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SOLUTION OF SICK BUILDING SYNDROME PROBLEM USING INDOOR PLANTS[*]

Tetiana Tkachenko[**], Viktor Mileikovskyi

Kyiv National University of Construction and Architecture,
Povitroflotsky ave., 31, Kyiv, 03680, Ukraine

Abstract

In modern urbocenoses, a person spends most of the time in closed rooms with many negative factors causing risks for human health. The combination of negative factors inside the premises contributes to the development of a mass disease called "sick building syndrome". It is possible to avoid it by eliminating sources of pollution and using certified environment-friendly building and finishing materials. However, these activities require time and investment. It is possible to improve the quality of indoor air by using a natural biological filter – indoor plants. Vegetative organs of plants precipitate dust, absorb and neutralize harmful chemicals, emit phytoncides, increase air humidity. The microbiological studies of air quality in the experimental (with plants) and control (without plants) rooms according to the Koch method are conducted. It is established that the microbial number in the room with plants is significantly lower than in the control (without plants). In a room with plants, the number of microorganisms is 1.5 ... 5 times less, depending on the observation period. Thus, the proposed assortment of plants: *Ficus benjamina*, *Ficus benjamina Wiandi*, *Zamioculcas Zamiifolia*, *Dracaena marginata*, *Dracaena fragrans*, *Yucca elephantipes*, *Schefflera digitata*, *Aspidistra elatior*, *Crassula ovata*, *Spathiphyllum wallisii* – is recommended for use in residential, public and industrial buildings.

Keywords: indoor plants, living environment, microbial count, sick building syndrome, urbocenosis

1. Introduction

Ensuring the safety of the living environment is one of the most important components of human ecology, since the quality of the living environment, in which a person spends more than 80 % of his life, can become a risk factor for the development of various

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[**] Corresponding author: tkachenkoknuba@gmail.com

diseases, including allergy. For the energy saving of the building, the premises are hermetic, and the air exchange is reduced to the minimum possible value. Modern furniture, appliances and finishing materials, household chemicals, etc. are consist of synthetic compounds that slowly decompose in the process of exploiting with emissions of toxic substances (Rumiantseva et al., 2005). All these factors create the preconditions for mass development of "sick building syndrome". There are breathing problems, then – pains in joints and insomnia. Symptoms may resemble influenza, but this sluggish "influenza" lasts for weeks, months, years. The immune system is gradually breaking down (Kocheliaev et al., 2001; Marova et al., 2007; Rumiantseva, 2003). In our opinion, one of the most effective, fast and optimal mechanisms for improving the air condition in the premises are plants. It has already been scientifically proven (Van der Neer, 2005) that plants perform not only aesthetic and recreational but also prophylactic sanation function. Therefore, the method of environmental phytodesign (Boyko, 2012; Snezhko and Kharytonova, 2006) today is very relevant and effective.

The main objective of this study is to research the possibility of effective usage of phytoncide indoor plants for increasing the quality of indoor air and for avoiding the sick building syndrome. For this purpose, monitoring of the purity of the air environment of the office premises was carried out in the presence of various types of phytoncide plants in them.

This work is divided into three main parts:

- selection of case studies: different office rooms: a meeting room and a winter garden – with ten different species of plants: *Ficus benjamina*, *Ficus benjamina Wiandi*, *Zamioculcas Zamiifolia*, *Dracaena marginata*, *Dracaena fragrans*, *Yucca elephantipes*, *Schefflera digitata*, *Aspidistra elatior*, *Crassula ovata*, *Spathiphyllum wallisii*; an accounting room without plants has been used for reference values measurements;
- evaluation of the microbiota in the rooms with different plants and comparison of the results with reference values in the room without plants;
- analysis of results, drawing conclusion and formulation of recommendations for improvement of the indoor air quality.

2. Materials and methods

2.1. Object of the study

There are different factors causing the sick building syndrome. In this study, we will focus on the factor of the microbiota. Determination of the influence of plants was carried out by monitoring the microbiological state of air in several office premises in order to select promising plants for the creation of sanifying interiors. We should determine how effective the phytoncide plants act on the microflora of air space. To do this, we chose three premises (figure 1): reference room – an accounting (equivalent to other premises by area and anthropogenic load) that does not contain plants; a meeting room; a winter garden.

The reference room – accounting (Fig. 1a) – consists of two windows facing the southeast. The jalousie cannot be fully opened. Therefore, the illumination is in the range of 8000 ... 15000 lux, depending on the position of the jalousie. There are five desktops and five computers in the room. There are permanently five to six people. This room has no plants.

The meeting room (Fig. 1b) has two windows facing the southeast. The jalousie cannot be fully opened. Therefore, the illumination is in the range of 8000 ... 15000 lux, depending on the position of the jalousie. The working area (meeting table) is perpendicular to the windows. There is also a large plasma TV in the room. There are five plants in the meeting room: on the window sills there are two *Yucca elephantipes* of 0.45 m height, near to the table and the wall there is a *Zamioculcas Zamiifolia* of the height of 2.0 m.

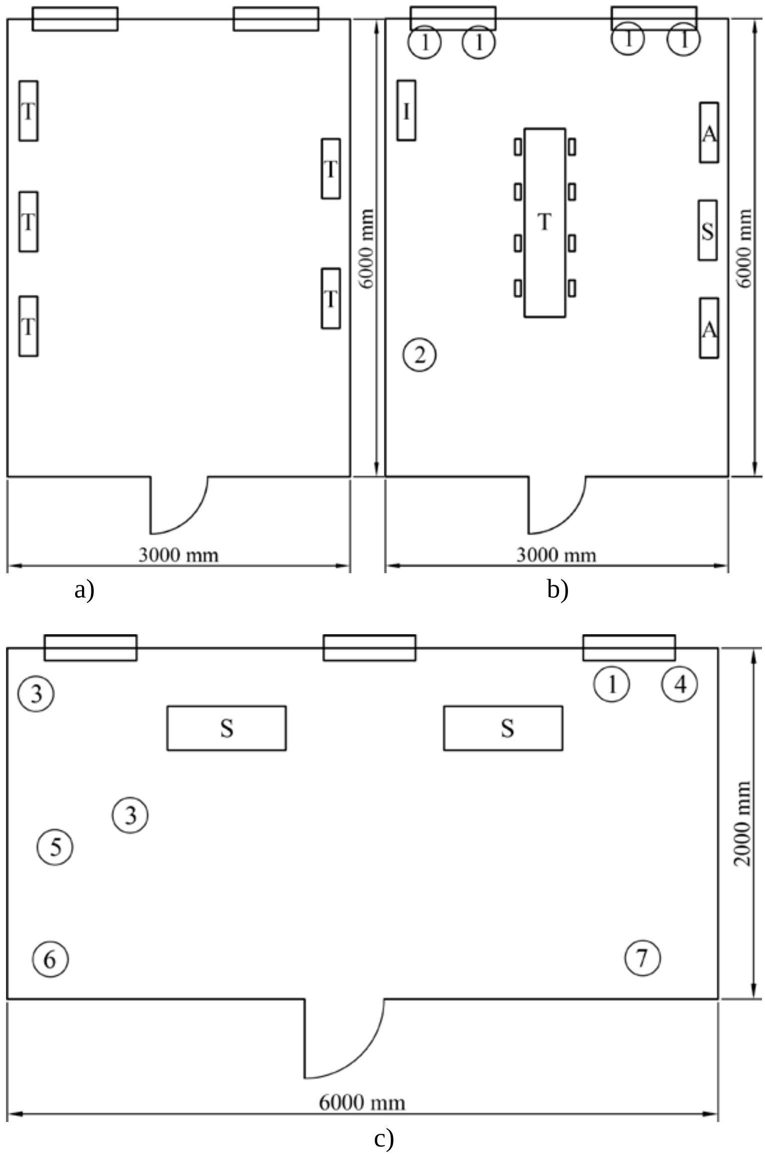

Fig. 1. Studied rooms: a) accounting room for reference values measurement, b) meeting room and c) winter garden

The winter garden (Fig. 1c) also has two windows, oriented to the southeast. Jalousie can be fully opened, so the room is the brightest. In the winter garden, there is the largest number of plants – seven, – because this place originally (despite the small area) was created as a zone of rest and comfort. Here are the most favorable conditions for the growth and development of plants: a lot of light, no permanent working area. Here are *Ficus benjamina Wiandi* (1.2 m height), *Ficus benjamina* (2.5 m), *Dracaena marginata* (1.5 m), *Dracaena marginata* (0.60 m), *Yucca elephantipes* (1.5 m), *Dracaena fragrans* (2.5 m) and a *Spathiphyllum wallisii* (0.50 m).

The experiment involved 10 species of plants with a sufficient amount of foliage to detect phytoncide activity: *Ficus benjamina*, *Ficus benjamina Wiandi*, *Zamioculcas Zamiifolia*, *Dracaena marginata*, *Dracaena fragrans*, *Yucca elephantipes*, *Schefflera digitata*, *Aspidistra elatior*, *Crassula ovata*, *Spathiphyllum wallisii*.

2.2. Methods of the study

The following methods are used to study the microflora of the air:

- natural sedimentation – the so-called dish passive method of depositing of microbes on the surface of dense environments for a certain time (Koch method);
- forced sedimentation of microorganisms (aspiration method) – using special devices, such as Dyakonov or Krotov device;
- filtration method – air is cleaned through water and filters with subsequent measurable sowing in nutrient media.

In our research, we used the first method – a passive method of depositing microbes on the surface of dense nutrient media (nutrient medium – meat-peptone agar).

To determine the microbial number (the number of microorganisms in 1 m^3 of air), the rule of V. L. Omelianskyii (Bilyk et al., 2018) was used: the amount of microorganisms deposited on the surface of 100 cm^2 in 5 minutes is equal to the amount that contained in 10 dm^3 of air. The number of microorganisms in m^3 of air (m^{-3}0 (Eq. 1):

$$X = (a \cdot 100 \cdot 1000 \cdot 5)/(b \cdot 10 \cdot t) = 50000 \cdot a/(b \cdot t) \quad (1)$$

where a – number of colonies in a cup; $b = \pi R^2$ – area of the cup, m^2; R – radius of the cup, m; t – exposure time (5 min); 5 – time according to Omelianskyi, min; 10 – volume of air from which the precipitation occurs, dm^3; 100 – the area on which the precipitation occurs, cm^2; 1000 – desired volume of air, dm^3.

Microbiological monitoring of the indoor air environment was carried out within seven months. This term allows studying the process in dynamics and observing microbial contamination in different periods: autumn-winter and spring. Samples (seeding in Petri dishes with meat-peptone agar) were taken for the third day with three-time repeatability.

3. Results and discussion

According to the results of the study (Figs. 2-8), the number of microorganisms in m^3 of air in the rooms with plants (blue columns) is much less than in the reference room (red columns). The natural dynamics of the microbial number was observed: some increase in winter and decrease in spring. Interesting bursts of microbial semination was obtained on holidays: December 27 and December 30, when there was anthropogenic pressure due to the presence of guests. After the holidays (from January 3 to January 9), there is a recession of the microbial number because at that time there were winter vacations. After January 12, the number rises again because people return to work. All indicators were even lower than the permissible microbial numbers.

Another situation was observed in the reference room. At this place, the value of the microbial number dynamically increased. This is evident in the period from the end of November (7,000 bacteria per m^3) to March inclusive, when the rate of microbial contamination reached 7800 ... 8000 bacteria per m^3 of air. Based on the results obtained, phytoncides of plants in the premises have a detrimental effect on the microflora in air space, reducing the number of bacteria. Observation data clearly demonstrate the bactericidal properties of investigated phytoncidal plants.

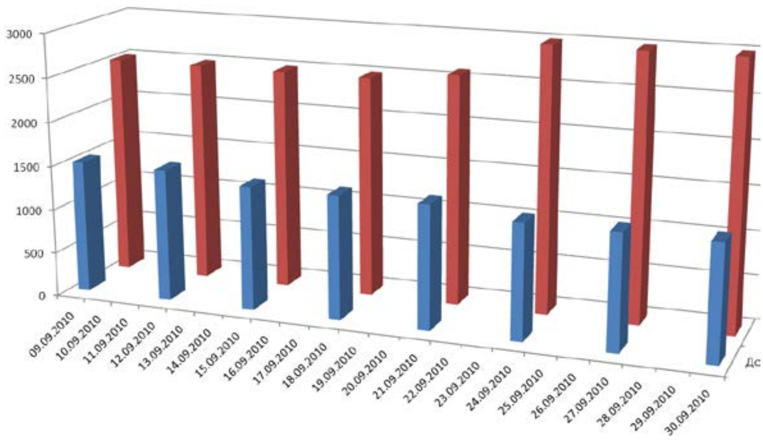

Fig. 2. The number of microbes per m^3 in September: red – control room, blue – rooms with plants

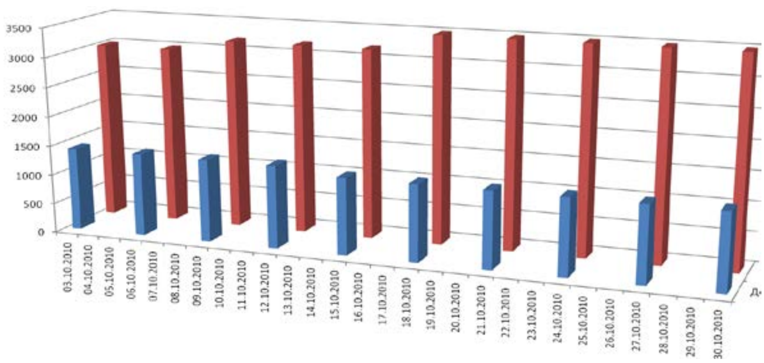

Fig. 3. The number of microbes per m^3 in October: red – control room, blue – rooms with plants

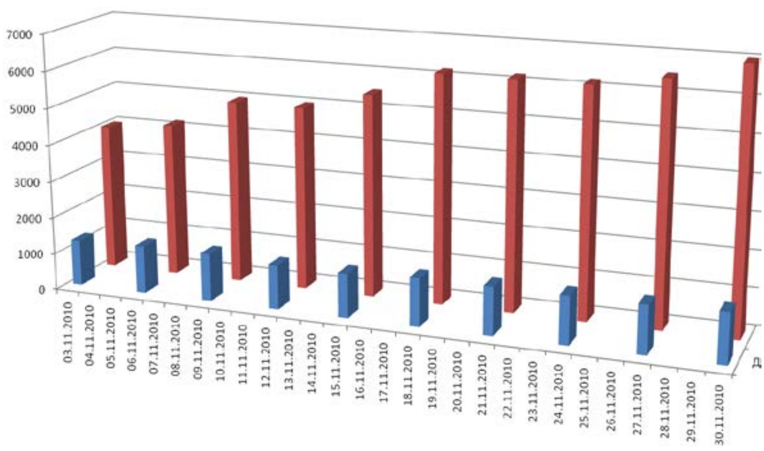

Fig. 4. The number of microbes per m^3 in November: red – control room, blue – rooms with plants

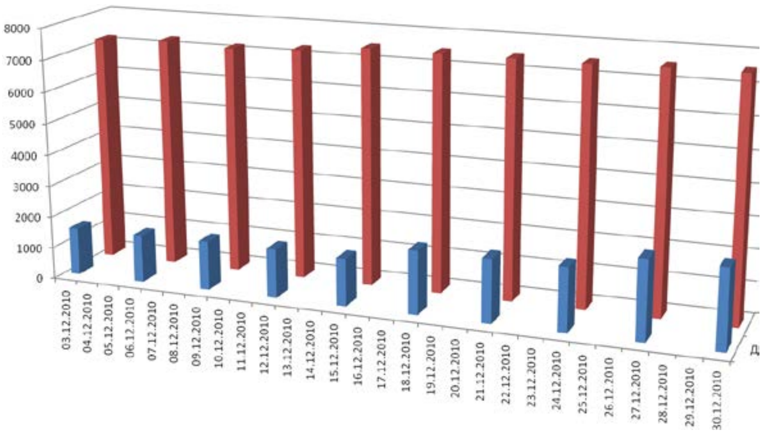

Fig. 5. The number of microbes per m^3 in December: red – control room, blue – rooms with plants

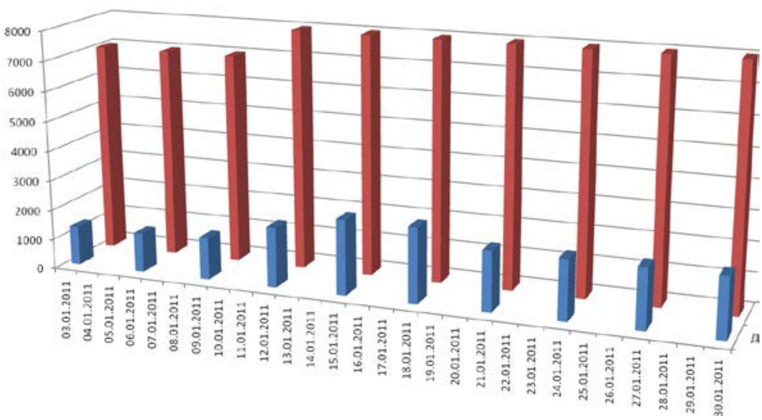

Fig. 6. The number of microbes per m^3 in January: red – control room, blue – rooms with plants

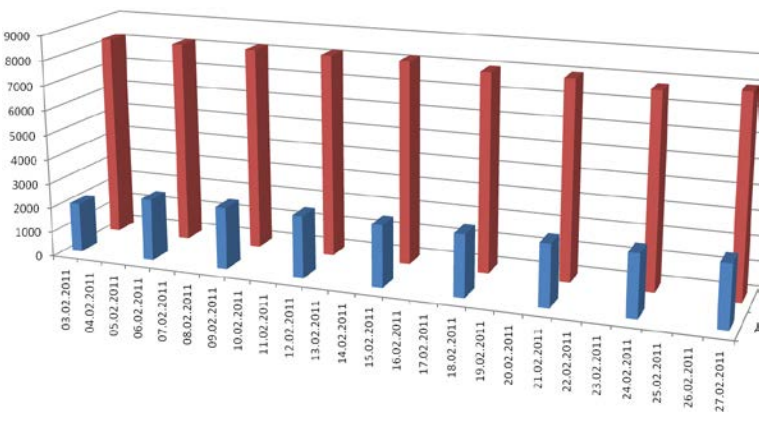

Fig. 7. The number of microbes per m^3 in February: red – control room, blue – rooms with plants

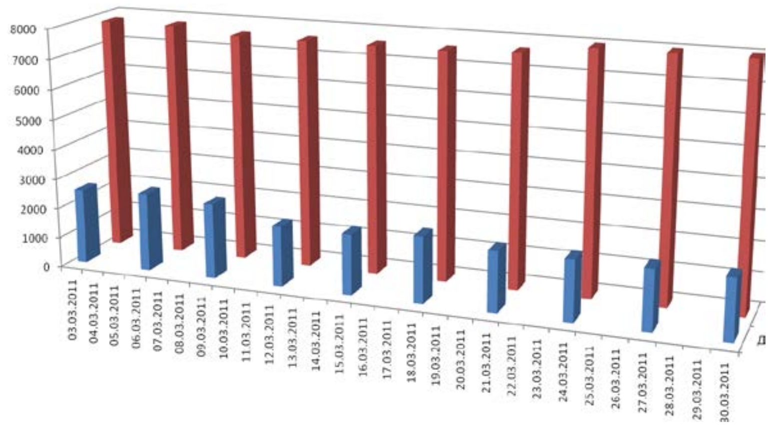

Fig. 8. The number of microbes per m^3 in March: red – control room, blue – rooms with plants

4. Conclusions

It has been experimentally established that the microbial number in the rooms with plants is significantly lower than in the reference one without plants. In a room with plants, the number of microorganisms 1.5 ... 5 times less, depending on the period of observation.

Thus, the proposed assortment of plants, namely, *Ficus benjamina*, *Ficus benjamina Wiandi*, *Zamioculcas Zamiifolia*, *Dracaena marginata*, *Dracaena fragrans*, *Yucca elephantipes*, *Schefflera digitata*, *Aspidistra elatior*, *Crassula ovata*, *Spathiphyllum wallisii*, is recommended for use in residential, public and industrial buildings.

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