Improvement of the safety of multi-floor housing

IOP Conf. Series: Materials Science and Engineering **907** (2020) 012064 doi:10.1088/1757-899X/907/1/012064

Improvement of the safety of multi-floor housing

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Abstract. To improve the safety in common areas of multi-storey buildings (lift halls, common corridors), it is proposed to renovate interiors of the areas. Such areas usually have no permanent ventilation. Thus, they can accumulate pathogenic microorganisms and viruses. The effective solution for reducing the danger is phytoncides plants. For successful phytodesign, an assortment of phytoncides plants of 11 species has been developed: *Aspidistra elatior*, *Aglaonema "Silver queen"*, *Aglaonema "Maria"*, *Chlorophytum comosum*, *Chlorophytum capense*, *Dracena marginata*, *Monstera deliciosa*, *Philodendron scandens*, *Sansevieria triaeffieria trichelifera*, *Zamiaculcas zamiifolia*. The offered assortment completely corresponds to climatic features of premises. For the normal growth and development of plants in the absence of natural light, three options for additional effective illumination are proposed.

1. Introduction

The main components of the sustainable development [1-2] concept are social, economic and environmental. The social component, among other things, is about improving people's health. The residential area of the modern city has individual and multi-apartment buildings. In the first kind of apartments, all rooms can be easily fitted for comfortable living of residents. They can set comfortable climate, illumination etc. and take care of their safety. It is possible to use energy efficient equipment for microclimate [3-4] and energy supply [5-6]. However, there are problems even in such kind of buildings, especially if builders and assembly workers made mistakes or dwellers of neighbouring houses violate building and sanitary standards. Examples are the supply of radon [7-11] and moisture [12-13], the growth of fungi and so on. All these factors contribute to the development of the sick building syndrome [14-19], especially if the proper air exchange is not provided on the premises to save energy.

In apartment houses, it is more difficult to create a safe environment due to dependence on collective systems, possible unauthorized interventions in the systems and violations of sanitary-hygienic requirements by neighbours. Public areas are especially dangerous: lobbies, lift halls, inter-corridors, stairwells etc. Together with outerwear, pets and during coughing or sneezing, microorganisms and viruses are constantly brought there. When used improperly (smoking, storage of garbage, old things, bicycles, sleighs, baby carriages etc.), harmful substances and microorganisms enter the area. It worsens people's health.

In modern high-rise building lift halls and inter-corridors are performed without natural lighting and ventilation, which leads to the absence of insulation and close to zero air exchange. This poses a direct threat to the uncontrolled growth of pathogens and the spread of viral infections, especially airborne (*Adenoviridae, Coronaviridae, Orthomyxoviridae, Picornaviridae, Paramyxoviridae* etc.). The growth of fungi leads to the release of strong carcinogens – mycotoxins. Chemical methods of disinfection incl. chlorine and spirits are harmful to humans causing intoxication and irritations. Lift halls are usually separated from other rooms. They are not a part of fire escape routes.

One of the effective methods of dealing with these threats is biological – phytodesign of premises. As early as the 1930s, Boris Tokin discovered phytoncides – volatile biologically active substances released by plants that kill or slow down the growth of bacteria, fungi, and protozoa [20]. Professor D. Verderevsky hypothesized about the effect of phytoncides on viruses. His follower N. Moldovan proved the influence of phytoncides against individual viruses. After that, the antiviral effect was confirmed by many scientists [21].

NASA scientists have proven that different types of houseplants can absorb harmful emissions. However, different species respond to the volatile organic matter in different ways. Some prefer to absorb formaldehyde from the atmosphere, while others absorb acids or toluene. NASA experts have calculated the total coefficient of effectiveness of air purification by plants. It was obtained taking into account the degree of danger of the absorbed gases, the width of their spectrum, and the rate of their absorption. This coefficient is expressed in units from 0 to 10 [22]. Based on the analysis, we propose using this biological method of phytodesign for public areas of apartment buildings.

The purpose of the work is the recommendations of a renovation of interiors for public areas of apartment buildings.

Tasks of work:

1. Selection of the optimal range of phytoncidal tropical and subtropical plants based on many years of author's research taking into account the climatic conditions of the experimental interiors;
2. Propositions for additional effective illumination to adapt the limiting abiotic factor of illumination in the public areas without natural illumination.

2. Object and research methods

This work is based on long-term studies of the ecology and volatile properties of houseplants [23-28]. Preferably, these are tropical and subtropical plants, which are divided into three groups:

1. By morphological and physiological characteristics;
2. By climatic factors;
3. By useful properties (Figure 1).

Combining knowledge of climatic features of the interior and plant classification is the key to successful and efficient phytodesign. The efficiency and success of phytodesign are determined by the life expectancy of plants in the interior while preserving decorative qualities and beneficial properties. This is especially important for the creation of disinfection interiors. The ability of phytoncide emission, harmful substances absorption from the air, as well as dust catching and maintenance of comfortable air humidity depends on the morphological and physiological properties of plants.

Plant phytoncidal properties were determined by the method of passive sedimentation using sanitary indicative bacteria [29]. Determination of the influence of phytoncides on moulds was determined by the method of L. A. Grape [30]. The common areas in apartment buildings were considered:

- lift lounges, 2×4 m on the floor plan;
- apartment areas, 2×7 m on the floor plan.

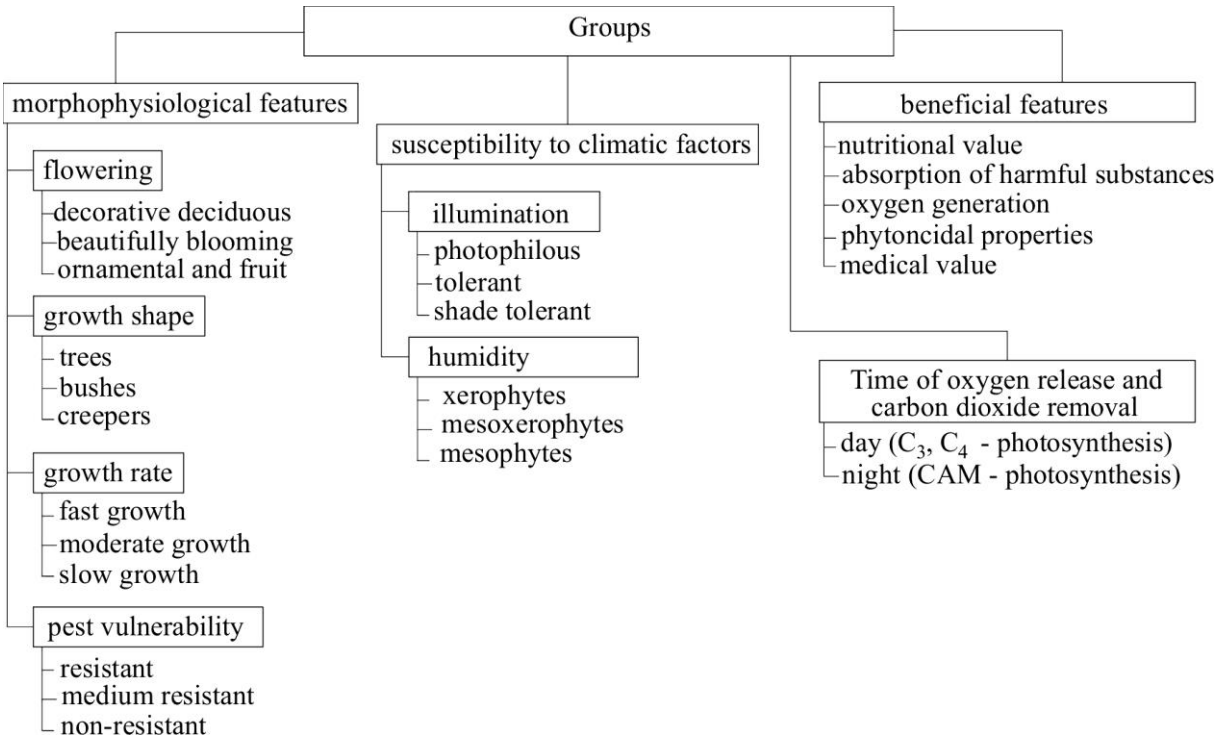

Figure 1. Classification of plants by useful properties.

There is no daylight, which promotes the development of pathogenic microflora. Therefore, it was decided to create or renovate interiors of these premises achieving the goals of healthy environment and effective growth of plants with minimum maintenance and energy consumption. For interiors of this type it is necessary to select plants that meet the following requirements:

- decorative-deciduous (have a significant amount of leaf mass, which can precipitate dust, release phytoncides and moisten the room air);
- trees and shrubs with a compact or ampelous shaped crown, which does not interfere with the movement of people and the movement of household and sports items: bicycles, baby carriages, sledges, scooters, etc.;
- moderately growing plants whose crown requires minimal care and pruning;
- resistant to diseases and pests;
- non-poisonous;
- shade durable (able to grow in the interior without daylight);
- xerophytic (resistant to dry air and substrate);
- phytoncydal;
- ability to absorb harmful substances from the air;
- unpretentious in care.

3. Research results

The author's research has found that for effective air purification of a room of 18 m^2, 5 - 7 plants with a height from 60 cm to 1.0 - 1.5 m are needed [24]. We have proposed the range of plants (Table 1), which consists of 11 species. For a room of 8 m^2 2 - 3 plants are enough. For the convenience of moving people, we recommend using ampelous plants in wall pots: *Philodendron scandens* and *Chlorophytum*. For visual improvement, five staggered pots are enough (Figure 2).

For a room of 14 m^2 four plants are enough to place along the free wall. Here we recommend choosing small trees and tall bushes, for example, *Dracena marginata*, *Aspidistra elatior*, *Philodendron scandens* (on support), *Zamiaculcas zamiifolia* (Figure 3 and Figure 4). It is possible to

create any composition of plants from the range offered to fit the liking of residents. The main thing is to place the plants so that they do not interfere with the movement of residents with any things.

Table 1. An assortment of phytoncidal plants for the creation of disinfection interiors for multi-apartment buildings

Name of the plant	Form of growth	Height, m	Coefficient of the effectiveness of air purification [22]
	Asparagaceae family		
Aspidistra elatior	bush	0.7	data is missing
Dracena marginata	small tree	1.5-2.0	7.8
Chlorophytum comosum	bush	0.35	7.8
Chlorophytum capense	bush	0.35	7.8
Sansevieria trifasciata Laurentii	bush	0.60	6.8
	Araceae family		
Aglaonema "Silver queen"	bush	0.50	6.8
Aglaonema "Maria"	bush	0.60	6.8
Monstera deliciosa	liana	≥ 0.6-2.0	data is missing
Philodendron scandens	liana	≥ 0,6-2,0	7,0
Zamiaculcas zamiifolia	bush	0,5-1,0	data is missing
	Araliaceae family		
Schefflera "Nora"	small tree	2,0	8,0

Our offered assortment consists of shade-resistant plants. Nevertheless, no plant can live without light. In the absence of natural illumination, artificial lighting must be used, which satisfies the requirements of effective photosynthesis of plants, safety and human comfort.

For this purpose, the spectrum of chlorophyll absorption and human eye perception was analyzed, as well as the spectrum of UV radiation that is safe and dangerous for humans. Effective and safe illumination for plants can be provided by LED phytolamps. However, they do not meet the conditions of human comfort due to the lack of green light, which is most effectively felt by human eyes.

The photosynthesis surfaces of plants reflect the green radiation. This forms the green colour of leaves. Because of this, when the phytolamps are illuminated, the decorative qualities of the plants are reduced and leaves appear grey or black. There are three effective illumination options available from currently available sources at the market:

- a combination of general lighting with phytolamps and green LED lamps;
- combination of general illumination with white lamps and ultraviolet LED lamps;
- general white illumination and local illumination of the plant area by ultraviolet LED lamps or phytolamps.

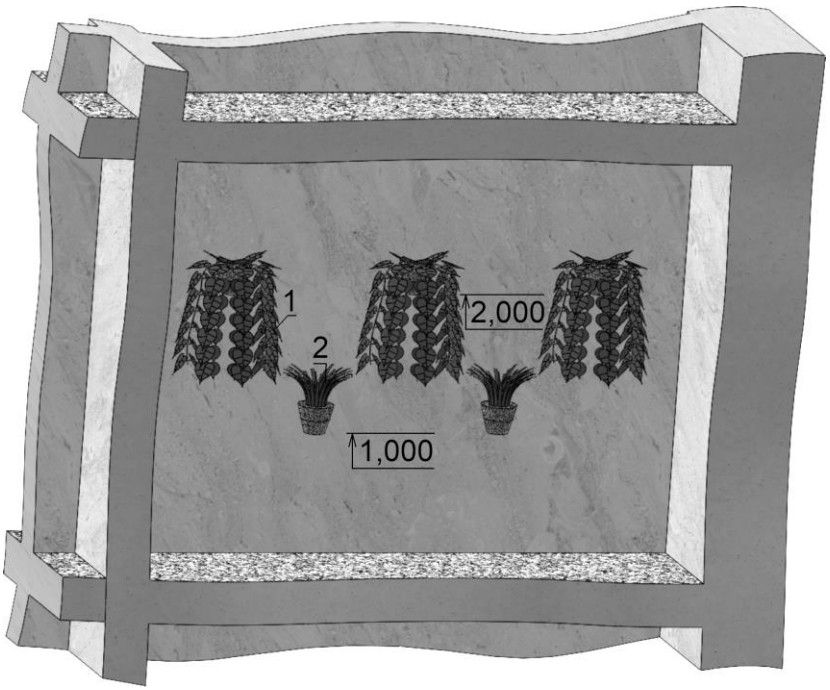

Figure 2. Example of phytodesign by five plants in wall pots:
1 - *Philodendron scandens*; 2 - *Chlorophytum*.

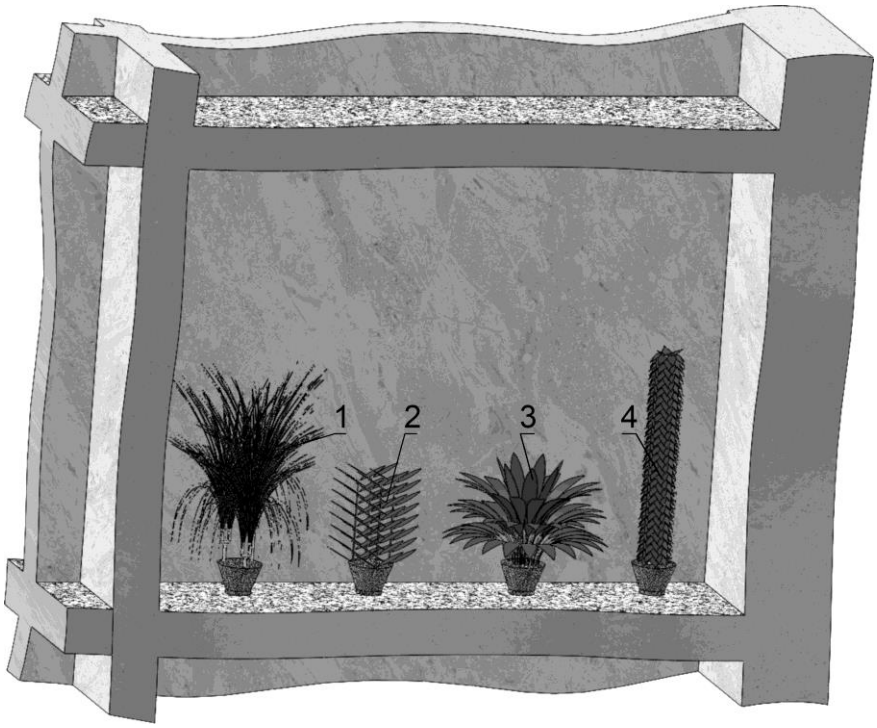

Figure 3. Example of phytodesign by four plants in wall pots:
1 – *Dracena marginata*; 2 – *Zamiaculcas zamiifolia*; 3 – *Aspidistra elatior*; 4 - *Philodendron scandens*.

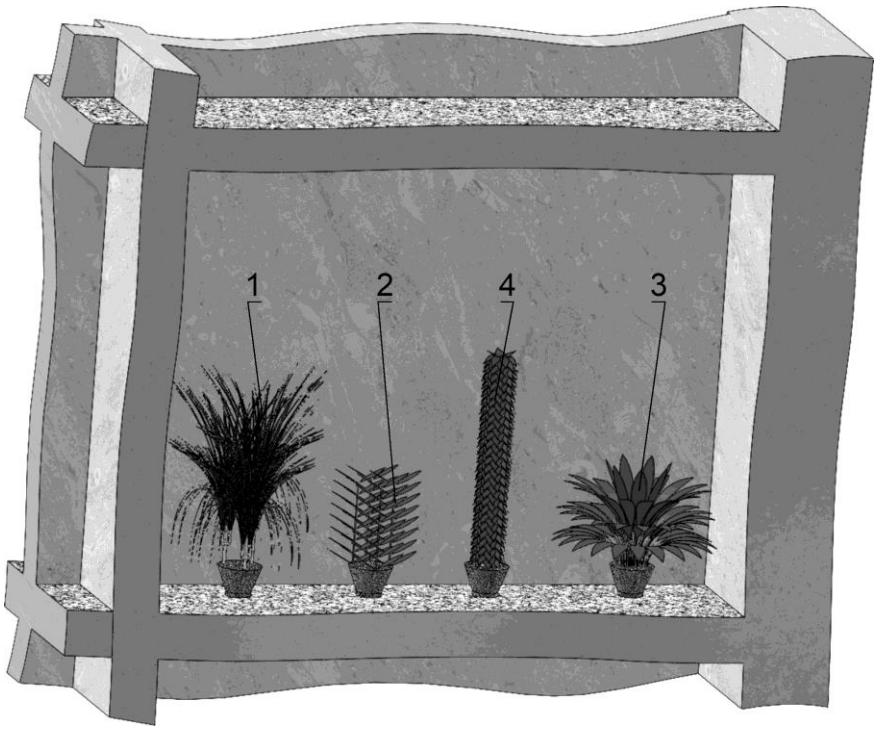

Figure 4. Second example of phytodesign by four plants in wall pots:
1 – *Dracena marginata*; 2 – *Zamiaculcas zamiifolia*; 3 – *Aspidistra elatior*; 4 - *Philodendron scandens*.

To fit the natural biorhythm of the plants, phytolamps and ultraviolet lamps should be switched off at deep night.

4. Conclusions

For the first time, we have offered an assortment of phytoncidal shade-resistant plants for sanitary interiors in common areas of apartment buildings, consisting of 11 species: *Aspidistra elatior*, *Aglaonema "Silver queen"*, *Aglaonema "Maria"*, *Chlorophytum comosum*, *Chlorophytum capense*, *Dracena marginata*, *Monstera deliciosa*, *Philodendron scandens*, *Sansevieria trifasciata Laurentii*, *Schefflera "Nora"*, *Zamiaculcas zamiifolia*. Indoor plant placement options are suggested for the typical types of common areas. To preserve the decorative and physiological features of the plants, there are three options of effective artificial illuminations. Thanks to the beneficial properties of plants, the proper phytodesign can enhance the safety of multi-storey housing in a short time with minimal cost.

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