

The Effects of Indoor Plants Acting as Natural Biofilters on Indoor Air Quality, Human Health, and Indoor Environments

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ABSTRACT

Indoor plants are widely acknowledged as an essential component of sustainable and healthful indoor settings, especially as people spend more time indoors due to urbanization and modern lifestyles. This study focuses on various functions of indoor plants such as indoor air quality, microclimate regulation, psychological well-being, and human health. *Aloe vera*, *Sansevieria trifasciata*, *Spathiphyllum wallisii*, *Epipremnum aureum*, *Aglaonema*, and *Syngonium podophyllum* are among the indoor plants chosen for the study; their indoor adaptability and their biological and environmental advantages are presented. These indoor plants affect physiological processes as well as airborne contaminants, particulate matter, carbon dioxide concentration, and relative humidity. The report also provides an overview of the research on how indoor plants affect physical well-being, perceived comfort, productivity, mood, stress reduction, and attentiveness. Although their efficacy relies on plant species, light availability, ventilation, growing medium, plant density, and indoor climatic conditions, indoor plants are an aesthetically pleasing part of biophilic indoor design. Standardized, practical trials combining plant physiology, indoor air quality monitoring, and human health effects should be the main focus of future research.

Keywords: Indoor plants, microclimate, human health, air quality.

1. INTRODUCTION

1.1. Background and Significance of the study

The incorporation of natural elements, typically indoor plants, into built environments fosters a connection between humans and nature. Indoor plants enhance aesthetics and may positively impact air quality, humidity, and well-being they also release oxygen and water vapor, while aiding in the uptake of airborne pollutants [1]. Additionally, the presence of indoor plants was also linked to psychological benefits, including stress reduction and improved mood, attention, and comfort [2]. The growing popularity of indoor plants was linked to their aesthetic appeal and their ability to foster healthier, sustainable indoor environments [3]. However, their effectiveness in improving indoor air quality varies by species, light, temperature, humidity, and other environmental factors [4]. Studies indicate that foliage plants can affect indoor particulate matter [5], humidity, and human responses to their surroundings. Thus, the advantages of indoor plants should be critically evaluated, especially when laboratory results are compared to real-world performance. Indoor plants have been recognized globally as environmentally friendly and natural

air purification mechanisms.

The Urban population spends 80% -90% of their time indoors; indoor air quality (IAQ) has become a pressing public health concern. Indoor air pollution can have detrimental effects on human health, and the concentration of carbon dioxide (CO₂) in indoor environments [6]. Indoor plants enhance indoor environmental quality and human well-being; consequently, plant-based mechanisms have emerged as natural air purification tools.. This study also explores the physiological interactions between plants and indoor pollutants, and suggests future studies on indoor plants' sustainable use in environmental management. As indoor time increases, the aesthetic and health benefits of these plants have gained popularity, proven to alleviate stress and promote ecological diversity [7].

2. FACTORS INFLUENCING THE GROWTH OF INDOOR PLANTS

2.1. Light and Environmental Conditions

Light acts as the basic energy source for photosynthesis and is also involved in material synthesis and multiple aspects of plant physiological processes. The rational use of the light environment can improve plant quality and regulate sugar metabolism [8]. With manipulations of light quality affecting specific plant traits such as flowering, plant architecture, and pigmentation, the focus has been placed on the ability to precisely manage the light growing environment, proving to be an effective tool to produce tailored plants according to market requests [9]. Furthermore, temperature fluctuations cause leaf yellowing, making temperature tolerance a key factor for the plant species to thrive.

2.2. Substrate, Humidity and Biological Mechanisms

Plants which are non-toxic, healthy, and suitable for its light, temperature, and humidity needs are selected to be planted indoors. Proper light is vital; too much can cause browning, while insufficient light may lead to bud drop. Temperature shifts can result in yellowing leaves, while a humidity level of at least 50% is ideal. Watering should be done based on soil moisture, avoiding overwatering, especially for succulents. Fertilization can include natural sources like banana peels and cow dung for better growth. Regular grooming and maintenance, including leaf cleaning and pruning, enhance plant attractiveness and health. Repotting should consider pot size and involve trimming long roots, followed by a resting period. Diseases such as spots and wilts, caused by bacteria and fungi, can be managed with fungicides. Temperature tolerance determines whether plants are grown indoors or outdoors [10], with growth dependent on container size. The indoor environment can be adjusted to meet plant needs.

3. AIR PURIFICATION USING HOUSE PLANTS

3.1. Biofiltration of Volatile Organic Compounds (VOCs)

Indoor air pollution, caused by accumulated pollutants and chemicals in tightly constructed homes and offices, can lead to various health issues. Immediate effects include irritation of the eyes, nose, and dizziness, while long-term exposure can result in serious conditions like respiratory diseases, heart disease, and cancer. Health effects may manifest shortly after exposure or years later, highlighting the importance of addressing indoor air quality. Indoor air pollution has become a global issue and affects nearly all domains of life; indoor air pollutants lead to the deterioration of the ecosystem and negatively impact human health. Plant-based methods and their associated microorganisms utilize phytoremediation to eliminate toxins from the indoor environment. Phytoremediation [5] refers to using plants to lower pollutant levels in soil and water [11]. Plants also mitigate dust accumulation and reduce particulate matter, contributing to better air quality, particularly against harmful substances like formaldehyde, which can

cause health issues such as sick building syndrome.

Cost-effective plant-based approaches can help to improve indoor air quality (IAQ), regulate temperature, and protect humans from potential health risks. Potted plants, green walls, and their combination with bio-filtration are such emerging approaches that can efficiently purify the indoor air [12]. They help purify the air by absorbing pollutants such as formaldehyde, benzene, and trichloroethylene, while increasing oxygen levels and humidity [13]. In this context, recent investigations have shown that potted plants can aid in the removal of a wide range of indoor air pollutants, especially Volatile Organic Compounds (VOCs), and can be engineered in aesthetically attractive configurations [14]. The major sources of indoor air pollution include combustion byproducts such as carbon monoxide and sulfur dioxide, as well as tobacco smoke. Synthetic materials contribute harmful gases like formaldehyde, which can cause watery eyes, nausea, and wheezing. Other pollutants include benzene, which can lead to dizziness and unconsciousness, trichloroethylene, a liver carcinogen, and toluene, which can cause memory loss and unconsciousness at high levels. Household products like adhesives and disinfectants, along with excess moisture, and outdoor sources such as pesticides and dust also contribute to indoor air pollution [15].

Moreover, indoor studies suggest that in addition to cleaning the air, indoor plants offer psychological, physiological, and cognitive benefits. Studies from NASA indicate that common foliage can decrease indoor pollutants like carbon monoxide due to beneficial bacteria on roots [16] (Wood et al 2006). Additionally, microorganisms in soil help break down pollutants, further enhancing air purification [17]. A recent study in scattering indoor plants among university students finds a significant enhancement in the connection to nature through a three-dimensional spatial interaction, potentially improving well-being [18].

3.2. Particulate Matter and Carbon Dioxide Reduction

Through normal photosynthesis plants assimilate Carbon dioxide and release oxygen improving indoor air quality. Negative air ions (NAI) are negatively charged gas ions that are frequently released by plant metabolism in the natural world. It has been demonstrated that exposure to NAI-enriched environments has significant health benefits. Because of its capacity to charge particulate matter (PM) and precipitate it from the airstream, it has been suggested as a possible component of indoor botanical air purification systems. [19]. Plants play a role in regulating indoor air temperature and humidity through their own transpiration, which has prompted the use of plants to reduce air pollution through phytoremediation from interior spaces, especially in enclosed rooms with air-conditioning and heating [20]. Results from various experimental studies support the beneficial effects of indoor plants and mental health outcomes, such as reducing stress, depressive symptoms, and negative emotions [21]

3.3. Selecting Species for Indoor Environment

Selecting appropriate indoor plant species depends on the availability of light, maintenance capacity and target pollutant removal goals. Studies indicate that foliage plants can elevate indoor relative humidity to healthier levels, which is typically below 30% to 60% [22]. Low indoor humidity can lead to frequent colds and wood damage. Concerns exist that plants might raise humidity excessively; however, low light and dry substrate limit plants' capacity to absorb CO₂ and enhance humidity through transpiration [23-25]. Increasing light to approximately could improve occupant comfort and CO₂ assimilation [26-29]. The study by Costa and Lothian explored the impact of indoor plants on acoustics in interior spaces, finding that they can effectively reduce high-frequency sounds. Plants interact with sound through deflection, absorption, and refraction: they deflect sound waves and lessen noise by breaking them into different energy forms, absorb ambient noise via their leaves and wood, and refract sound to eliminate echoes caused by hard surfaces. Notable sound-absorbing plants include *Ficus elastica*, Fiddle leaf fig, *Areca*

palm, and peace lily.

4. IMPACT ON HUMAN HEALTH AND WELL BEING

4.1. Effect of Plants in Work Environments

In a study on the effects of plants in work environments, it was found that participants felt more attentive in rooms with foliage compared to those without [5]. Additional research showed that interior plants contributed to feelings of friendliness and affection among individuals [5]. Various experiments explored how characteristics such as color, odor, and size of plants influenced human comfort, measured through satisfaction surveys and physiological metrics like EEG and ECG. Results indicated that offices with plants were preferred, with the most comfortable environment containing small, slightly scented green plants. Significant physiological differences were observed with changes in the environment, suggesting these metrics could serve as indicators of human comfort [30].

Indoor plants can significantly reduce stress, with research indicating people recover from stress more quickly when exposed to nature, whether through images or in real life. Studies [31,32,5] shows that even minimal contact with indoor plants can lead to a decrease in stress indicators, such as systolic blood pressure. Similar calming effects have been noted by emphasizing the nonverbal and intuitive nature of plant interaction [33]. Benefits include enhanced job satisfaction [34], mood improvement [35] and cognitive health enhancement [36], which can contribute to resistance against diseases and chronic stress, although rigorous evidence is still needed [37]. Studies show that in the presence of plants, productivity will be higher. Mental fatigue has also been shown to be reduced by Plants [38].

4.2. Psychological and Physiological Benefits of Indoor Plants

The researchers found that patients recovering from surgery in rooms with plants had improved recovery rates and felt better, particularly if they had a view of trees. Additionally, indoor plants increased pain tolerance in individuals not experiencing acute pain, indicating that the benefits of plants extend beyond mere decoration, as colorful objects did not have the same effect on pain tolerance. The presence of indoor plants has been shown to have positive effects on physical symptoms, such as reducing coughing and fatigue. Participants in a project reported improved health feelings after interacting with plants [39]. Research indicates that houseplants contribute to both psychological and physiological benefits, enhancing comfort and work productivity [40-42]. Keeping and caring for houseplants shows positive impacts on mental well-being and mindfulness among adults. It is a green prescription, an effective means of interacting with nature and improving mental outcomes [43]. Placing a small indoor plant on office workers' desks often contributes to improving the office environment. The passive observation of these plants has become an easy way to reduce stress [44].

5. EXAMPLES OF COMMON INDOOR PLANTS

5.1. ALOE

Binomial: Aloe vera (L.),

Aloe is a tropical, succulent plant known for its fleshy leaves and attractive flowers, commonly grown in greenhouses. Its leaves are medicinally used for conditions such as fever, liver and spleen enlargement, skin diseases, and more. Aloe vera exhibits the Crassulacean Acid Metabolism (CAM) pathway, allowing it to fix atmospheric carbon dioxide at night and benefiting from a diurnal pattern of organic acid accumulation. This adaptation enables water conservation, making it suitable for arid environments, characterized by thick leaves, a thick cuticle, and sunken stomata.

5.2. SNAKE PLANT

Binomial: *Sansevieria trifasciata*

The plant described is an evergreen, perennial species that spreads through a creeping rhizome and has stiff, dark green leaves with light-grey cross-banding. It utilizes the Crassulacean Acid Metabolism (CAM) process to exchange gases, opening its stomata at night to minimize water loss and is well-suited for low-light conditions, making it a popular houseplant. The plant can filter indoor air, removing major toxins associated with sick building syndrome, and release moisture, thereby reducing airborne allergens. It is noted for its unique ability to convert CO₂ into O₂ at night, requiring 6-8 plants per person in stagnant air. However, it contains mildly toxic saponins that can cause gastrointestinal upset in pets.

5.3. PEACE LILY

Binomial: *Spathiphyllum wallisii*

Spathiphyllum, or peace lily, is a popular foliage plant known for its white flowers and dark green leaves, thriving in indoor environments. Native to the tropical regions of Central America and Asia, it transitioned from traditional propagation methods to tissue culture in the 1980s, resulting in a significant increase in cultivars. This herbaceous perennial features a spadix surrounded by a spathe and functions as an air purifier, breaking down pollutants like benzene and formaldehyde. It also helps humidify rooms and is beneficial for allergy sufferers. Although it can attract pests, it is toxic to humans and pets if ingested, causing nausea and diarrhea.

5.4. MONEY PLANT

Binomial: *Epipremnum aureum* (L)

Golden pothos, also known as the money plant, is an evergreen plant distinguished by its thick, waxy, heart-shaped leaves with yellow splashes. It climbs using aerial roots and is commonly propagated through cuttings, making it popular in hanging baskets. The plant has beneficial features, including air purification, particularly against formaldehyde, and pest control capabilities. It can accumulate radioactive isotopes such as Co-60 and Cs-137, thereby enabling its use in phytoremediation. Additionally, it exhibits antimicrobial properties and should not be consumed by pets or children due to its calcium oxalate crystals, which can cause dermatitis and allergic reactions. The benefits of the money plant include air purification from chemicals, stress reduction, activation of positive energy, anti-inflammatory effects, and antibacterial and antifungal properties. Its extracts have shown various antioxidant activities and enzyme enhancements.

5.5. CHINESE EVERGREEN

Binomial: *Aglaonema rotundum*

Aglaonemas, commonly known as 'Chinese evergreens,' are stylish and easy-to-grow houseplants native to Indonesia. They feature attractive pinkish spots and stripes on green foliage and thrive in partly shaded areas. Valued for their air-purifying properties, *Aglaonemas* emit oxygen and remove toxins like formaldehyde and benzene, significantly improving indoor air quality. They can adapt to various moisture levels and contribute to humidity indoors. Benefits include purifying air, absorbing CO₂ at night, and enhancing productivity and well-being in living and working spaces. However, ingestion can cause irritation and vomiting.

5.6. STROMANTHE TRIOSTAR

Binomial: *Stromanthe sanguinea*

This ornamental plant is a tropical perennial native to Brazil, characterized by its multicolored foliage with green, white, and cream patterns on the upper surface and a pinkish color below. It thrives in bright indirect light and requires minimal maintenance, though direct sunlight can cause variegation loss and

harm the plant. Notably, it purifies air and is non-toxic to pets. Members of the Marantaceae family have thin leaves that benefit from regular misting. The plant has a unique light exposure control mechanism, with leaves folding at night to reveal glossy undersides. Flowers are rarely produced, with the inflorescence being a panicle.

5.7. ARROWHEAD PLANT

Binomial: *Syngonium podophyllum* (L)

Syngonium podophyllum, commonly known as African evergreen or Arrowhead plant, is noted for its decorative qualities and air-purifying abilities. It thrives in low light, with young heart-shaped leaves maturing to arrow-shaped foliage. This plant effectively absorbs pollutants, including benzene and formaldehyde, and is recognized by NASA for its air-cleaning properties. Studies have identified its phytochemical richness, revealing compounds like terpenoids and flavonoids, as well as notable antioxidant and antimicrobial activities. Additionally, the plant's extracts have medicinal uses, such as treating leg pain and headaches, while its seed oil has purgative properties.

5.8. ZZ plant

Zamioculcas zamiifolia (G.Lodd.) Engl.

ZZ plant is emerging as an important foliage plant due to its aesthetic appearance, ability to tolerate low light and drought, and resistance to diseases and pests. Plants perform well in a variety of shaded conditions, including morning sun with afternoon shade or in bright indirect light. Plants should be regularly watered, but allow the soil to dry between applications. Avoid wet soils. Propagate by leaf cuttings or division. This plant can be treated in much the same way as cactus and other succulent plants. While they will grow in very low levels of light, even in areas with only fluorescent light, they do best with bright indirect sunlight. Scalding and browning of leaves can occur if the plant is placed in direct sunlight. Propagate by division or leaf cutting. This plant has a medium toxicity to cats and dogs.

6. CONCLUSION

Plants are essential to daily life, enhancing both physical and mental health. Many indoor plants originate from warmer climates and serve to make spaces more attractive and engaging. They boost mood, productivity, and creativity while reducing stress and indoor pollutants. Plants help purify air, increase humidity, and promote a healthier atmosphere, making them vital in urban settings where natural environments are limited. Concerns about indoor air quality, caused by various pollutants, have led to a growing interest in sustainable solutions for improving indoor environments. Additionally, houseplants positively impact psychological and cognitive health by enhancing mood, productivity, and concentration, and reducing stress and fatigue. Overall, incorporating indoor plants not only enhances aesthetics but also contributes to a healthier living environment.

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Figure 1: Examples of Common Indoor Plants



