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**ANALYSIS OF VERTICAL
LANDSCAPING AND
RECOMMENDATIONS FOR ITS
IMPROVEMENT IN THE CLOSED
ENVIRONMENT**

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*The article presents scientific and experimental research on the prospects for creating «green constructions» for the design of an enclosed environment when landscaping interiors, special-purpose facilities such as halls and foyers of educational institutions. The evaluation of decorative qualities and selection of crops for the design of «green constructions» in the interior of an enclosed environment was carried out on the basis of Vinnytsia National Agrarian University. The ecological and decorative value of ornamental plants for modern landscaping has been proven. During the study, 5 plant species with similar eco-biological characteristics were selected. All of these plant species are shade-tolerant, i.e. well adapted to low-light conditions, which is an important factor for growing indoors. They also require moderate watering, with some variations in the frequency and intensity of watering in summer. In addition, all of these plants demonstrate resistance to diseases and pests, making them suitable for use in the design of green constructions. Based on the data obtained, the scientific basis for the introduction of promising plant species into culture and the peculiarities of organizing space in the interior were developed. It has been proven that the following species are the most appropriate for creating modern garden compositions in a closed environment: *Hedera helix* «Green Ripple», *Syngonium podophyllum* «Pixie», *Chlorophytum comosum* «Variegatum», *Nephrolepis exaltata*, *Aglaonema* «Suksom Jaipong», that meet all the requirements for the correct selection of plants of this design. It was found that the cost of a 2.5 m² green construction with 90 plants in a closed environment is 58425 UAH, with the highest cost being the design of the modular system – 70% (41100 UAH). While the amount of costs for plant communities is 30% (17310 UAH) of the total cost of the system. It is noted that the possibility of introducing an environmentally friendly and aesthetic way to improve the health of the population will attract the attention of specialists involved in the design of buildings for various purposes.*

Key words: vertical gardening, green constructions, interior, design, phytodesign.

Table 5. Fig. 2. Lit. 17.

Statement of the problem. The human desire to be alone with nature and enjoy the beauty of the world around us has led landscape designers to search for new original plant species to implement design solutions in phytodesign [1]. The result of these searches was the idea of using vertical gardening in the living space. Recently, the use of vertical compositions has become very popular. This is due to space saving in the apartment, the use of phytomodules for zoning, and improving the air microclimate by saturating the air with oxygen [2]. Modern technologies make it possible to create «green constructions» with visualization of decorative solutions using a variety of plants, ranging from herbaceous plants and flower plants to shrubs. According to literature, it is known that the use of vertical gardening in the interior can achieve spectacular technological solutions:

– use of monoculture (moss, vines, ivy, etc.) over the entire wall area or its separate part or several parts. For example, to highlight a seating area, greenery is placed above the sofa or symmetrically on either side of it;

- placement of plants in horizontal rows or diagonally, which gives a visual expansion of the room space;
- creation of a geometric composition with a protruding central part and lower-growing plantings along the edges;
- creating a composition of green plants, periodically diluted with flowering specimens as interior accents.

Research and publication analysis. Climbing plants are characterized by multifaceted qualities when used in landscaping. They play a great positive hygienic and practical architectural and decorative role, have economic and, in some cases, special importance. The application and use of climbing plants are diverse. They are widely used for decoration of gazebos, trellises, fencing of sports and other playgrounds, for shading pedestrian and driving roads («green tunnels»), for shading and decoration of balconies, terraces, facades of houses, for decoration of pavilions, fences, grottoes, arches, retaining walls, etc. Interior landscaping is a part of interior design that will help create coziness and a favorable atmosphere. The green color of plants is very good for the eyes, which allows a person to relax even in a very stressful situation. Therefore, considering such properties of plants, it is quite clear why they are placed in offices. Landscaping of the office is the creation of comfortable conditions for employees, customers, partners by selecting and correctly placing plants from an aesthetic and ecological point of view [3]. Office interiors can be ennobled by three types of landscaping: fragmentary (decoration with details), complex (large groups of plants) and temporary (festive decoration). Offices, as a rule, order exactly fragmentary landscaping, during which small compositions, single and group plants are used, located both in the vertical and horizontal planes. Properly located plants in the office space will look luxurious and will complement the interior advantageously. The plants should correspond to the dimensions of the room, be healthy, have an attractive appearance, do not disturb and be easy to care for. Plants can be placed stationary or in mobile containers. They are planted in identical designer pots or ordinary containers that are placed in planters. Containers [4] can also be used. Large solitaires are perfect for spacious offices, corridors, halls. Such plants attract the eye, give solidity to the room and can be used to separate different zones. Examples of plants that can serve as a solitaire are ficus, palms, vines (philodendron, grapes, thunbergia, hoyo, monstera), ampelous plants (zygocactus, columnea, chlorophytum), variegated plants (begonia, caladium, codieum, cordylina), and also some decorative flowering plants (hydrangea, pelargonium, cyclamen) [2].

It is customary to place such plants in pots that match the interior style. Solitaires are the most popular and optimal form of landscaping. Landscaping is also possible in other ways. Small plants located near the workplace or in the rest room will create coziness and comfortable conditions at the workplace. These can be plants such as streptocarpus, chlorophytum, gloxinia, synningia, peroromia, as well as most succulents [1]. If there is a large area of the room, you can create compositions or apply vertical landscaping. The compositions are located, mainly, in spacious rooms

where they will not create obstacles (corridors, halls). The plants can be placed in one large container or each one in a separate pot. In turn, the pots with the plants are placed in the planter and sprinkled with decorative soil. Today, vertical landscaping in the form of phytowalls and phytomodules is relevant. This landscaping option solves such design tasks as the allocation of functional zones and the creation of an original interior. Landscaping with fresh flowers creates the effect of a park area and improves the microclimate. It is necessary to give preference to plants that are combined in color, texture and size of leaves. It is better if the plants are bushy, the same in habit size and without a pronounced trunk. Decorative plants, such as bromeliads, are used for these purposes [1]. The idea is based on planting plants in a special structure. Due to the system of automatic watering and illumination with phytolamps, the «green» wall requires minimal care [4]. As a result of the study of the features of the landscaping of the premises, options for the landscaping of the office were proposed. As the best option, vertical gardening and the possibility of its application were considered.

Material and methods of research. Today, phytodesign requires the scientifically based introduction of plants into interiors, which should create an aesthetically pleasing and comfortable environment for humans. In addition, the action of plants should be aimed at disinfecting indoor air from pathogenic microflora, cleaning the airspace from industrial dust and gas. No less important are the issues of air ionization and humidification, sound absorption, and most importantly, air enrichment with oxygen [2, 3, 4]. This is possible only with a qualitative selection of plant species composition for landscaping interiors of various functional purposes, taking into account the microclimate of the premises and the bio-ecological characteristics of phytocoenoses (Table 1).

Table 1

Ecological and biological features of priority plants for the design of «green constructions» in the interior of an enclosed environment

Types of plants	Attitude to light	Attitude to moisture	Resistance to diseases and pests
<i>Hedera helix</i> «Green Ripple»	Shade-tolerant	Moderate and regular watering	The plant is resistant
<i>Syngonium podophyllum</i> «Pixie»	Shade-tolerant	Moderate watering	The plant is resistant
<i>Chlorophytum comosum</i> «Variegatum»	Shade-tolerant	Moderate to abundant watering in summer	The plant is resistant
<i>Nephrolepis exaltata</i>	Shade-tolerant	Moderate to abundant watering in summer	The plant is resistant
<i>Aglaonema</i> «Suksom Jaipong»	Shade-tolerant	Moderate and regular watering	The plant is resistant

source: formed on the basis of own research

The assessment of the eco-biological characteristics of priority plants for the construction of a green wall (phytomodule) takes into account such indicators as the relationship to moisture; the relationship to light; plant resistance to diseases and pests; the possibility of using the studied species for landscaping the phytomodule. In

the course of the study, 5 plant species with similar eco-biological characteristics were selected. All of these plant species are shade-tolerant, i.e. well adapted to low light conditions, which is an important factor for growing indoors. They also require moderate watering, with some variations in the frequency and intensity of watering in summer. In addition, all of these plants demonstrate resistance to diseases and pests, making them suitable for use in the design of green constructions. «Green constructions» is the creation of an open recreational space that provides an opportunity to learn among nature in a new, relaxed format. The creation of such a project will help to reach a new level in recreational activities (Table 2).

Table 2

General data on the object

№	Type of work	Constructional features
1	Vertical gardening system	«green constructions»
2	Landscaping dimensions, area m2	2,5
3	Type of system	block «Green Block»
4	Surface of the composition	front
5	Construction color	white
6	Number of plants used, pcs.	90
7	The watering system	running water
8	Lighting system	Energy-saving phytolamps

source: formed on the basis of own research

The vertical gardening system consisted of blocks, special fasteners for the blocks to the main surface of the wall, facing ends, a pump, an irrigation station, pipes and drippers, a water inlet tray, and planting material (Fig. 1).

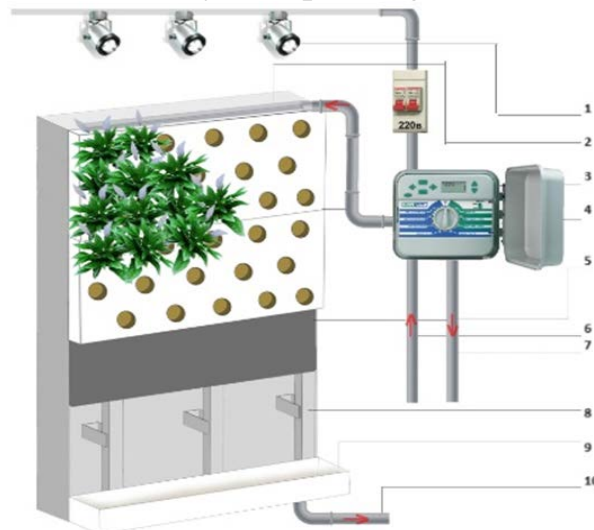


Fig. 1 Technical design scheme of the «Green Block» vertical gardening system

1. Additional illumination; 2. A pipe of drip irrigation; 3. An automated irrigation station; 4. The blocks; 5. Waterproof basic panel; 6. Water supply to the irrigation station; 7. A pipe to the sewer network; 8. Guides; 9. Water tray; 10. A pipe into the sewer network with a siphon.

source: formed on the basis of own research

Research results and their discussion. Professionally made “green structures” made of indoor plants should be equipped with an automatic micro-drip irrigation system, but if the composition is small, it should be arranged in such a way as to create constant access for regular watering. The lighting model has a backlight consisting of two phytolamps with a control unit located on the top panel of the module. It is powered by a 220V network. It has been established that the phytomodule as an element of vertical interior landscaping has high decorative and aesthetic qualities, a long decorative period and high ecological value, which made it possible to consider this composition promising for widespread implementation and for improving the state of landscaping of various types of premises.

The assortment list of plants for the formation of «green structures» includes such indicators as (Table 3): species diversity of indoor plants, their quantitative composition for wall decoration; origin and natural habitat and some decorative features, including plant size, bush habit, features of leaves, flowers, fruits.

Table 3

The assortment list of plants of «green constructions» in the interior of a closed environment

Types of plants	Quantity, pieces	Family.	Origin	Decorative features
<i>Hedera helix</i> «Green Ripple»	29	Araliaceae	Forests of Europe and Western Asia	Decorative deciduous, ampelous
<i>Syngonium podophyllum</i> «Pixie»	20	Araceae	Tropical forests of Central and South America	Decorative deciduous, ampelous
<i>Chlorophytum comosum</i> «Variegatum»	14	Liliaceae	Subtropical regions of South America, Africa, South Asia, Australia	Decorative deciduous, ampelous
<i>Nephrolepis exaltata</i>	21	Nephrolepidaceae	Subtropical and tropical regions of the globe	Decorative deciduous, ampelous
<i>Aglaonema</i> «Suksom Jaipong»	6	Araceae	South Asia, India, China	Decorative deciduous
Total, pcs.	90			

source: formed on the basis of own research

Thus, we propose to use 90 indoor plants to form the phytomodule: *Hedera helix* «Green Ripple» – 29 pcs, *Syngonium podophyllum* «Pixie» – 20 pcs, *Chlorophytum comosum* «Variegatum» – 14 pcs, *Nephrolepis exaltata* – 21 pcs, *Aglaonema* «Suksom Jaipong» – 6 pcs. To treat the plants before planting them in pots, we used the growth stimulator Kornevin (0.1%, i.e. 1 gram of Kornevin per 1 liter of water).

As a result of the research, it was determined that the priority species for the formation of the phytomodule and its use in interior landscaping are the following (Table 4): *Hedera helix* «Green Ripple», *Syngonium podophyllum* «Pixie», *Chlorophytum comosum* «Variegatum», *Nephrolepis exaltata*, *Aglaonema* «Suksom

Table 4

Options for the use of vertical gardening in the interiors of a closed environment

Types of plants	Use in interior landscaping
<i>Hedera helix</i> «Green Ripple»	Vertical gardening: living walls, modules, hanging pots and structures
<i>Syngonium podophyllum</i> «Pixie»	Compositions, pot culture, vertical gardening: green walls, modules, planters, hanging baskets, stands and structures
<i>Chlorophytum comosum</i> «Variegatum»	Compositions, flowerpots, pot culture, greening of living walls, phytomodules
<i>Nephrolepis exaltata</i>	Vertical landscaping: living walls, modules, paintings, hanging baskets and structures
<i>Aglaonema</i> «Suksom Jaipong»	Compositions, pot culture, landscaping of living walls, phytomodules for vertical gardening

source: formed on the basis of own research

Jaipong», which meet all the requirements for the correct selection of plants of this design (Fig. 2).

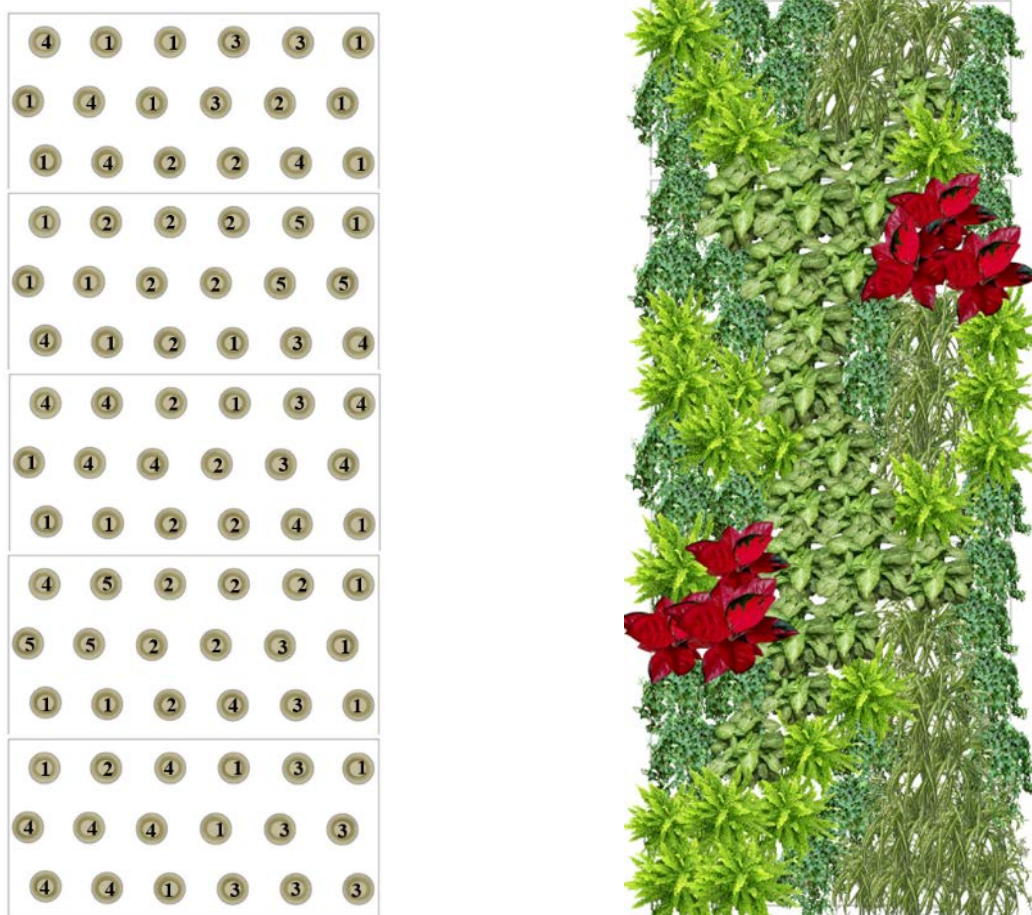


Fig. 2 Planting drawing and visualization of the phytomodule

1 – *Hedera helix* «Green Ripple»; 2 – *Syngonium podophyllum* «Pixie»; 3 – *Chlorophytum comosum* «Variegatum»; 4 – *Nephrolepis exaltata*; 5 – *Aglaonema* «Suksom Jaipong»

source: formed on the basis of own research

Thus, the «green construction» as an element of vertical interior landscaping has a high decorative and aesthetic value, a long decorative period and ecological significance, and this allows us to consider such a composition promising for widespread implementation and for improving the state of landscaping of various types of premises. The inclusion of such an element of landscaping as a phytomodule in the interior is a scientifically based task of a modern interior designer, and its use will create conditions not only to ensure the comfort of the human environment, but will also be a prerequisite for the formation of a special ethical climate that will promote the cultivation of a careful attitude towards nature, expanding the recreational functions of indoor plants. In the course of the study, we calculated the economic costs of plant communities and materials for the arrangement of a «green construct» (Table 5).

Table 5

Economic evaluation of the design of «green constructions» in the interior of an enclosed environment

Types of plants	Quantity, pieces	Cost, UAH/piece	Total cost, UAH
Plant material			
<i>Hedera helix</i> «Green Ripple»	29	85	2465
<i>Syngonium podophyllum</i> «Pixie»	20	310	6200
<i>Chlorophytum comosum</i> «Variegatum»	14	160	2240
<i>Nephrolepis exaltata</i>	21	185	3885
<i>Aglaonema</i> «Suksom Jaipong»	6	420	2520
Total	90		17310
Constructions and lighting			
Modular system with substrate	2,5 m ²	1 m ² 15000	37500
Energy-saving phytolamps	3	1200	3600
Total			41100
Additional materials			
Kornevin	10 г	15	15
Total, UAH			58425

source: formed on the basis of own research

It has been established that the cost of installing a 2.5 m² «green construction» with 90 plants in a closed environment is 58425 UAH, with the largest cost being the construction of a modular system – 70% (41100 UAH). While the cost of plant communities is 30% (17310 UAH) of the total cost of the system.

Conclusions and prospects for further research. The technology of vertical gardening is innovative not only for Ukraine but also for the whole world, as there are no scientific principles of using plants to improve the air environment of buildings. However, due to the growing attention to phytodesign, this technology (or its individual elements) can be widely used in the landscaping of newly constructed industrial, public and private buildings. This will improve the health and quality of life of the population, reduce losses from temporary disability, and have a pronounced social and economic effect. Expanding the range of plants for vertical gardening using design methods will make it more accessible. It is the possibility of

introducing an environmentally friendly and aesthetic way to improve the health of the population that will attract the attention of specialists involved in the design of buildings for various purposes.

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АННОТАЦІЯ

АНАЛІЗ ВЕРТИКАЛЬНОГО ОЗЕЛЕНЕННЯ ТА РЕКОМЕНДАЦІЇ ЩОДО ЙОГО ВДОСКОНАЛЕННЯ В ЗАКРИТОМУ СЕРЕДОВИЩІ

У статті наведено науково-експериментальні дослідження з вивчення перспектив створення «зелених конструкцій» задля проектування закритого середовища під час озеленення інтер'єрів, об'єктів спеціального призначення – холів і фойє закладів освіти. Проведення оцінки декоративних якостей та підбору культур для проектування «зелених конструкцій» в умовах інтер'єру закритого середовища здійснювали на базі Вінницького національного аграрного університету. Доведено екологічне й декоративне значення декоративних рослин для сучасного озеленення інтер'єрів. Під час проведення дослідження було вибрано 5 видів рослин зі схожими екобіологічними особливостями. Усі зазначені види рослин є тіневитривалими, тобто добре пристосованими до умов недостатнього освітлення, що є важливим фактором для вирощування у закритих приміщеннях. Вони також вимагають помірного поливу, з деякими варіаціями в частоті й інтенсивності поливу влітку. Крім того, усі ці рослини демонструють стійкість до хвороб і шкідників, що робить їх придатними для використання у проектуванні «зелених конструкцій». На основі одержаних даних розроблено наукові основи введення у культуру перспективних видів рослин й особливості організації простору в інтер'єрі. Доведено, що для створення сучасних садових композицій в умовах закритого середовища найбільш доцільними у використанні є такі види: Плющ звичайний «Грін Ріпл» (*Hedera helix* «Green Ripple»), Сингоніум Подофілум «Піксі» (*Syngonium podophyllum* «Pixie»), Хлорофітум чубатий «Варієгантна» (*Chlorophytum comosum* «Variegatum»), Нефролепіс піднесений (*Nephrolepis exaltata*), Аглаонема «Суксом Джайпонг» (*Aglaonema* «Suksom Jaipong»), які відповідають усім вимогам правильного підбору рослин такої конструкції. Встановлено, що рівень затрат на влаштування «зеленої конструкції» площею 2,5 м² із 90 рослинами в умовах закритого середовища становить 58425 грн, водночас найбільшу вартість становить конструкція модульної системи – 70 % (41100 грн). Тоді як сума витрат на рослинні угруповання становить – 30 % (17310 грн) від загальної вартості системи. Відзначено, що можливість впровадження екологічного й естетичного способу оздоровлення населення приверне увагу фахівців, які займаються проектуванням будівель різного призначення.

Ключові слова: вертикальне озеленення, зелені конструкції, інтер'єр, проектування, фітодизайн.

Табл. 5. Рис. 2. Літ. 17.

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