenols. There are numerous places where phenolic compounds regularly thrown off by industrial enterprises, penetrate in water sources, became a permanent factor in the environmental situation. It turns out that chlorination of water with molecular chlorine under normal temperature conditions, even without a special selection of catalysts, for example, iron, leads to the formation of an extremely large amount of PCDF and PCDD [16].

Dioxins are extremely stable in living organisms, as a result of which they are stored in the biosphere for a long time.

Toxic-kinetic studies in recent years showed that dioxins are very slowly eliminated from living organisms, and there is almost no eleimination from the human body in general. Table 1 shows the half-life of highly toxic dioxin 2,3,7,8-TCDD in living organisms.

Table1. Half-life Period of dioxin 2,3,7,8-TCDD in living organisms

Living organism	Half-life period (days)
Mouse, hamster	15
Rat	30
Guinea pig	30-94
Monkey	455
Human	2120 (5–7 years)

Highly-chlorinated PCDD have a comparable half-life in the human body - about 3 to 6 years. For high-toxic PCDF, the half-life in a human body is slightly smaller - from 1 to 3 years. Scientists have established the obvious dependence of this value on the structure of PCDF. The half-life of highly toxic PCB-169 in the human body is approximately 10 years [16].

Dioxins overcome the placental barrier due to their pronounced lipotropic properties. From the mammals body, they are isolated mainly through the intestine in the form of phenolic metabolites, as well as milk.

Like most chlorinated compounds, dioxins are well absorbed in the gastrointestinal tract, lungs, and also through the skin. More than 87% of dioxins 2,3,7,8-TCDD, which enter the body by oral administration, are absorbed into the gastrointestinal tract. They are accumulated mainly in the adipose tissue, skin and liver. Table 2 shows data on the efficacy of dioxin accumulation in organs, tissues and human excretions relative to blood (the distribution coefficients are given).

Table 2. Data on the efficacy of 2,3,7,8-TCDD dioxin accumulation in human organs, tissues and secretions relative to blood

Tissues, organs, seecretions	Distribution coefficient
Fatty tissue	300
Skin	30
Liver	25
Breast milk	13
Walls of the intestine	10
Organs with intense blood circulation (brain, spleen, thyroid gland)	10
Kidney	7
Muscles	4
Feces	0,6
Bile	0,5
Placenta (fetal blood)	0,1
Urine	0,00005

Thus, it can be concluded that dioxins are one of the most dangerous substances, a biophysical poison that, due to its properties, causes a huge variety of toxic effects.

MAIN METHODS OF DIOXINS DETECTION

Careful studies of various samples from the environment (waste products, soils, industrial wastes, human fatty substances, etc.) indicate that most of the isomers and homologues of PCDD and PCDF are present in them. Thus, people and the environment are exposed to the complex mix of these pollutants, and there is a need for an adequate assessment of such exposure [9].

For this purpose, the concept of toxic equivalents is used, according to which the toxicity of any mixture of PCDD and PCDF or the toxicity of each DLC from the series of PCDD and PCDF is determined in comparison with the toxicity of 2,3,7,8-TCDD. For DLC and their mixtures, the toxic equivalent (TE) is calculated for 2,3,7,8-TCDD, for which the value of this characteristic is taken as a unit [16].

There are several national systems for calculating the toxic equivalent found in practical applications (USA, Canada, Switzerland, Germany). In recent years, the following systems became especially popular in the international community - the US system and two international (NORDIC and NATO working group).

Table 3 shows the toxic equivalents of DLC from the series of PCDDs and PCDFs, which are officially accepted in EU countries [16].

Table 3. Toxic equivalents of DLC from the series of PCDD and PCDF

Compound	Toxic equivalemnt
2,3,7,8-tetrachlorodibenzo-n-dioxin	1
1,2,3,7,8-pentachlorodibenzo-n-dioxin	0,5
1,2,3,4,7,8-hexachlorodibenzo-n-dioxin	0,1
1,2,3,7,8,9-hexachlorodibenzo-n-dioxin	0,1
1,2,3,4,6,7,8-heptachlorodibenzo-n-dioxin	0,01
1,2,3,4,5,6,7,8-octachlorodibenzo-n-dioxin	0,001
2,3,7,8-tetrahlorodibenzofuran	0,1
2,3,4,7,8-pentachlorodibenzofuran	0,5
1,2,3,7,8-pentachlorodibenzofuran	0,05
1,2,3,4,7,8-hexachlorodibenzofuran	0,1
1,2,3,7,8,9-hexachlorodibenzofuran	0,1
1,2,3,6,7,8-hexachlorodibenzofuran	0,1

Quantitative and even qualitative definition of dioxins in natural objects is an extremely complex, labor-intensive and expensive task. The cost of each dioxin analysis is between $ 500 and $ 3,000, depending on various factors. Difficulties related to the very low content of these compounds in the samples (10^{-12} - 10^{-15} g/g). In addition, there are many isomers and homologues of dioxins with similar physical and chemical properties in samples, as a rule [16].

Each method for determining dioxins includes:

- sampling and their homogenization;
- extraction;
- introduction of labels or standards;
- purification;
- concentration;
- identification;
- processing results.

The stages of the samples preparation for identification include many very complex procedures. For the final analysis, the only method is used - gas or liquid chromatography/mass spectrometry. The presence of large differences in the toxic properties of isomers requires identification for each of them in a mixture of pollutants. Therefore, it is necessary to have all standard samples of a specific group of isomers for unambiguous identification. High-resolution chromatographs with capillary columns, which are directly connected to the ion source of the mass spectrometer, are used to identify individual isomers. The best results can be obtained with the use of two-stage and two-dimensional liquid chromatography. In the case of the consistent connection of capillary columns with less polar and more polar phases, the first column ensures a clear distribution of the analyzed mixture into groups containing dioxins with the same number of chlorine atoms, and the second column allows the accurate distribution of isomers in each group. Using two-dimensional chromatography, only tetrachlorous isomers can be prepared from the mixture of PCDD and PCDF: 7 - in the TCDD series and 10 in the series of TCDF, with the sequential determination of each within the standard procedure [16].

For quantitative determination, mass spectrometric detection (mass fragmentography) is used. The definition is based on measuring the peak area and comparing it using isotope labeled (13C or 37Cl) internal standards or calibrated curves of external standards.

It should be noted that reliable analytical data on the dioxins content can only be obtained in stationary specialized laboratory complexes. The cost of such complexes is 1.5-2 million USD at the end of the twentieth century. There are about 50 such laboratories in the world certified by WHO to determine dioxins in the environment.

CONCLUSIONS

1. The problem of dioxins is one of the highest priority in the world. It is possible to draw conclusions from dioxin toxicity, even from epithets, which these substances obtained not only by journalists, but also by serious scientists: "superoxidants", "chemical AIDS", "ecological hormones", "ecological bomb of delayed action".

2. Dioxins are characterized by a wide range of biological effects on living organisms, due to the structure and properties of these compounds. DLC molecules contain aromatic nuclei of benzene in their composition, have a planar structure and are characterized by high symmetry. According to the electron density distribution, its maximum is located on the oxygen and chlorine atoms, and at least in the centers of benzene nuclei. The features of the electronic structure determine the corresponding properties of DLC molecules: high melting temperatures, low volatility and water solubility, high thermal stability, as well as resistance to the action of oxidizers, acids, alkalis, extremely low activity of halogen atoms, high adhesion to any surfaces, ability to accumulate in fatty tissues (lipophilic).

3. The chemical properties of dioxins determine their high stability in environmental objects. The half-life of 2,3,7,8-TCDD in the soil exceeds 10 (and sometimes 20) years, in water and bottom sediments - more than 2 years.

4. Dioxins belong to compounds for which it is impossible to establish a toxicological limit, as they affect the human body at the molecular level. Consequently, the concept of MPC (maximum permissible concentration) should in fact be absent for dioxins.

5. It is proved that among the large number of DLC the most toxic are dioxins containing halogen atoms in the lateral positions of 2,3,7,8. The highest toxicity in relation to the most sensitive species - guinea pigs - detects 2,3,7,8-TCDD, and the smallest - 2,3,7,8-tetrahloronapthalene, and, reducing or increasing the number of halogen atoms in PCDD molecules dramatically reduces their toxic properties.

6. The quantitative and even qualitative definition of dioxins in natural objects is an extremely complex, labor-intensive and expensive task. The cost of each dioxin analysis is between $ 500 and $ 3,000, depending on various factors. Difficulties are related to the very low content of these compounds in the samples (10- 12 - 10 - 15 g/g). In addition, there are many isomers and homologues of dioxins with similar physical and chemical properties in samples, as a rule.

7. One of the important problems encountered at the present stage of human society development is the problem of improving ecological and analytical monitoring and providing real data on DLC in the objects of the natural environment of Ukraine in accordance with the requirements of the Stockholm Convention on Persistent Organic Pollutants for Effective Health Protection of People and the environment from the harmful effects of ecotoxicants of the 21st century - dioxins.

REFERENCES

1. Більченко М. М., 2007. Лабораторний практикум з аналітичної хімії. Кількісний аналіз: Навчальний посібник. Суми, 142 с.
2. Зайцев В. М., Зуй М. Ф., 2007. Поліхлоровані біфеніли – одне з основних джерел антропогенного забруднення. Роль освіти, просвіти та поінформування при вирішенні проблеми небезпечних відходів та непридатних пестицидів в Україні: Матеріали міжнародного круглого столу. К., 67−70.
3. Каретникова О., 2004. Діоксини і людина. Матеріали до уроку. Шкільний світ, вип.2, 89−91.
4. Маликов О. Я., Афонин А. П., Шумлянский Л. А. и др., 2007. Химические загрязнения и здоровье человека. Матеріали VI Міжнародної науково-практичної конференції «Проблеми екології та екологічної освіти». Кривий Ріг, 120−122.
5. Михайленко П. М., 2001. Діоксини і людина. Екобюлетень «Людина. Суспільство. Природа», № 5, 4−7.
6. Степаненко О. І., 2002. Світ у пошуках нового Геракла, або як позбутися гір побутових відходів. Екобюлетень «Людина. Суспільство. Природа», № 9, 4−7.
7. Толмачова В. С., Ковтун О. М., Кремень О. С., Цигульова О. М., 2007. Діоксини – пріоритетні органічні забруднювачі біосфери. Роль освіти, просвіти та поінформування при вирішенні проблеми небезпечних відходів та непридатних пестицидів в Україні: Матеріали міжнародного круглого столу. К., 70−84.
8. Трахтенберг І. М., Левицький Є. Л., 2006. Українська профілактична токсикологія сьогодні: зв'язок часів у вирішенні актуальних проблем. Довкілля та здоров’я, №4, 3−7.
9. Consonni D, Sindaco R, Bertazzi PA., 2012. Blood levels of dioxins, furans, dioxin-like PCBs, and TEQs in general populations: a review, 1989-2010. Environ Int., 44:151-62.

10. Dearfield KL, Edwards SR, O'Keefe MM, Abdelmajid NM, Blanchard AJ, Labarre DD, Bennett PA., 2013. Dietary estimates of dioxins consumed in U.S. Department of Agriculture-regulated meat and poultry products. J Food Prot., 76(9):1597-1607.
11. Fernandes AR, Mortimer D, Wall RJ, Bell DR, Rose M, Carr M, Panton S, Smith F., 2014. Mixed halogenated dioxins/furans (PXDD/Fs) and biphenyls (PXBs) in food: occurrence and toxic equivalent exposure using specific relative potencies. Environ Int., 73:104-110.
12. Fernández-González R, Yebra-Pimentel I, Martínez-Carballo E, Simal-Gándara J., 2015. A Critical Review about Human Exposure to Polychlorinated Dibenzo-p-Dioxins (PCDDs), Polychlorinated Dibenzofurans (PCDFs) and Polychlorinated Biphenyls (PCBs) through Foods. Crit Rev Food Sci Nutr., 55(11):1590-617.
13. Furst P., 2006. Dioxins, polychlorinated biphenyls and other organohalogen compounds in human milk. Levels, correlations, trends and exposure through breastfeeding. Mol. Nutr. Food Res., 50 (10): 922–933.
14. Hites RA., 2010. Dioxins: an overview and history. Environ Sci Technol., 45(1):16-20.
15. Hutchinson T. H., Brown R., Brugger K. E., 2000. Ecological risk assessment of endocrine disruptors. Environ. Health Perspect, vol. 108, № 11, 1007−1014.
16. Kim M, Kim DG, Choi SW, Guerrero P, Norambuena J, Chung GS, 2011. Formation of polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDD/Fs) from a refinery process for zinc oxide used in feed additives: a source of dioxin contamination in Chilean pork. Chemosphere, 82 (9): 1225–9.
17. Marinković N, Pašalić D, Ferenčak G, Gršković B, Stavljenić Rukavina A., 2010. Dioxins and human toxicity. Arh Hig Rada Toksikol., 61(4):445-453.
18. Stockholm Convention on Persistent Organic Pollutants (POPs), 2001.
19. Watanabe MX, Kunisue T, Ueda N, Nose M, Tanabe S, Iwata H., 2013. Toxicokinetics of dioxins and other organochlorine compounds in Japanese people: association with hepatic CYP1A2 expression levels. Environ Int., 53:53-61.
20. Zhang Q, Gao L, Zheng M, Liu L, Li C., 2014. Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) in water samples from the middle reaches of the Yangtze River, China. Bull Environ Contam Toxicol., 92(5):585-589.

АНОТАЦІЯ

ДІОКСИНИ – СУЧАСНІ ПРІОРИТЕТНІ ОРГАНІЧНІ ЗАБРУДНЮВАЧІ ДОВКІЛЛЯ

Актуальним питанням сьогодення є проблема збереження навколишнього середовища, від якості якого залежить життя і здоров'я людей. В процесі господарської діяльності використовуються понад 120 тис. хімічних речовин, серед яких – 70% з невизначеною токсичністю. До пріоритетних органічних забруднювачів довкілля належать і діоксини.

Діоксини – це речовини I (найвищого) класу токсичності. Проблема діоксинів є однією з першочергових в усьому світі. Про токсичність діоксинів можна роботи висновки навіть з епітетів, якими ці речовини нагороджують не лише журналісти, а й серйозні вчені: «*суперекотоксиканти*», «*хімічний СНІД*», «*екологічні гормони*», «*екологічна бомба сповільненої дії*».

Для діоксинів характерний широкий спектр біологічної дії на живі організми, що обумовлений будовою і властивостями цих сполук. Молекули ДПС (діоксиноподібних сполук) містять у своєму складі ароматичні ядра бензену, мають площинну будову і характеризуються високою симетрією. Згідно розподілу електронної густини її максимум

знаходиться на атомах Оксигену і Хлору, а мінімум – у центрах бензенових ядер. Особливості електронної будови обумовлюють відповідні властивості молекул ДПС: *високі температури плавлення, низьку леткість і розчинність у воді, високу термічну стійкість, а також стійкість до дії окисників, кислот, лугів, надзвичайно малу активність атомів галогенів, високу адгезію до будь-яких поверхонь, здатність до накопичення в жирових тканинах (ліпофільність).*

Хімічні властивості діоксинів визначають їх високу стабільність в об'єктах навколишнього середовища. Період напіврозпаду 2,3,7,8-ТХДД (2,3,7,8-тетрахлор-дибензо-*п*-діоксин) у ґрунті перевищує 10 (а іноді 20) років, у воді та донних відкладах – понад 2 роки.

Кількісне і навіть якісне визначення діоксинів у природних об'єктах є надзвичайно складною, трудомісткою та дорогою задачею. Вартість кожного аналізу на діоксини складає від 500 до 3000 доларів США в залежності від різних факторів. Труднощі пов'язані з дуже малим вмістом цих сполук у зразках (10^{-12}–10^{-15} г/г). Крім того, в пробах, як правило, присутня безліч ізомерів та гомологів діоксинів з подібними фізико-хімічними властивостями.

Кожна методика визначення діоксинів включає: відбір проб та їх гомогенізацію; екстракцію; введення міток або стандартів; очистку; концентрування; ідентифікацію та визначення; обробку результатів.

Для кількісного визначення використовують мас-спектрометричне детектування (мас-фрагментографію). Визначення базується на вимірюванні площі піків та порівнянні їх з використанням ізотопно мічених (^{13}C або ^{37}Cl) внутрішніх стандартів або каліброваних кривих зовнішніх стандартів.

Отже, однією з важливих проблем, яка постає на сучасному етапі розвитку людського суспільства, є проблема вдосконалення еколого-аналітичного моніторингу та надання реальних даних про ДПС в об'єктах навколишнього природного середовища України згідно з вимогами Стокгольмської конвенції про стійкі органічні забруднювачі для ефективного захисту здоров'я людей і довкілля від шкідливого впливу екотоксикантів XXI століття – діоксинів.

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EDUCATIONAL POTENTIAL OF MUSEUMS IN IMPLEMENTATION OF PATRIOTIC EDUCATION OF PRIMARY SCHOOL STUDENTS AT EDUCATIONAL INSTITUTIONS

Abstract. In the article was elucidated an educational potential of museums near educational institutions in the implementation of the patriotic upbringing of junior pupils, an attention was paid to the history of the creation of the first diverse forms of museum and the first educational museums near higher educational institutions of Ukraine; three types of school museums are distinguished: school, regional and central. An attention was focused on the conditions inherent in the creation of school museums in order to reflecting the result of purposeful work in the execution of tasks of patriotic education of junior pupils. Relying on modern educational documents, in the article was elucidated an important tasks necessary for the creation of museums near educational institutions, the such types of funds of the school museum as main and auxiliary was singled out. In the article we submitted also such a conceptual apparatus: «museum near educational establishments», «school museum», «museum near educational institutions»; we outlined educational, communicative, organizational and informational functions of the school museum. The special attention was paid on the principle of interactivity, which is necessary in realization of a person-oriented approach in the educational process of the primary school. Also, we singled out the specifics of school museums, we filed a comparative characteristic of the peculiarities of public and school museums through the prism of the elaborated tables, and the main directions of activity of school museums was elucidated: educational, scientific-search, stock and mass-educational. Also, the emphasis was put on the creation of school museum complexes, intercurricular local lore and reference museums, which play an important role in the patriotic education of primary school students today.

Keywords: museums at schools, educative potential of museums, patriotic education, elementary school students.

INTRODUCTION

Contemporary museology has broad prospects in Ukraine, because actively implemented in the educational area secondary schools, particularly at primary school. The wide network of school museums are operating in Ukraine which has gained special significance in terms of the existence of the Ukrainian state.

Analysis scientific and educational sources shows that at the current stage of development of Ukrainian museum arts first ever truly highlights the national liberation movement of the Ukrainian people for their own state 1914-1945 y., state-activities ZUNR, publication societies «Prosvita», «Native school», «Shevchenko Scientific Society», information about the Organization of Ukrainian Nationalists, events in 1939-1941y., at West Ukraine, on the activities of Ukrainian Insurgent Army, the Holodomor in Ukraine1939 y., Genocide during the Stalinist repression and so on.

Among school museums the local history are occupying important places now, each materials complements and specify the curriculum of natural science, Arts and Music. We must say, that in the key change to this training programs elementary school attention is focused on reducing the theoretical information, and more attention given for development of creativity, physical activity, art [16]. The exhibits in museum helps forming in students pedagogical

thinking, raising national pride for the state Ukraine. In order to develop museums job search educates students conscious and careful attitude to monuments of culture and nature of the region, love for its history, expanding their world, creating independence, initiative, responsibility and tolerance. School Museum also help to feel involvement in homeland traditions and values, educating students patriots of their country.

The patriotic training is important things for museums. Pupils are forming a common moral culture, a sense of pride for their own school and they employees, by means of scientific processing and storage of museum collections and the creation of expositions. The popular of school museum, museum rooms are growing up every year. These rooms are being created thanks to ethnographers, pedagogical staff of educational institutions, as well as to the exploratory work of pupils.

Different aspects museum's pedagogy are reflected in the works of modern scholars. In particular museums pedagogy as promising direction in the modern system of national education, its formation and development are considered [1; 2] ; the problem of forming normative and legal framework the activities of museums at educational institutions of Ukraine is highlighted [6; 10] gives the peculiarities of pedagogical interaction in modern «A society of knowledge» through the prism of institutes the museum - school – university; [13] analyzes pedagogical means of implementation of museum's pedagogy in out-of-school educational institutions; [12; 13] are considering educational functions of museums pedagogy as important part of education and upbringing pupils and students ets.

The purpose of the article is disclose the importance of educational potential of museum at educational institutions in the implementation of pupils patriotic education in elementary school.

BASIC PRESENTATION OF THE MATERIAL

As the scientific-pedagogical literature certifies first than a museum appeared as a specialized structure

Scholar L. Hayd astandsth at *first educational museums* were founded in Kyiv, Lviv and Chernivtsi universities [6]. Historical heritage of modern scholars shows that acertain net work of educational museums as subject rooms at city schools has been for medon the first half of 19^{th} century, and then it gradually converted into independent museums. There were founded first modest museum at provincial schools; visual-subject principle of training lied into the base of educational process, for they represented small groups of visual means, natural scientific and other collections necessary for illustrating the content of educational subjects [15].

At the beginning of 20^{th} century school museums were represented as *interschool mobile museums of* educational out fit. Their function was to provide educational institutions with necessary visual means and manual sand to promote pedagogical knowledge of teachers. We want to notice that progressive educators payed great attention on school museum. They believed that school of those times could not function well without museum like workshop does not function without tools. These museums were founded for development an deducation of students creative activity, for they became the object of observation and a means of cognition of the environment and regional studies.

Scientific and pedagogical sources of modern scholars show that an important role palyed *«childrens museum»*. It had to bring children closer by the things they had seen and by the things they had heard, to make their own discoveries by making own exhibits and enriching visual information using principle – knowledge of the subject means to follow it [20].

Contemporary scholar L. Hayd argues that the following three types of museums should be distinguished in the system of educational institutions:

1) school (collection of visual devices and collections at school);

2) regional (composition and exhibition of visual devices);

3) central – county as a general education with a regional study area [6].

There fore, visual-subjectprinciple of training lied into the base of educational process of museums of 19th century. It had spontaneous character, for formation of museums at the beginning of 20th century paid great attention on its educational-developing functions, for museum converted from educational-subject cabinet to interschool exhibitions of visibility.

Analysis of scientific sources shows that museums asocial institute were formed in the process of long-term historical development that was based on enriching of content and methods of activity and searching of own place in society. Anessential feature was the collection of museum stuff [7].

It is worth noting that state authorities paid special attention to educational museums in the 70-80th of 20th century, Therefore, the museums carried out ideological and educational role. We have coveredi nformation gathered from Soviet textbooks for primary school students [3; 4].

A new stage in the history of educational museums has come after declaration of independence in Ukraine; In the process of reorganization museum institutions devoted to the history of the party and the Komsomol, V. Lenin and the October Revolution disappeared, there were founded museums of Ukrainian national movement devoted to famous events of Ukrainian history, life and activity of outstanding leaders.

Modern scholars out line characteristic *features* of educational museum – i.e. proper arrangement of funds and ensuring of their keeping [13] *The aim of school museums foundation* is a significant event that is not limited to a formal act, but is the result of a purpose ful systematic, creative and research exposition that contributes to successful implementation of thet asks for the upbringin go for primary school students. All the collected material softhe expositions houldbe a live mention of the historical past, history of the motherland, which contribute to revival of the national education system as the most important link in the education of consciouscitizens of the state. *The basis of educational museums activity* is the idea of establishment of the statehood of Ukraine, upbringin gof the real patriots of the Motherland in order to increase the efficiency of the educational process of primary school students [9; 18].

Taking into consideration the educational document «Regulations on the museum at the educational institution» (№ 640) (Pravda M. and scientific sources of M. Falinskyi, I. Lychak, educational museums are founded on public foundations and implementa range of important educational *tasks* [12; 20].

It is worth noting that the set asks enable to deepen the study subjects of the state component of primary school («Literary reading», «Natural science», «Man in the world», «Fine arts», «Labour training»), and subjects of school component («Folk Studies», «Christian ethics», «Folklore»). Culture function is the main among basic functions of educational museum, the leading place is defined by development of culture and erudition of primary school student. For example, there are suggestions to create classroom museums and projects in textbook «Man in the world» [15]. We outlined these subjects by analyzing textbooks for primary school students published in independent Ukraine [3; 4].

We also highlighted the types of collections in the school museum:

– the main fund – original historical sights, nature, real memorials (tools of labor, household items), written memos (books, newspapers, documents, works of fine art, botanic and zoological materials);

– auxiliary fund – materials, which are created in the process of organizing the activities of museums for a more complete disclosure of a topic, explanation of original sights (maps, diagrams, models) [12].

Analysis of normative and legal act sin the field of preservation of museum sand memorials, inparticular «Regul ationson the museum at the educational institution» allows to stand that ***educational museum*** is a component of system of educational work at educational institution, that remains in the sphere of governing of Ministry of Education of Ukraine,

approved by decree of Ministry of Education of Ukraine № 640 from 04.09.2006 [12]. These museum sare founded with the aim «involving student out to studying and keeping Ukrainian historical and cultural heritage, formation of educated developed personality and assistance in upbringing patriotism, love to Ukraine, respect to national customs, traditions and national values of Ukraine [1]. Museum documentation consists of: Inventory book, book of excursions, training sessions, planned mass events, act so freceiving and giving of exhibits, work plans, book of reviews about museum.

There should be divided notions «educational museum» and «study cabinet», that is educational subdivision of school, clearly defined set of manuals, educational furniture. We agree with the opinion of scholars I. Lychak and M. Pravda that educational museum and study cabinet should complement each other [12; 18].

Where as educational museum is one of important means of improving complex education of students process, expansion of their horizons, development of cognitive interests and abilities, we submit an interpretation of this concept from different points of view of modern scholars.

The museum at the institution of education is alive not died exhibition of photographs and documents; significant potential in the educational process of students, center for the formation of socio-cultural competence of students, the main conditions for the creation of which is the presence of original materials [9]. In these centers, research is being activated, artistic and aesthetic and patriotic activities, focuses on forming the inseparability of the elementary school pupils in the past, present and future of Ukraine.

The school museum is creative laboratory of national-patriotic education of youth; it is a cell, which is arranged according to a certain theme and contains, in addition to museum exhibits, pupils works created by pupils before and after visiting classical museums. The pupils reviewing museum exhibits and getting a positive impression in these room [14; 19].

The school museum is a special developing space, created to bring students to the world of art, expanding their cultural and national outlook, expanding their cultural and national outlook, the formation of the ability to creativity, their vital competence, the development of representation, fantasy through the implementation of productive activity and autonomy, is the result of communication, the joint work of the teacher, the student and their parents [3; 4].

The school museum is a socio-cultural center of spirituality and village culture, the repository of human memory in which objects and exhibited objects of culture, life and art. However it is not the store of old things but the space for creativity where the dialogue between the old and the new epochs takes place. It is a panorama of human life that reveals universal and personal values, since the museum materials are presented the characters and destinies of the past and present, the motives of its actions and the model of their behavior [11; 17].

The museum at the institution of education is a place of scientific and pedagogical processing of the collected material created by their hands under the guidance of a teacher. It is such visiting card of the educational institution because it reveals its history from its inception to the present [5; 12].

We submit an authors definition of a school museum. ***The museum at the institution of education*** is creative laboratory, which covers the important potential of the educational process in order to create a plunge of elementary school students into the world of art for the purpose of cultivating patriotic feelings in them.

Analysis of scientific and pedagogical and psychological and methodological literature allows to distinguish a number of functions school museum: educational, communication, organizational (creation of various variable exhibitions), cognitive (acquaintance with the cultural), informational (formation of a steady need for obtaining relevant information).

An important principle, for our view, is a principle of interactivity, that reflects personality didactics with the aim of acquiring personal experience of collision with reality of history and culture: «Museum is a laboratory», «Museum – theater», «Museum is a game». It is the realization of students in various activities with the use of exhibits in story-role games.

Consequently, the implementation of the principles of museum pedagogy serves an important component in the creation of school museums as a significant event in the life of the school.

Detailed analysis of scientific works of modern scholars allows to distinguish the specifics of school museums:

– school museum is a part of the school structure, meets its needs their materials are used in the educational process;

– take part in the creation of museums and act not as passive observers, but as an authors and creators of exhibits;

– work in the museum captures students, Naturally stimulates their creative thinking, strengthens and develops their creative interests;

– collected exhibits in the museum allow students to learn more about their people, their life, art, folk art, nature and attractions, that is laying the foundations of patriotism;

– each exhibit is an accessible for pupil , which he can consider;

– educational potential is aimed at social adaptation and development of pupils' emotional sphere, implementation of the subject-subject relations, creating a situation of success and a welcoming atmosphere;

– participation in the creation of exhibits as pupils, parents and families.

The main feature of the museum, in our opinion, is the availability of a fund of original materials, which correspond to his profile and can grow into a folk museum [15; 18; 20].

The museum at the institution of education from public museum is distinguished scientific value, collection of collections and depth of scientific development of issues. We provide a comparative description of the characteristics of public and school museums (Table 1).

Table 1. Comparative description in the features of public and schools museums

State-owned museums	School museums
Expand the history of the great region	Expand the story closer to the locals
You can not touch the exhibits with your hands	Pupils have the opportunity to take exhibits in their hands, consider them, move it to another location, create own exposition
Visitor is a passive observer	Student - co-author, co-worker

G. Oleksenko highlights difference between school and school museum which we also cover in the table 2 [15]:

Table 2. Differences betwen school and school museum

School	School museum
Provides basic education to specific programs	Provides selective education
An informative approach is being implemented	Education is carried out through the expansion of human sensory-emotional experience
Communication is verbal	Students are trained using primary sources
Uses a class-specific type of behavior	Introduced museum etiquette
Advantage of verbal-visual-practical methods	The prerogative is the innovative methods

We also highlights common features inherent in the museum and school, they wants to cultivate a sense of patriotism, conscious attitude to the achievements of world and domestic science and culture. We agree with the opinion of modern scholars such as N. Hannusenko, O. Lyapin, T. Maciejuk, R. Derrick, O. Valenkevich, that today must be new subject in school associated with museum pedagogy [2; 7; 8].

As we can see the work of museums at educational institutions is multifaceted. Today, the use of modern technologies in museum pedagogy Requires the practical realization of the experience of all the cultural and educational potential of the museum, such as «translation» information, which focuses on museum exhibits [2].

We outline the main directions activities of school museums for this purpose (Table 3) [10]:

Table 3. Basic directions of activity at schools museums

Name of the field of activity of the museums	**Forms of the direction of work of school museums**	**Results**
Educational	Tour and thematic excursions, thematic lessons, mobile and stationary exposition	Development of abilities to perceive the museum information through the language of museum exhibits; development imagery; creating an emotional atmosphere, favorable conditions for the purpose of labor efficiency; Use and popularization new educational technologies in the form of individual projects; formation of creative activity; the upbringing of a value relation to a cultural heritage, respect for museum values; education of patriotic qualities of pupils in elementary school
Scientific research	Search activity, independent work on information retrieval	Formation of creative activity; development of interest in the work performed; possession of relevant information
Stock	Video recordings, replenishment of exhibits, presentations, memories	The ability to present the material
Mass-educational	Excursions, exhibitions, meeting, round tables	Enrichment with information; Competence of possession information; Formation of subject-subject relations

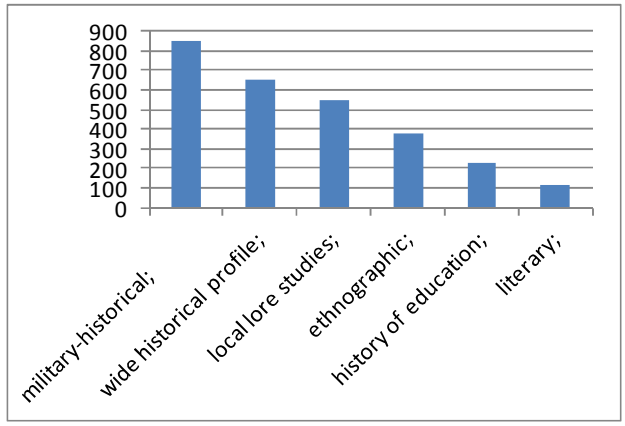

Figure 1. Working museums at Ukrainian educational institutions

According to the results of the departmental registration of modern scientist L. Gaida, the following museums at the educational institutions of Ukraine are in force, as shown in the diagram (Figure 1):

- 847 military-historical;
- 649 - wide historical profile;
- 547 - local lore studies;
- 380 - ethnographic;
- 231 - history of education;
- 114 - literary;
- 721 – others [6].

Consequently, the types of museums listed by us in educational institutions play an important role in the process of collecting, systematizing materials, and educating the patriotic qualities of elementary school students.

CONCLUSIONS

Scientific sources stand that educational museums play role of methodological centers of school regional studies that suggest forms of different work among teachers and parents on school, district and regional levels. On the base of them there are conducted seminars, conferences, open classes for leaders of other museums, educators, organizers.

Educational museum complexes, *interschool llocal history museums* and so called *supporting museums* also play an important role today. Scholars I. Lychakand H. Yasiev stand that supporting museums at educational institutions are the centers of patriotic work inextra time, for there is formed museum active leaders of districts, heads of museum sex change experience and study new forms and methods of activity there. Personal activity of heads of museums plays an important role, most of them work on a voluntary basis.

Thus, for today educational museum is cultural and educational institution, that set not only specific professional tasks but also scientific, aesthetic and educational tasks. In the process of scientific research students study history and traditions of their native land, take part in preservation of memorials and revival of the national and spiritual heritage.

REFERENCES

1. Вайнберг Т. Б., 2014. Музейна педагогіка – перспективний напрям у сучасній системі національної освіти. Vyvchaiemo ukrainsku movu ta literaturu. Pozaklasna robota, Vol, № 2 (02).
2. Валенкевич О. В., 2015. Становлення та розвиток музейної педагогіки Problemy osvity: nauk-metod. zb. / Instytut innovatsiinykh tekhnolohii i zmistu osvity MON Ukrainy, Vol. 85, Kyiv.
3. Гайда Л., 2011. Формування нормативно-правової бази діяльності музеїв при навчальних закладах України, Krayeznavstvo, Vol. 3.
4. Ганнусенко Н., 1991. Шкільні музеї: посібник для вчителя, К.: Rad. shkola, 110.
5. Дерик Р. А., 2007. Музей – історичний скарб народу: метод. посібник. Uzhgorod: Grazhda, 68.
6. Караманов О., 2013. В. Музей – школа – університет: особливості педагогічної взаємодії в сучасному «суспільстві знань» Osvita ta pedagogichna nauka, Vol. 4 (159), 44-50.
7. Кубрак О., 2015. Круглий стіл «Музеї навчальних закладів як осередки патріотичного виховання» Elektronny`j resurs. Rezhym dostupu // http://pmu.in.ua/news/info_letter_2015_1/.

8. Личак І. С., 2013. Організація музейної справи в навчальному закладі: методичний посібник. Bila Cerkva, 116.
9. Музеї при закладах освіти – творчі лабораторії національно-патріотичного виховання молоді [Elektronnyj resurs], Rezhym dostupu www.osvitportal.lviv.ua/novyny?id=77950.
10. Ясєв Г. Є., 2007. Опорні музеї при навчальних закладах: узагальнений досвід, Kyyivskyj miskyj istorykopatrioty chnyj klub «Poshuk», 104.
11. Ang I., 2005. The Predicament of Diversity: Multiculturalism in Practice at the Art Museum // Ethnicities, No. 5 (3), 305-320.
12. Dede C., 1995. The evolution of constructivist learning environments: Immersion in distributed, virtual worlds // Educational technology, No. 35 (5), 46-52.
13. Desvallees A., 2010. Concepts cles de museologie. Paris: ICOM, 32.
14. Geladaki S., 2014. University Museums as Spaces of Education: The Case of the History of Education Museum at the University of Athens // Procedia – Social and Behavioral Sciences. No. 147, 300-306.
15. Hooper-Greenhill E., 1983. Some basic principles and issues relating to Museum education // Museums journal, No. 83 (213), 127-130.
16. Hooper-Greenhill E., 1988. The „art of memory" and learning in the museum. The challenge of GCSE // The international Journal of Museum Management and Curatorship, No. 7, 129-137.
17. Lucie J., 2015. Muzejni pedagogjako (semi) profese // Muzeologia a Kulturne dedicvo, T.3, C.2, 39-58.
18. Mitsel I.-E., 2006. Educational programs and Pedagogical applications of the Museums (Experiences from the Museums of USA): Thesis, Volos University [in Greek], 37-38.
19. Papanikolaou P.M., 2016. Homage to Melina's Programme „Education and Culture" : From the Educational Programmes of Greek Museums to Art Competitions in Schools // International Jounal of Education and Social Science, Vol. 3, No. 5 / [електронний ресурс] режим доступу: http: // www. Ijessnet.com/wp-content/uploads/2016/06/3. pdf.
20. Wisniewska M., 2004. Muzeum Powstania Warszawkiego otwarte // Muzealnictwo, Vol, 45 / [електронний ресурс] режим доступу: http: // nimoz. pe/upload/ wydawnictwa/ Muzealnictwo/ muzealnictwo45/muz_45-3. pdf.

АНОТАЦІЯ

ОСВІТНЬО-ВИХОВНИЙ ПОТЕНЦІАЛ МУЗЕЇВ ПРИ НАВЧАЛЬНИХ ЗАКЛАДАХ У ЗДІЙСНЕННІ ПАТРІОТИЧНОГО ВИХОВАННЯ УЧНІВ ПОЧАТКОВОЇ ШКОЛИ

У статті висвітлено освітньо-виховний потенціал музеїв при навчальних закладах, акцентовано увагу на музеї як спеціалізованій структурі, розкрито домузейні форми нагромадження культурних цінностей, які збереглись у формі скарбів, колекцій, що мають пізнавальне, естетичне та історичне значення; подано інформацію про перші навчальні музеї при університетах, міжшкільні пересувні музеї, а також перші «дитячі музеї». Виокремлено три типи музеїв, зокрема шкільний (збірка наочних приладь та колекцій у школі); регіональний – пересувний (склад і виставка наочних приладь) та центральний – повітовий як загальноосвітній з краєзнавчим напрямом. Авторами також виокремлено умови, притаманні шкільному музеєві. У статті звернена увага на мету створення шкільних музеїв, що є значною подією, результатом цілеспрямованої систематичної, творчо-пошукової та дослідницької експозиційної роботи, акцентовано на основній діяльності шкільних музеїв, що виступає важливою ідеєю становлення державності України, виховання справжніх патріотів Батьківщини. У статті зроблено

висновок, що музеї при закладах освіти створюються на громадських засадах і виконують низку важливих освітніх завдань. Авторами виокремлено такі види фондів шкільного музею, як основний фонд (оригінальні пам'ятки історії, природи, речові пам'ятки (знаряддя праці,предмети побуту), письмові пам'ятки (книги, газети, документи, твори образотворчого мистецтва, ботанічні та зоологічні матеріали) та допоміжний фонд (матеріали, що створюються в процесі організації діяльності музеїв для більш повного розкриття тієї чи іншої теми, пояснення оригінальних пам'яток (карти, діаграми, макети, моделі). У статті стверджено, що шкільний музей є складником системи освітньої роботи при навчальному закладі, який перебуває у сфері управління Міністерства освіти і науки України. Також висвітлена інформація про музей при закладі освіти як живу, дійову силу, а не мертву виставку фотографій і документів.

Авторами виокреслено понятійний апарат, подано авторське визначення шкільного музею як творчої лабораторії, яка охоплює важливий потенціал освітнього процесу з метою створення поринання учнів початкової школи у світ мистецтва задля здійснення в них виховання патріотичних почуттів. У статті також виокремлено низку функцій шкільного музею: освітньо-виховну; комунікаційну; організаційну (створення різноманітних змінних виставок); пізнавальну (ознайомлення з надбанням культури); інформаційну (формування стійкої потреби в отриманні відповідної інформації). Важливим принципом виокреслено принцип інтерактивності. Також виокремлено специфіку шкільних музеїв, у поданих таблицях подано порівняльну характеристику особливостей громадських та шкільних музеїв, відмінність школи і шкільного музею, основні напрями діяльності шкільних музеїв, а крізь призму діаграми – профілі чинних музеїв при навчальних закладах України. У статті також є висвітлена інформація про спільні риси, притаманні музею і школи, акцентовано увагу на шкільних музейних комплексах, міжшкільних краєзнавчих музеях та так званих опорних музеях при навчальних закладах, що на сьогоднішній день у позаурочний час виступають важливими осередками патріотичної роботи з молодшими школярами.

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