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THE TECHNOLOGY OF THE NEW INSTRUMENTAL ESTIMATION METHOD OF THE VEGETATION COVER MICROCLIMATIC CHARACTERISTICS

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Abstract

Purpose: *Development and approbation of the program-apparatus complex for the measurement of the basic microclimatic characteristics at the vegetation cover.* ***Methods:*** *The complex allows to measure simultaneously the air temperature and humidity, direct and indirect illumination into the sublayers and over the grass stand with the entry of the findings into the acting permanently storage device.* ***Results:*** *The device features control carried out on the experimental areas with the mire vegetation (Phragmito-Magno-Caricetea class association of the Klika in Klika and Novak 1941) demonstrated the compliance of the declared characteristics with the obtained results.* ***Discussion:*** *The question on the dependency form of the vegetation ecological role in the natural settings has not only practical importance, but vital theoretical significance, as the consequence transformation, in particular, the ecosystems, leads to the limit of their buffer possibilities and to the cessation of work on supporting of the existing soil and atmosphere balances. natural conditions, and under the anthropogenic impact, as well as the measures forming on the base of the obtained results, aimed to their conservation, recovery and inexhaustible use, is important and burning question. The systematic observation carrying out for the environment forming role change of the different ecosystem types under natural conditions, and under the anthropogenic impact, as well as the measures forming on the base of the obtained results, aimed to their conservation, recovery and inexhaustible use, is important and burning question.*

Keywords: automation; device; monitoring; microclimate; nature management.

1. Introduction

The estimation and monitoring of the vegetation cover microclimatic indexes are the practical tasks of big importance in view of the intensification of the anthropogenic impact and global climatic changes disturbing the balance of nature and the ecosystems stable functioning. The development and perfection of the vegetation cover microclimatic characteristics estimation direct methods is one of the key factors for the complex finding formation on the ecosystem current state. The development and upgrading of the direct methods of the vegetation cover microclimatic characteristics is one of the key factors in formation of the complex conclusion of the ecosystems current state. The development of the methods in this direction will provide the activity of immediacy and efficacy for the prevention of the nonreversible consequences and will allow to take measures on theirs localization, consequence ecosystem recovery and maintenance in virgin state. Not less important is the realization of the total ecological evaluation and monitoring of the vegetation environment forming role at the area of economic use.

2. Analysis of the latest research and publications

There exists the broad store of means and methods for ecological monitoring [1-8]. It was established that the formation and steady existing of the

vegetable associations is possible at the certain range of the microclimatic characteristics – the temperature and air humidity, direct and indirect illumination, albedo. Differing by considerable variability of values, depending of vertical and horizontal structures and vegetation state, the necessity arises in the synchronous measurement of characteristics enumerated above by all-height alignment of vegetation cover in the different points of experimental area, distributed on the considerable distance. The use of the conventional devices and technics imposes the limit on time for the experimenter movement from one point to another one, in preparation stage to the gauging, in convenience of measuring carrying out, and expectancy of the result wrongly recorded.

The creation of the efficacious control facilities operating with the minimum of hand man participation during the ecological investigation carrying out is very complicated problem, the decision of that is the object of interest through worldwide. The automatic posts for environment ecological monitoring has proved to be the most effective, have received the largest distribution [8] and the self-acting portable complex of meteorological stations too [9].

3. Research tasks

The similar posts created with some automation level are used in the USA (Chicago, Los-Angeles, and New-York) for example, in Japan, Gumma prefecture, Nagoya city, in Great Britain (the posts of Telstor firm), in Poland (Silesia mining industrial district) and others. The program-apparatus complex on such posts allows measuring of the temperature, the environment humidity, the wind direction, strength and velocity. Such posts are related to the posts of stationary type of automation posts for the environment ecological monitoring and are located into the specially equipped halls or into the heat-insulated containers. They are very complicated during the fabrication and operation and they do not allow deciding the problem of the microclimatic characteristic change in the specific vegetation associations. The second group, these are the separate devices that can carry out the necessary measurements as prepared for special tasks [11-12], and as well as industry output. The most close on the technical matter to the proposed method is the way of the multipoint temperature measurement necessary for the estimation of the environment forming vegetation role measurement, that are realized in the structures of A. Balakhtar [13] and I. Nechaev [14]. The versions of the multipoint measurement of the air relative humidity, direct and indirect illumination are absent.

4. Materials and methods of research

One of the modes for this problem deciding is the application of the technology on temperature, humidity and illumination sensors connection under the 1-Wire record with the obtained results fixation. As the temperature and humidity sensors, were selected the DHT22 chips of the Aosong Electronics Company [15]. In the range of -10°C up to +85°C, the producer warrants the absolute measurement error not less than ±0.5°C. For the illumination determination, is to be used MAX 44009, the Maxim producer [16], as the most perfect one. The optimal metrological characteristics, successful hardware-constructive decision, the possibility to joining up into the distributed network, makes attractive the digital sensors use at the microclimatic characteristics measurement under the field conditions. The chips transform the meaning of the temperature, humidity, and illumination into the digital code, that don't need the calibration and can be used in the temperature range of - 40 up to +85°C.

The task of the device created by the authors is the prompt measurement of the vegetation microclimatic characteristics (air temperature and humidity, as well as direct and inverse intensity of the solar radiation) in the different layers of the vegetation cover and of realizing it program-apparatus means, in that due to the introduction of the structure-time duplication, it provides the technical result obtaining, consisting of the linearity calibration parameters providing, increasing the sensibility, and practically, the exclusion of dependency from the instability of the semiconductor sensor individual parameters (Fig.1).

The given problem is to be decided by the unification of the air temperature, humidity and direct and inverse illumination sensors in the structural blocks of the information channel, that are connected with the electronic module for data processing and the investigation results storage (electronic memory).

The developed device involves the additional facilities: RTC (real time clock with the calendar) and the pressure sensor. All of them are connected in parallel with the electronic modules for data processing and the investigation results storage.

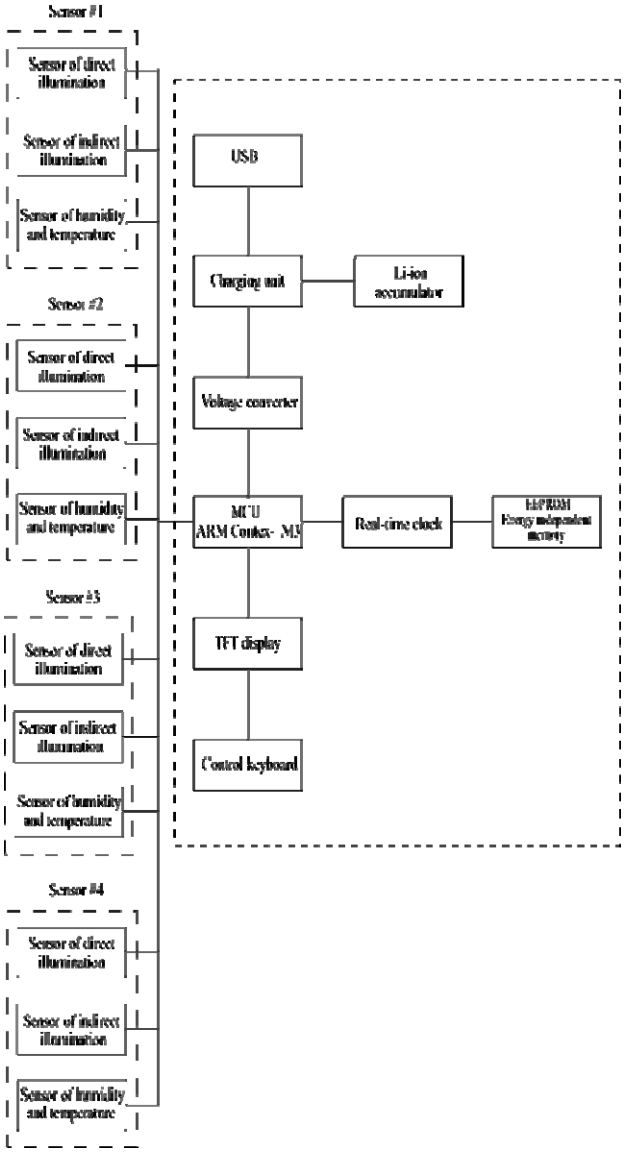

Fig. 1. Structural device chart for the microclimatic condition measurement

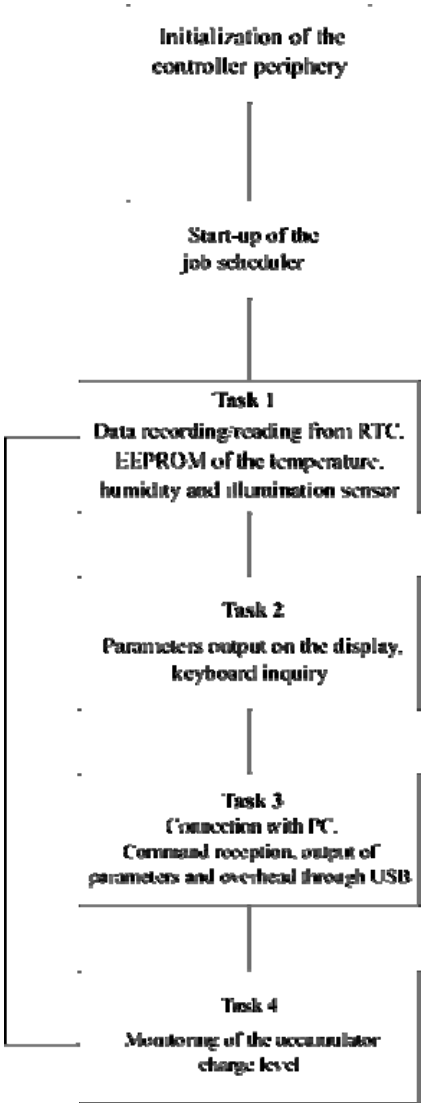

Fig. 2. Flow-chart of device operating

The device basic version allows connect four remote sensor blocks that can determine the air temperature in the range of -5° up to 100° C; the relative air humidity: of 10 up to 100%; the direct solar illumination of 1 to 999990 Lx; the backscattered solar radiation of 1 up to 99999 Lx.

The device operates as follows (Fig. 2):

1. At device switching, the microcontroller periphery initialization occurs: the readout from EEPROM (energy independent memory), task dispatcher starting. In case of malfunction detection (the data-transmitter unit didn't connect, or battery constant-voltage charge is insufficient), the text information is projected on display showing the malfunctions character and the recommendations on their elimination.

2. For user, on the display screen, the menu with the functions "Adjustment" and "Work" selections are proposed. The function "Adjustment" allows to a user with help of the key buttons "Up" and "Down", "Menu" and "Ok" to install the following parameters: the date (day, month, year), the time, manual or automatic mode for the characteristics measuring, the sensors sampling periodicity (in minutes), and the measuring result record in PSD (permanent storage device), as well as the work time beginning and end.

The function "Work" runs one of three modes selected by the user: "Manual", "Automatic", or "Data transfer to PC".

In any of listed modes, "Program control core" is monitoring the battery voltage measuring, is making the device keyboard sampling with the data reporting on display.

3. At "Manual" operation mode, the measuring is making on the "Ok" button press. It is reading the current time from the real time clock chip, reading of the air temperature and humidity values, the illumination level (direct and indirect), recording of the date, time, sensor indications into the energy independent memory with the data reporting on display.

4. At "Automatic" operation mode, the measuring is started to be conducted on the preset time achievement. Reading of the current time from the real time clock chip, reading of the air temperature and humidity values, the illumination level (direct and indirect), recording of the date, time, sensor indications into the energy independent memory are produced. At automatic mode operation, the display supply is switched off, and the output of the sensors stored data doesn't occur.

5. "Data transfer to PC" function is intended for the device porting through the USB port to the personal computer. The obtained measuring results represent the text file there the data are represented as follows:

- The date and the time of the gagging carrying out, the serial number of the gagging;
- The serial number of the data-transmitter units (upward) 0 – 3. Where 3, the data-transmitter units, shows the values of the abiotic parameters over the vegetation level. The data-transmitter units 0–2 show the values of the abiotic parameters at I-III vegetation sublayers;
- Sensor readout.

The transport of the obtained data to the Personal Computer should be carried out in the operating system Windows and Linux using the programs with access to the virtual serial port, for example, Cutecom.

The checkup of the functional possibilities put in the designed device was carried out at the areas occupied by the conventionally undisturbed mire vegetation located on the Trukhanov island, Kyiv city.

5. Results of the research

The determination of the mire vegetation microclimatic condition dynamics were carried out at the conventionally undisturbed *Phragmito-Magno-Caricetea*class associations of Klika in Klika et Novak 1941 represented by the *Carici acutae-Glycerietum maximae* associations Jilek et Valisek 1964, *Typhetum latifoliae* Lang 1973, *Eleocharitetum palustris* Ubrizsy 1948. The microclimatic characteristic changes of considered cenosis are connected with the species composition, its density, the phytomass, the grass stand layer age, as well as the growth place conditions. The variability of these factors changes considerably the character of the solar radiation distribution at the considered associations that in the end, produces the impact on their heat, water and energy balance.

As the initial base point, for the determination of the paludal ecosystem vegetation microclimatic characteristic variability, the riverside sandy strip bare, close to the experimental areas was selected. The measuring of the microclimatic characteristic values at the pulpit was made at the height compliant to the mire vegetation cover sublayers. Their average values are represented at the Table 1.

6. Discussion of the results

The *Carici acutae-Glycerietum maximae* vegetation association put together 13 – 15 species, the general projective cover (GPC) consisted of 100%, the phytomass varied of 644 up to 1048 g/m^2 , average – 926.4 g/m^2. The dynamics of the microclimatic conditions values has changed in the following limits: the air temperature over the grass stand, min - 35.5°C, max – 36.5°C, average – 35.9°C; the relative air humidity min – 37.4%, max – 45.7%, average – 41.4%; direct illumination min – 57507Lx, max – 78520Lx, average – 63590Lx; indirect illumination min – 3503Lx, max – 4262Lx, average – 3841Lx; albedo min - 5.4%, max – 6.5%, average – 6%; at the 3rd sublayer, the air temperature value changed of min – 37.8°C, up to 38.7°C, average – 38.3°C; relative humidity min – 31.7°C, max – 36.6%, average – 33.4%; direct illumination min – 56770Lx, max – 80732Lx, average – 67461Lx; indirect illumination min – 3087Lx, max – 3594Lx, average — 3427Lx; albedo min – 3.8%, max – 6.2%, average – 5.2%. The data for II and I sublayers are represented at the Table 1. At the *Typhetum latifoliae* vegetation association, it is represented 2 – 4 species, GPC – 100%, the phytomass varied of 1556 up to 6108g/m^2, average – 4255g/m^2. The data for II and I sublayers for the given association are represented at the Table 1.

The *Eleocharitetum palustris* vegetation association put together 9 – 11 species, GPC – 100%, the phytomass varied of 368 up to 1148 g/m^2, average – 610 g/m^2. The data for II and I sublayers are represented at the Table 1.

Table 1

Microclimatic characteristic value changes of *Phragmito-Magno-Caricetea* class association

Grass stand sublayer	Air temperature (C)			Relative air humidity (%)			Illumination (Lx)						Albedo (%)		
							direct			indirect					
	x	min	max	x	min	max	x	min	max	x	min	max	x	min	max
Carici acutae-Glycerietum maximae															
Over grass stand	35,9	35,5	36,5	41	37	46	63590	57508	78520	3842	3502	4262	6,1	5,4	6,6
III	38,3	37,8	38,7	33	32	37	67461	56771	80732	3427	3087	3594	5,2	3,8	6,2
II	37,4	36,1	38,8	40	39	42	23806	5368	62669	640	66	1284	6,4	0,2	18,1
I	34,3	33,1	36,9	48	44	53	11572	1290	37786	29,3	9	63	0,5	0,2	0,7
Typhetum latifoliae															
Over grass stand	28,9	28,6	29,6	57	49	61	65249	57508	79258	61546	53292	75525	5,8	3,9	7,3
III	28,7	27,3	30,2	53	47	60	26254	7004	77414	23786	5564	75007	20,5	3,1	29,9
II	30,0	29,1	30,6	53	49	54	54755	6682	77783	2935	1394	4585	8,9	3,9	20,9
I	30,3	28,3	32,5	56	52	60	2693	2177	3133	153	107	207	5,7	3,5	7,9
Eleocharitetum palustris															
Over grass stand	26,9	25,7	28	56	52	60	12481	1901	18248	1388	622	2004	14,4	7,3	32,7
III	26,4	24,6	27,3	54	49	62	7995	3364	16128	766	307	1319	10,0	6,7	12,3
II	30,1	24,0	27,9	52	48	69	7144	2592	16036	513	81	1267	5,8	2,3	10,2
I	27,8	24,1	31,6	53	43	67	3935	392	9861	113	2	269	2,3	0,5	4,4
Sandy beach															
Over grass stand	42,9	-	-	33	-	-	72662	-	-	18524	-	-	25,5	-	-
III	31,0	-	-	37	-	-	73359	-	-	15465	-	-	21,1	-	-
II	26,9	-	-	37	-	-	63775	-	-	17787	-	-	27,9	-	-
I	25,8	-	-	42	-	-	63775	-	-	10045	-	-	15,8	-	-

The obtained result analysis showed that all experimental areas of the mire vegetation are characterized by 1.2–1.5 multiple lesser value of the air temperature over the grass stand in comparison with controls ones. Vertical temperature gradient at the grass stand of all sublayers of the mire vegetation is bigger on 15–20% in comparison with control readings. The data of the relative air humidity over the grass stand at the experimental areas were higher on 30–45% than the control ones. The analysis of vertical gradient of the relative air humidity value showed that at III sublayer of considered cenosis, they were at 3–5% lesser than over the grass stand, whereas at II and I sublayers, the values of the air humidity increased a few (Table 1). Such distribution at the vertical cenosis structure of the relative air humidity values is explained by this that at III sublayer, two airflows intermixing occurs.

First, that is over the grass stand, and second one, that arises up from II and I sublayers. So, like this, the moisture transport process from the vegetation to the ground atmosphere occurs.

The temperature and the relative air humidity are one of the basic limiting factors for the vegetation existing. It was noted, that the environment factors of the considered cenosis form some specific areas defining the conditions of their habitat at the given territory (Fig. 3a).

The vertical change gradient of direct, indirect illuminations and albedo of paludal cenosis is characterized, practically, by linear dependence of the values dropping, depending of the vegetation sublayers state, and were at 1.5–2 times less than the control values (Table 1).

The direct and indirect grass stand illumination, also are the basic limiting factors for the vegetation development. It was identified, that the *Carici acutae-Glycerietum maximae* and *Typhetum latifoliae* cenosis, form two separated areas, that correspond to III and I grass stand sublayers (Fig. 3b). Such a distributionn is stipulated by the vertical cenosis structure with the species predominance at III and I sublayers. The *Eleocharitetum palustris* vegetation association is characterized by dense vertical species distribution that stipulates the compact area of the values distribution.

For the revelation of interdependency between the habitat formation role change and the type of cenosis organization, the comparative analysis of the microclimatic characteristic changes with the normalization of obtained results was carried out.

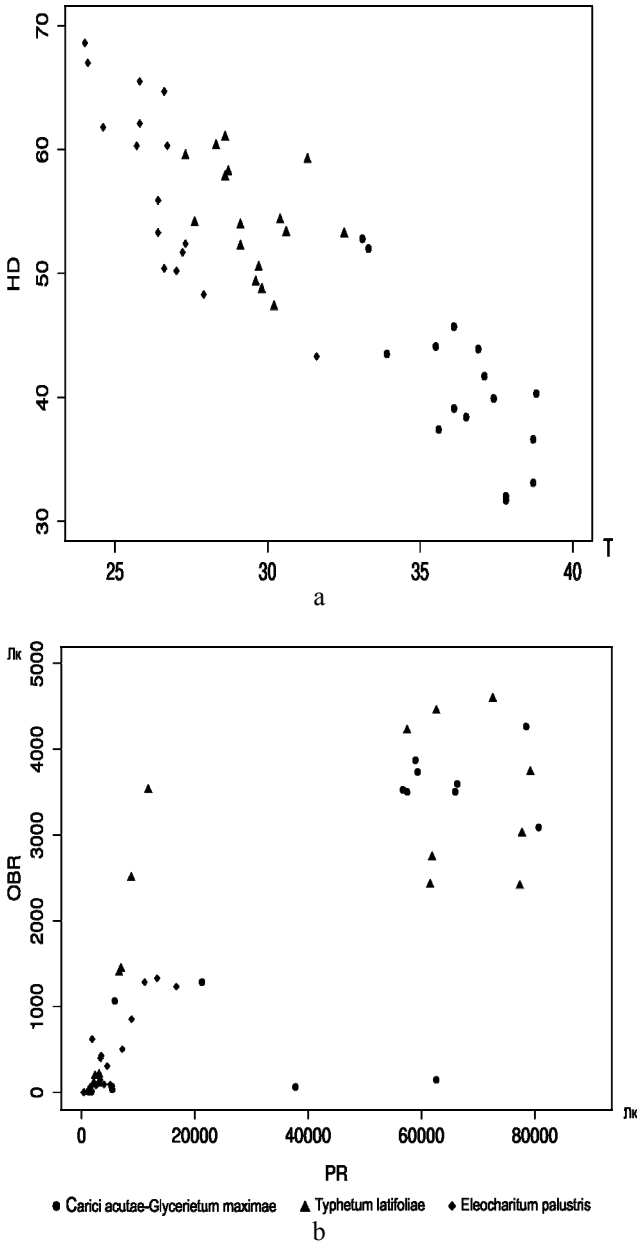

Fig. 3. Distribution of the basic microclimatic characteristics at the cenosis class Phragmito-Magno-Caricetea (Flood-lands of the Dnipro river, close to Kyiv city, Ukraine). Legend: T – air temperature in C, HD – relative air humidity in %, PR – direct solar radiation, OBR – indirect solar radiation.

In the capacity of 1, it was selected the values over the grass stand and was made the diagram of normalized value changes of the mire vegetation cenosis microclimatic characteristic (Fig. 4). The vertical gradient changes of the normalized temperature values and the relative air humidity for all considered cenosis are, practically, the same.

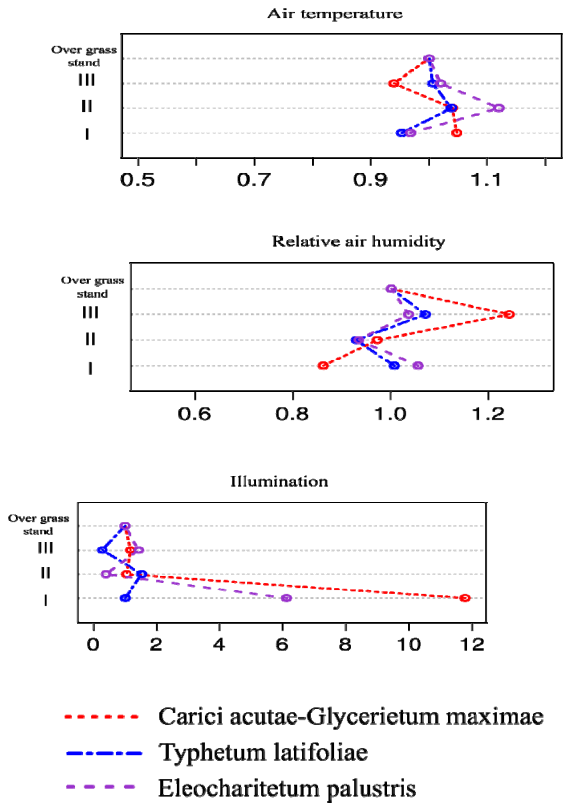

Fig. 4. Microclimatic characteristic value changes of the *Phragmito-Magno-Caricetea* class associations.

7. Conclusions

The question on the dependency form of the vegetation ecological role in the natural settings has not only practical importance, but vital theoretical significance, as the consequence transformation, in particular, the ecosystems, leads to the limit of their buffer possibilities and to the cessation of work on supporting of the existing soil and atmosphere balances. The systematic observation carrying out for the environment forming role change of the different ecosystem types under natural conditions, and under the anthropogenic impact, as well as the measures forming on the base of the obtained results, aimed to their conservation, recovery and inexhaustible use, is important and burning question. The analysis of the direct anthropogenic impact to the vegetation environment forming role, taking into account the nature changes, the most reasonably is to realize on the base of the complex approach – the consequence consideration of the basic factor impact to the ecosystem elements, the clarification of the relationships between them, the determination of the character and their interconnection direction. Evidently, to form the national policy on the anthropogenic impact consequence minimization, it

is necessary to carry out the permanent comprehensive tests aimed to the change determination of the vegetation microclimatic characteristics of the different ecosystem types.

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Технологія нового інструментального методу оцінки мікрокліматичних умов рослинного покриву.

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Мета: Розробка і апробація програмно-апаратного комплексу для вимірів основних мікрокліматичних характеристик в рослинному покриві. **Методи:** Комплекс дозволяє одночасно вимірювати температуру і вологість повітря, пряму і зворотну освітленість в під`ярусах і над

травостаном із занесенням отриманих даних в постійно запам'ятовуючий пристрій. **Результати:** Перевірка функціональних можливостей приладу, проведена на дослідних ділянках болотної рослинності (угруповання класу Phragmito - Magno - Caricetea Klika in Klika et Novák 1941) показала відповідність заявлених характеристик з отриманими результатами. **Обговорення:** Питання про форму залежності екологічної ролі рослинності в природних умовах має не лише практичне, але і дуже важливе теоретичне значення, оскільки подальша трансформація зокрема екосистем веде до межі їх буферних можливостей і припинення роботи по підтримці існуючих балансів ґрунту і атмосфери. Проведення систематичних спостережень за зміною средоутворючої ролі рослинності різних типів екосистем в природних умовах і під впливом антропогенних чинників, а також формування на основі отриманих результатів заходів спрямованих на їх збереження, відновлення і невичерпне використання є важливою і актуальною проблемою.

Ключові слова: автоматизація; прилад; моніторинг; мікроклімат; природокористування.

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Технология нового инструментального метода оценки микроклиматических характеристик растительного покрова.

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Цель: Разработка и апробация программно-аппаратного комплекса для измерений основных микроклиматических характеристик в растительном покрове. **Методы:** Использование комплекса позволяет одновременно измерять температуру и влажность воздуха, прямую и обратную освещенность в подъярусах и над травостоем с занесением полученных данных в постоянно запоминающее устройство. **Результаты:** Проверка функциональных возможностей прибора, проведённая на опытных площадках болотной растительности (сообщества класса Phragmito-Magno-Caricetea Klika in Klika et Novák 1941) показала соответствие заявленных характеристик с полученными результатами. **Обсуждение:** Вопрос о форме зависимости экологической роли растительности в природных условиях имеет не только практическое, но и весьма важное теоретическое значение, поскольку дальнейшая трансформация в частности экосистем ведёт к пределу их буферных возможностей и прекращению работы по поддержанию существующих балансов почвы и атмосферы. Проведение систематических наблюдений за изменением средообразующей роли растительности различных типов экосистем в природных условиях и под воздействием антропогенных факторов, а также формирование на основе полученных результатов мероприятий направленных на их сохранение, восстановление и неистощимое использование является важной и актуальной проблемой.
Ключевые слова: автоматизация; прибор; мониторинг; микроклимат; природопользование.

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