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INDOOR FLOWERS: AIR PURIFYING PLANTS

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ABSTRACT

Indoor flowers are an unavoidable element in modern interior design. In addition to enriching the living and working space in terms of decoration, flowers also have a beneficial effect on people: it improves mood and increases productivity at work. The benefits of growing flowers in the interior are numerous and of particular importance for human health is the fact that they improve air quality and reduce the concentrations of many pollutants. Pollutants in the interior can be divided into non-biological and biological according to the source. In most cases, external pollution is mentioned as the main source of increased concentrations of non-biological indoor air pollutants. The assumption is that the mechanism of air purification implies the absorption of volatile compounds by plant leaves, which are then transported to the roots, and where they are then decomposed by microorganisms. On the other hand, it is supposed that certain compounds characterized as air pollutants are degraded and used in plant metabolism. Research shows that the ability to remove organic volatile compounds from the air into the interior is different and depends on the type of flower species. Indoor flowers that have been shown to be effective in air purifying are from the following families: Moracae, Araceae, Arecaceae, Araliaceae, Orchidaceae, etc. The choice of flowers to alleviate indoor air pollution depends not only on their ability to clean the air, but also on their needs for care, light and finally of personal taste.

Key words*:* indoor air pollution, interior flower species.

INTRODUCTION

The industrialization of society, the growth of the world's population, the excessive use of different energy sources and materials of diverse origin, is rapidly increasing the pollution of soil, water and air on a global scale. Due to the fact that in more developed societies, people spend more and more time indoors, the polluted air in them also represents an increasing risk to people's health (Fleck et al., 2020). The direct consequences of this trend are already reflected in the health of people all over the world (Bruce et al., 2000). That is why today's scientific community is focused on finding alternative and ecologically acceptable methods that can contribute to reduction the harmful consequences on human health (Barbes & Bărbulescu, 2022). Historically, interior air quality problems in past were much more pronounced than they are today. The soot found on the ceilings of prehistoric caves provides sufficient evidence of the high level of pollution that occurred as a result of the presence of open hearths and poor ventilation. It was only in the sixteenth century that awareness of the harmful effects of indoor air pollution began to gain importance (Seltzer, 1995). Today, solving the problem of increasing interior air pollution has global significance (Clements-Croome, 2006). Phytoremediation - a term that refers to the use of plants to remove toxins from the air, is recognized as an effective and economically profitable measure for improving air quality in the interior as well. Various authors point out that flower potted plants can remove volatile organic compounds (VOC) from interior air at different rates and

in different amounts. Also, their ability to absorb electromagnetic radiation is recognized as a very important feature, which stands out especially in the time in which we are live (Bandehali et al., 2021).

Interior air quality

External pollution is generally the most important source of increased interior air pollutant concentration. This is especially the case with contamination in spaces located in urban areas, either near industrial zones or busy streets. The influence of external pollution on interior air quality, according to Wanner (1993), depends on several factors, such as: the type of ventilation in use (natural or artificial), the frequency of ventilation (air exchange per hour) and the nature of the pollutant. Also, the quality of the air, in the interior depends on the buildings themselves, i.e. methods of their construction (construction, selection of materials for construction, etc.) (Cheng et al., 2017). In recent decades, and with respect to *energy efficiency measures*, there have been significant changes in construction, from the point of view of creation of buildings, methods of their building, as well as selection of materials for construction. Improved insulation accompanied by many other changes in the organization of the interior environment and advances in building technologies have contributed to the increased use of synthetic building materials (Kaur & Misra, 2014). All these changes have surely contributed to the greater comfort of the space, but they have also created an environment in which air pollutants are more easily produced, the concentration of which can be significantly higher than the concentration of pollutants in the external environment (Teichman, 1995). Interior air pollutants come from a number of sources, and can be divided into non-biological and biological (Table 1) (Spengler & Sexton, 1983).

Table 1. Pollutants and their sources in interior

Non-Biological pollutants	Main sorces of emissions
asbestos	against fire apparatus, insulation
carbon dioxide	metabolic activity, combustion, motor vehicles in garages
carbon monoxide	burning fuel, boilers, stoves, gas or kerosene heaters, tobacco smoke
formaldehyde	chipboard, insulation, furniture
nitrogen dioxide	outside air, burning fuel, motor vehicles in garages
organic substances	adhesives, solvents, building materials, evaporation, combustion, paints, tobacco smoke
ozone	photochemical reactions
particulate matter	suspensions, tobacco smoke, combustion products
polycyclic aromatic hydrocarbons	burning fuel, tobacco smoke
radon	soil, building material (concrete, stone)
sulfur dioxide	outside air, combustion
Biological pollutants	
allergens	house dust, pets, insects, mites
microorganisms	people, animals, plants, air conditioners
pollen	outside air, grass, weeds, trees, plants
fungal spores	soil, plants, foodstuffs, interior surfaces
Source: Spengler & Sexton (1983)	

The most important pollutants originating from non-biological sources include: asbestos, carbon dioxide, formaldehyde, tobacco smoke, sulfur dioxide and volatile organic compounds.

A wide range of non-biological pollutants are associated with combustion. Heating and cooking are common and basic indoor activities that produce smoke and gases that are difficult to remove (Liquna & Yanqun, 2011). This difficulty is most pronounced in colder climates where it is necessary to retain heat while simultaneously removing combustion byproducts. In Serbia, but also in most countries, wood and coal are most often used for heating rooms in the colder period of the year, and the smoke created as a result of their combustion dominates the list of pollutants. Tobacco smoke is also a source of indoor pollution related to combustion. Exposure to tobacco smoke is related in connection with a wide range of acute and chronic health consequences and is for many a major pollutant (Jenkins et al., 1992).

Construction materials are also classified as non-biological sources of pollutants. A large number of chemical compounds that are present in the air in the interior originate from paints, varnishes, solvents and preservatives used in construction (Liquna & Yanqun, 2011). Pollutants from these sources are difficult to quantify because they are found in relatively small amounts, but their sources are volatile. Possible health risks from pollutants from construction materials are highly dependent on their origin as well as the concentration of pollutants in them.

The main source of biological pollutants in the interior is house dust, in carpets, on sofas and in air cavities. The best studied source of biological allergens in the interior are dust mites. According to the data provided by D'Amato et al. (1994), especially in a moderate climates, ten species of mites can be found from the genera: *Dermatophagoides, Euroglyphus, Malayoglyphus*, *Hirstia* and *Sturnophagoides*. Except for mites, a large number of types of fungi and bacteria are also found in the interior, which is related to the presence of organic matter. Outside air is, as indicated by Wanner et al. (1993), one of the main sources of fungi and bacteria in interior spaces, especially during summer and autumn. According to a research, conducted in Great Britain by Hunter et al. (1996) and which included a large number of households (more than 100), *Penicillium* was the most frequently isolated fungus, found in 53% of the sample, followed by fungi from the genera *Cladosporium* and *Aspergillus*. As dominant bacteria, were isolated those who are belonging to the genera *Bacillus, Staphylococcus* and *Micrococcus*.

The influence of the air quality in interior space on health

Monitoring the impact of interior air quality on the human health is of crucial importance. Because of that the consequences on human health are being studied today, which are caused by exposure to combustion products released during heating, cooking or smoking cigarettes in interior space. There is also discussed about symptoms which are associated with pollutants emitted from building materials, and of particular importance are substances known as volatile organic compounds (VOC), which come from various sources including paints, varnishes, solvents and preservatives (Guieysse et al., 2008).

It is also discussed about the harmfulness of biological particles, because they can also have a significant impact on health, given that a large number of biological substances are present in interior space. Their role in causing disease as a consequence of the weakening of the immune system is especially considered (Guo et al., 2003)

Concept *sick building syndrome* arose in connection with air quality in interior space (Wallace, 1997). Namely, residents of certain buildings exposed to pollutants pointed out a number of health problems (Table 2), which are attributed to poor air quality.

Table 2. Common symptoms of "*sick building syndrome*"

• Headache and nausea
• Nasal congestion (runny/stuffy nose, sinus congestion, sneezing)
• Congestion in the chest (difficulty breathing, tightness in the chest)
• Eye problems (dry, itchy, watery or painful eyes, blurred vision, contact lens problems)
• Throat problems (sore throat, hoarseness, dry throat)
• Fatigue (unusual tiredness, sleepiness)
Chills and fever
• Muscle pain (muscle or joint pain, upper/lower back pain or stiffness, shoulder/neck pain or stiffness, arm or wrist pain or numbness
• Neurological symptoms (difficulties in memory or concentration, feeling depressed, tense or nervous)
• Dizziness
•Dry goat

Source: Wallace (1997).

Numerous studies indicate that a large part of the public believes that the health risks of bad outside air quality are significantly greater than the risks of interior pollution.

These perceptions are created although it is known that in developed societies people spend most of their time indoors (Fleck et al., 2020). A survey were conducted in USA by Robinson & Nelson (1995) showed that respondents spend an average of 88% of their time indoors, 7% in vehicles, and only 5% of their time actually spent outdoors.

The role of indoor flowers in air purification

In interiors, leaf-decorative species of flowers are dominantly used, which are characterized by the extraordinary beauty of the leaves or flowers. For most people, the choice of species depends on the ease of their cultivation and maintenance as well as on personal taste. With NASA's discovery that plants can be an effective way to filter interior air, numerous species of flowers have been subjected to various experiments and have proven to be good purifiers of volatile organic compounds, formaldehyde, benzene, ammonia, carbon dioxide and other important pollutants (Wolverton et al., 1989).

The mechanisms of reducing the concentration of pollutants in the air by plants are different (*Llewellyn and Dixon*, 2011). Namely, plants absorb volatile organic compounds through the leaves, and then move them to the root zone, where they are decomposed by soil microorganisms, and further used them in the soil, as food source. Some organic compounds that plants absorb from the air are destroyed in the metabolic processes of the plant itself. As air is also present in the zone of the root system, uptake by the root tissue is another mechanism by which air can be purified (Kvesitadze et al., 2009). When interior spaces are decorated with plants, the relative humidity of the air increases, than reduces the accumulation of dust particles and other pollutants, which directly reduces the risk of allergies (Tudiwer & Korjenic, 2017).

In previous researches, that have been carried out with a few indoor plants, and which are used most often, it has been determined that not all of them are equally effective in reducing the emission of harmful gases or particles. As efficient species in purifying air in the interior, those that belong to families were singled out: Moraceae, Araceae, Palmae, Araliaceae, Orchidaceae and species (Figure 1) stand out among them: *Ficus* L. (a), *Phoenix* L. (b), *Chamaedorea* Mart. (c), *Phylodendron* Schott (d), *Phalaenopsis* Blume (e), *Epipremnum* Schott, *Spathiphyllum* Schott, etc. (Teiri et al., 2018; Bandehali et al., 2021).

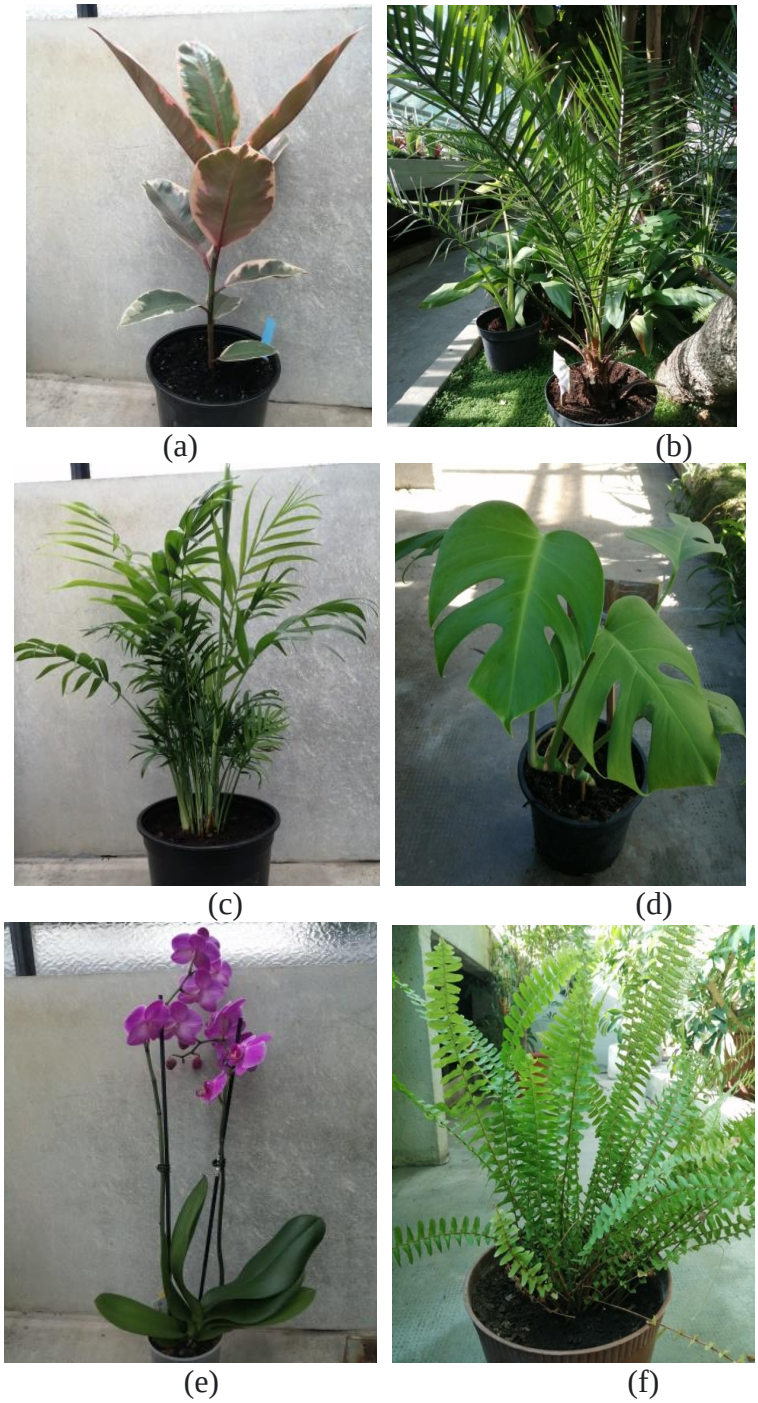

Figure 1. (a) *Ficus*; (b) *Phoenix*; (c) *Chamedorea*; (d) *Philodendron*; (e) *Phalaenopsis*; (f) *Nephrolepis*. (*Source*: author)

Similar results were reached by Dela Cruz et al. (2014). Namely, based on the hypothesis that only certain pollutants can be removed by indoor plants, research has found that, for example, the concentration of benzene in the air can be most effectively reduced by species such as: *Crassula portulacea* (Crassulaceae), *Hydrangea macrophylla* (Hydrangeaceae), *Cymbidium* (Orchidaceae), *Ficus microcarpa var. fuyuensis* (Moraceae), *Dendranthema morifolium* (Asteraceae), *Citrus medica var. sarcodactylis* (Rutaceae), *Dieffenbachia amoena* (Araceae), *Spathiphyllum supreme* (Araceae), *Nephrolepis exaltata* (Figure 1f) (Davalliaceae) and *Dracaena deremensis* (Dracaenaceae).

Although indoor plants are not a 'complete solution' for improving interior air quality, they should not avoid it as 'help' in creating the so-called healthier atmosphere.

CONCLUSION

The use of indoor flowers in modern interior design is unavoidable. Numerous studies have established the beneficial effect of flowers on people. In addition to enhancing and contributing to the aesthetic value of the living and working space, indoor flowers also play a role in the general health and well-being of people. The fact that indoor species of flowers improve air quality and reduce the concentration of many pollutants is particularly noteworthy, thus confirming their phytosanitary role in the interior. The sources of interior pollutants come from biological and non-biological sources. Of the numerous non-biological sources, synthetic materials that are widely used in building (paints, varnishes, solvents, preservatives, insulating materials) and which contribute to the retention of pollutants in the interior stand out. Previous research has proven that the most effective species of indoor flowers for this purpose are from following families: Moraceae *(Ficus sp.),* Araceae *(Phylodendron, Epipremnum, Spathiphyllum),* Arecaceae *(Phoenix, Chamaedorea),* Araliaceae, Davalliaceae, Orchidaceae, etc. The very choice of indoor flowers for mitigating interior air pollution should not depend only on their ability to *clean* the air, but must be adapted to interior conditions, especially light. Also, the selection of species will certainly depend on the ease of their cultivation and maintenance, but also on personal taste.

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