Systemic Review on Indoor Plants as an Alternative Technique for Reducing Indoor Air Pollutants

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Systemic Review on Indoor Plants as an Alternative Technique for Reducing Indoor Air Pollutants

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Abstract- **Around 2.4 billion people worldwide are exposed to critical levels of household air pollutants. WHO data show that almost all of the global population (99%) breathes air that exceeds WHO guideline limits and contains high levels of pollutants, with low- and middle-income countries suffering from the highest exposures. People spend nearly 90% of their time in indoors, whether they are at home or at work. As a result, the likelihood of developing Sick Building Syndrome (SBS), respiratory disorders such as asthma, COPD, and other disorders is high. The purpose of this review is to determine which indoor plants are most successful at lowering CO2, VOCs and other indoor air pollutants. Indoor plants remove a wide range of pollutants through phytoremediation; specifically, the leaf and root parts are involved in removing pollutants from the environment. Plants can also help to control temperature and relative humidity, which in turn reduces airborne pollution by evaporation and transpiration. Since humans have a close relationship with nature, integrating the natural world into the indoor space could effectively increase the air quality and provide a positive physiological effect. After analysing the effectiveness of the listed small-scale botanicals in improving IAQ, Golden Pothos, Snake Plant, and Areca Palm are the most popular and effective indoor plants because they can lower most of indoor air pollutants (Formaldehyde, Toluene, PM 2.5, PM 10, Xylene, Ozone, Ketones, and CO2) and outperform other indoor plants.**

Keywords: **Indoor air pollution, respiratory disorders, health impact, indoor plants and mitigation.**

INTRODUCTION

Poor air quality is still a global problem (World Health Organization 2014). Indoor air quality (IAQ) is important in buildings because it can affect inhabitants' health and productivity (Hashim et al. 2019). Due to outside and inside emissions of air pollutants, a variety of internal and external factors, including temperature, humidity, and ventilation levels, have an impact on indoor air quality (Moya et al. 2018). Nowadays indoor spaces including homes, schools, and offices are built with inadequate ventilation. Since they consume less energy for air conditioning and are more airtight, which results in an increase in indoor air pollutants. Particulate matter (PM), volatile organic compounds (VOCs), such as benzene, toluene, ethylbenzene, xylene (BTEX), formaldehyde, and polyaromatic hydrocarbons (PAHs), as well as inorganic pollutants (O3, NOx, CO2, and SO2), are the major indoor air pollutants and this type of pollutants will increases in ideal concentrations leads to Sick Building Syndrome (SBS), a condition such as respiratory dysfunction, severe headache, ocular and cutaneous irritations, allergies, fatigue, and metabolic abnormalities (Nezis et al. 2022). Hence, it can be lowered by employing indoor plants, which also give the added advantage of aesthetics (Su et al. 2015).

Air composed of 21% O2 and 0.033% CO2 taken in by people from the normal atmosphere becomes 16-17% O2 and 4% CO2 content during discharge from the lungs. This transition causes a sudden increase in CO2 content in places where people gather, such as schools, commercial malls, and hospitals (Kavathekar et al. 2022). Carbon dioxide (CO2), which is primarily produced by occupant respiration, is a primary factor of indoor air quality (Dominici et al. 2021). Carbon dioxide is relatively stable and inactive. However, it will react with water to form carbonic acid (H2CO3). Over the last 150 years, human activities have been responsible for nearly all of the rise in greenhouse gases in the atmosphere (Jay et al. 2010). 13% of CO2 emissions originate from workplaces and households, while 25% of CO2 emissions are caused by electrical products. A higher CO2 concentration indirectly impacts people by altering the climate. Humans are affected by air pollutants-induced allergies and asthma, vector-borne diseases (dengue, malaria, etc.), water-borne diseases (cholera), poor water quality (algal blooms), heat-related illness, and cardio-vascular disease, as a result of climate change. The average outdoor air concentration of CO2 is in the order of 300 to 400 ppm (0.4%). Indoor levels are often greater due to CO2 exhaled by building inhabitants. Especially in poorly ventilated spaces, human metabolism alone can cause CO2 levels to exceed 3,000 ppm. According to a research study (Joseph G. Allen et al. 2015), exposure to CO2 during working hours causes a 15% drop in cognitive function scores at 950 ppm and a 50% decline at 1,400 ppm. Some studies state that indoor CO2 concentration usually reach up to 2000 to 2500 ppm sometimes it can increase up to 5000 ppm. These can cause respiratory issues (such as a tight chest, wheezing or coughing, and shortness of breath) as well as mucus membrane symptoms (such as a sore/dry throat, dry eyes, and sneezing) (Gubb et al. 2018). Another study was conducted in a non-ventilated conference room for 4 hours by (Tommi Vehviläinen et al. 2016), and the average CO2 measured was 2756 ppm, which results in loss of concentration, dizziness, headache, chilly feet, shivering, and eye discomfort.

Volatile Organic Compounds (VOCs) are a large group of molecules found in numerous substances we use, such as paints, stains, varnishes, solvents, pesticides, adhesives, waxes, polishes, cleansers, lubricants, sealants, dyes, air fresheners, fuels, plastics, copy machines, printers, tobacco products, perfumes, dry-cleaned clothing, building materials and furniture, as well as extended exposure, can irritate the eyes, nose and throat, nausea, a loss of coordination, and headaches, some organics can cause cancer, while others can harm the liver, kidney, and central nervous system (USEPA). Formaldehyde, one of the most common VOCs, is a colourless gas with an unpleasant (sharp and bitter) odour. It can be found in a variety of building materials, including plywood, particleboard, and glues. Consequently, secondary production of formaldehyde occurs in air as a result of the oxidation of volatile organic compounds (VOCs), and interactions between ozone (mostly from the outdoors) and alkenes (particularly terpenes) have been widely reported (Rika Funaki et al. 2003). According to the International Agency for Research on Cancer (IARC), formaldehyde is a Group 1 carcinogen and the most commonly released pollutant among indoor volatile organic compounds. HCHO has been widely utilised in interior design and construction projects (IARC 2014). Higher concentrations of HCHO can cause nausea, vomiting, coughing, chest tightness, and asthma, as well as pneumonia, pulmonary edema, and mortality when exposed to more than 6.5 mg/m3 (Su et al. 2015).

Particulate matter (PM) is a complex mixture of solid particles and liquid droplets that are suspended in the air and have a range of sizes, shapes, and chemical compositions (Patel et al. 2020). Particulate Matter (PM) is divided into three types based on particle size: (i) coarse particles, PM10 with a diameter of <10 µm; (ii) fine particles, PM2.5 with a diameter of <2.5 µm; and (iii) ultrafine particles, PM0.1 with a diameter of<0.1 µm (Tran et al. 2020). When compared to PM10, PM2.5, and PM0.1, PM0.1 causes a larger harm to human health due to its ability to penetrate small airways and alveoli (Yu et al. 2015). Indoor PM includes particles that drift in from outside and particles that come from indoor activities such as cooking, fireplaces, smoking, fuel combustion for heating, human activities, and incense burning (Zhang et al.2021, Almeida et al.2022). Indoor PM can contain more inorganic and organic pollutants, such as harmful heavy metals and cancer-causing volatile organic compounds. Indoor exposure to PM has received significant interest in recent years as a potential health threat due to the fact that people spend the majority of their time indoors. Prolonged exposure to PM can result in early death in those with heart or lung illness, nonfatal heart attacks, irregular heartbeat, worsened asthma, impaired lung function, increased respiratory symptoms, and other complications (Hamanaka et al. 2018, Baudet et al. 2022, Zhang et al. 2022). Indoor NO2, SO2 and CO are mainly due to Gas-fueled cooking, tobacco smoking, and heating appliances and can cause enhanced asthmatic reactions, respiratory damage leading to respiratory symptoms (Bernstein et al. 2008), Asthma, chronic obstructive pulmonary disease (COPD), and cardiovascular diseases (Seow et al. 2018), fatigue, chest pain, impaired vision, and reduced brain function.

Low relative humidity (RH) is an additional problem in indoor environments. RH below 30% lead to produce eye discomfort and skin dryness, while RH below 10% causes nasal mucus membrane dryness. Low relative humidity can also increase the risk of influenza transmission, and raise indoor ozone concentrations. High RH ($>60\%$) can also cause problems by promoting fungal/mould development and contributing to the corrosion of building components (Gubb et al. 2018). By keeping indoor RH levels between 40 - 60%, the majority of RH-related negative health impacts may be prevented by using indoor plants. Prolonged exposure to those air pollutants and their combined effect is the primary cause of health-related issues induced by poor IAQ. Thus, maintaining an indoor air quality could be an essential for human health and comfort. Air filtration, ionisation, activated carbon absorption, ozonation, and photocatalysis are indoor air purification techniques that are efficient in reducing a specific type of pollutant such methods are difficult, possibly dangerous (especially ozonation (Ibrahim et al. 2018). The greatest method for eradicating interior air pollution is through phytoremediation, which uses potted plants, green roofs, living walls, and bio coverings. Phytoremediation is defined as the utilisation of plants and related soil bacteria to reduce the concentrations or harmful effects of pollutants in the environment (Kim et al. 2020). Some studies show that a green wall/indoor plant such as Areca Palm, Snake Plant, English Ivy, Peace Lily, and Bird Nest Fern etc., may be employed to reduce indoor carbon dioxide, formaldehyde, and other pollutants, resulting in better indoor air quality (Taemthong et al. 2022).

Table 1: List of air pollutants acceptable limits (Hashim et al. 2019, WHO)

Indoor Air Contaminants	Acceptable Limits
Carbon Dioxide	1000 ppm
Carbon monoxide	10 ppm
Formaldehyde	0.1 ppm
PM 2.5	12 μg/m^3
PM 10	15 μg/m^3
Ozone	0.5 ppm
Total Volatile Organic Compounds	3 ppm

Pollutants can be absorbed, distributed, and/or transported by ornamental plants via mechanisms such as rhizosphere biodegradation (by microorganisms), phytoextraction (plant-liquid extraction), stomatal uptake (plant-gas extraction), phytodegradation (via enzymatic catalysis inside tissues), and phytovolatilization (directly by evaporation from leaves or indirectly by plant transpiration) (Bhargava et al. 2020, Ravindra et al. 2022). In this research review, we have gone through lots of studies about the effectiveness of indoor plants to remove the air pollutants present indoors and discussed the most common contaminants found in indoor spaces as well as their mitigation method using household plants. Golden Pothos, Snake Plant, and Areca Palm are the most popular and efficient indoor plants, according to a study that examined the effectiveness of the listed small-scale botanicals in improving indoor air quality because they can reduce most indoor air pollutants such as formaldehyde, toluene, PM 2.5, PM 10, xylene, ozone, ketones, and CO2.

INDOOR PLANTS' ADVANTAGES FOR HUMAN COMFORT AND HEALTH

From the perspective of evolutionary history, plants were essential for survival. Plants served as a source of food, a means of protection, and a sign of the presence of water for humans. Due to their capacity to purify the air, indoor plants are used for both physiological and psychological well-being (Kavathekar et al.2022). Plant evapotranspiration lowers the temperature around the growing environment, which can be used for air cooling and humidity control (Moya et al. 2018). According to several research studies, working in biophilic environments and interacting with plants may change attitudes and behaviours in people as well as increase productivity and mental happiness (Kavathekar et al. 2022, Hashim et al. 2019). Indoor plants have the potential to be useful in a variety of sectors, including sensing, solar energy, acoustics, and human health and comfort (Deng et al. 2018). The techniques used by plants to absorb harmful pollutants include soil sorption, leaf sorption, and microorganisms that decompose near the plant's roots (Su et al. 2015). Plants absorb pollutants while taking up more CO2 through their stomata during photosynthesis. The quantity of natural or artificial light, the size of the plant's leaves, and other factors affect the absorption of CO2 and the release of O2 (Kavathekar et al. 2022). Fig. 1 shows the benefits of indoor plants for human comfort and heath. Along with air velocity and humidity, temperature has an impact on the VOC emissions from building materials. Similarly, relative humidity impacts formaldehyde emissions in particle board. Consequently, plants can control temperature and relative humidity, which can also control airborne contaminants in addition to cleaning the air through photosynthesis and phytoremediation. (Gubb et al. 2018, Kim et al. 2020), They suggested during their research on how plants might be used to purify air and water, retired NASA scientist Bill Wolverton discovered an interesting finding: when air circulation to plants' roots is increased, they become much better air filters. Rhizosphere microorganisms, which are prevalent in growth media, have been discovered in certain studies to be important as direct agents of VOC removal, which is significant for biofiltration (Moya et al. 2018). Unlike gaseous pollutants, PM is primarily deposited on the surface of leaves through wet or dry deposition. Compared to the abaxial side, the adaxial surface of leaves gathers more PM, and the cuticle is another channel for lipophilic contaminants, such as aromatic hydrocarbons. After entering the leaf, xenobiotics can be subjected to a variety of processes that protect the organism against contaminant toxicity, including excretion, conjugation, compartmentalization, or reduction to simple cell metabolites (Wroblewska et al. 2021). (Kavathekar et al. 2022) found that plants enhance thermal comfort, and the effect of plants on thermal comfort was not reduced over time or by season. According to Moya et al. 2018, indoor plants may be used as a passive acoustic insulation solution to lower noise levels. Biofiltration and living wall systems are new technologies that have positive effects on improving interior comfort.

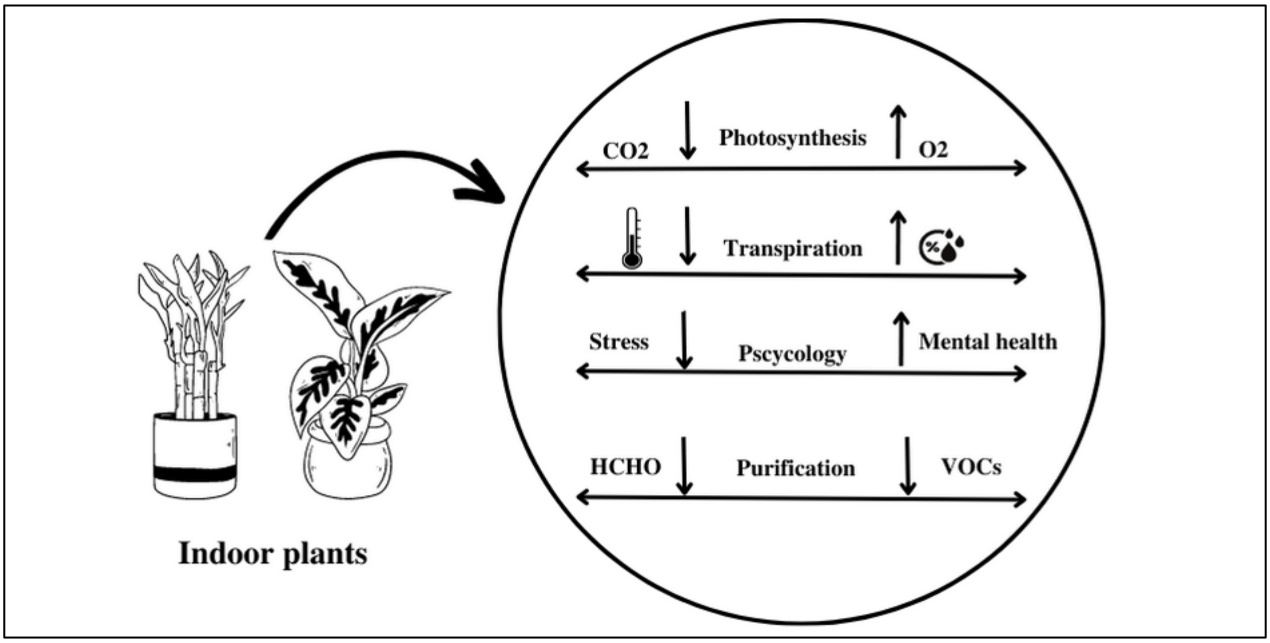

Fig. 1 The benefits of indoor plants for human comfort and health are shown in the above figure.

MOST COMMONLY USED INDOOR PLANTS FOR ELIMINATING AIR POLLUTANTS

A. Areca Palm

Areca palm, scientifically known as *Chrysalidocarpus lutescens*, is a genus in the Arecaceae family. It is an attractive plant that grows well in low light conditions and is commonly found in tropical and subtropical locations (Yaodong et al. 2021). Areca palm potted plants are inexpensive, easy to cultivate and maintain, and are well known for effectively removing acetone, CO2, xylene, toluene, benzene, trichloroethylene, carbon monoxide, and formaldehyde pollutants released by petroleum goods, paints, wooden furniture, and so on (Bhargava et al. 2020), mentioned in table 2. Basically, it may remove air pollutants either by stomatal absorption and sorption to the plant cuticle or through non-stomatal adsorption by the plant microbiome. According to an earlier chamber test, the Areca Palm can reduce CO2 by 88.5% (Hashim et al. 2019). According to a study done using Areca palm, Song of India, and Lady palm, Areca palm has a greater potential to absorb CO2 than the other two species (Kavathekar et al. 2022). Another study by (Bhargava et al. 2020) found that the pollutant levels (TVOCs, CO2, and CO) decreased following the installation of 6 to 9 potted Areca palms, and they highlighted the usefulness of Areca palm potted plants in lowering TVOCs, CO2, and CO to a large extent that is up to 95.70%, particularly 67% of TVOCs, 35.5% of CO2, and 83% of CO.

B. Peace Lily

Peace Lily, scientifically known as Spathiphyllum wallisii, is a genus in the Araceae family (Deng et al. 2018). Peace lilies evolved in tropical America and Southeast Asia's dense rain forests. Because of their light tolerance, long-lasting showy white blooms, and dark green leaves, members of the peace lily family are well-liked plants all around the world. S. wallisii are ideal for modern indoor living wall designs because they can withstand low light levels (Dominici et al. 2021). Additionally, it provides oxygen while using less light, lowers the carbon dioxide level, and cleanses the air. According to a NASA study of indoor houseplants, Piece Lilies are the most effective at removing airborne Volatile Organic Compounds like formaldehyde, trichloroethylene, and benzene (Kulkarni et al. 2018). The Peace Lily should be grown in an environment with average daily temperatures of 20°C to 22°C, relative humidity of 60–70%, and light intensity of 20000 Lux (Tan et al. 2022). According to previous chamber studies, peace lilies may reduce 361 ppm of

CO_2 each hour (Hashim et al. 2019). Numerous studies suggest that using peace lilies in a living wall system may reduce pollutants and CO_2 levels (200 µmol m− 2 s − 1 (~10500 lux at 45◦ C)) (Dominici et al. 2021). (Deng et al. 2018) Peace lily leaves may reduce benzene by 93–94% in 75 minutes, as well as toluene and 2-ethylhexanol by 15%. (Tan et al. 2022). As a result, peace lilies are one of the best indoor plants for efficiently reducing a variety of air pollutants.

C. Dumb Cane

Dieffenbachia seguine, often known as dumb cane, is a member of the Araceae family (Hashim et al. 2019). Dump canes are found in tropical America in shady wet conditions (relative humidity of 60% - 70%) and humid tropical lowlands in the United States, Brazil, and North to West Indies or India. The phrase "dumb cane" refers to the temporary inability to speak that can happen after biting off a portion of the stem (Kumara et al. 2019). Dumb Cane is typically kept indoors, such as in the house, business, and other places. It is known for its lovely variegated leaves, resistance to the interior atmosphere, and ease to maintenance. A Dumb Cane prefers air temperatures of 20°C to 25°C, relative humidity of 60–70%, and light intensity of 20000Lux (Deng et al. 2018). According to earlier studies, dump cane can reduce 216.5 ppm of CO_2 per hour (Hashim et al. 2019). Indoor plants may have a significant impact on lowering CO_2 levels in city buildings, which would reduce the need for air cooling and the city's carbon footprint (Kumara et al. 2019).

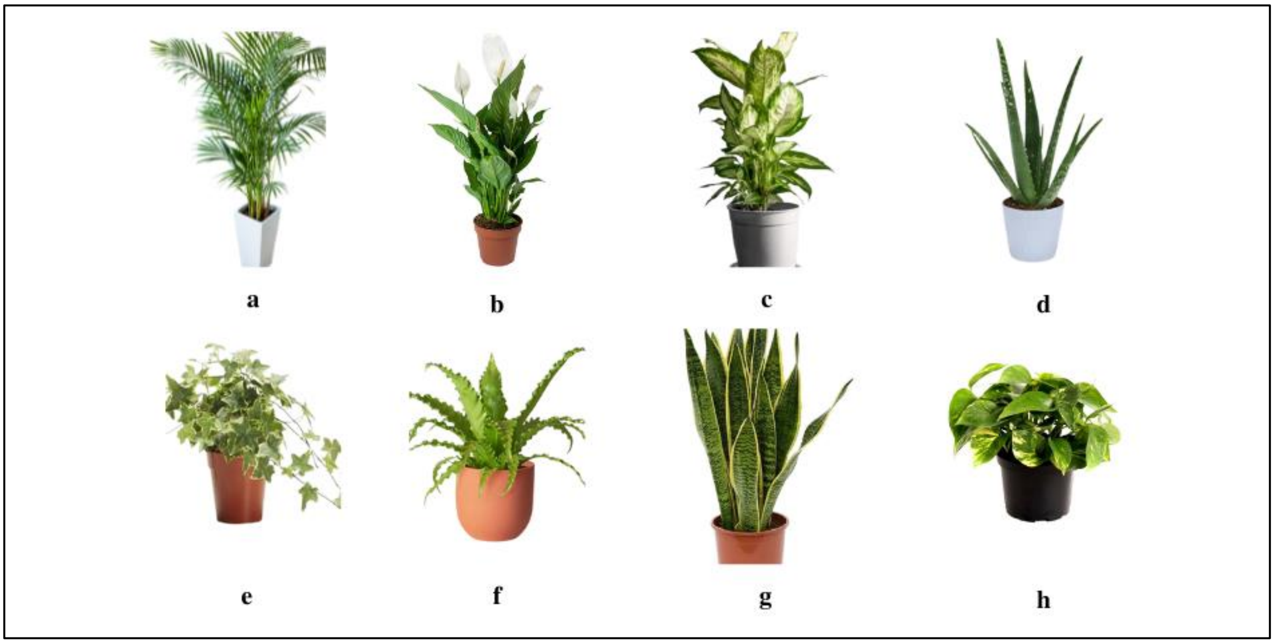

Fig. 2 shows the digital image of a) Areca palm, b) Peace lily, c) Dumb cane, d) Aloe vera, e) English ivy, f) Bird nest fern, g) Snake plant, h) Golden pothos

D. English Ivy

English ivy, scientifically known as Hedera helix, is a thick, evergreen climbing vine found across Europe and much of West Asia (Tan et al. 2022). Hedera helix comes in many variations, and they are frequently grown as decorative plants. They prefer moist, dark environments and avoid direct sunlight. Additionally, Hedera helix is frequently ranked among the top 10 houseplants for VOC elimination (Lin et al. 2017). Light intensity of 1200 Lux, ambient temperature of 22 to 26 °C, and relative humidity of 40 to 60% were the ideal conditions for English ivy (Tan et al. 2022); Potted Hedera helix can also remove residual HCHO from the atmosphere, improving indoor air quality. According to research (Lin et al. 2017), potted Hedera helix can speed up the process by 70% as compared to natural dissipation in order to obtain 0.5 ppm of gaseous HCHO, and (Deng et al. 2018), the root of English ivy can lower formaldehyde by 81–96% over a period of 24 hours. (Gubb et al. 2018) shows that the majority of CO_2 is removed by Hedera helix. In addition, raising indoor light levels to 300 mol m^2 /s would significantly improve most species' capacity to absorb CO_2. The greatest increase in RH was likewise caused by the species that absorbed the most CO_2

Table 2: Indoor pollutants that can be removed by common indoor plants

Indoor Plant Common Name	Scientific Name	Pollutants That Can Be Removed	Reference
Areca palm	*Chrysalidocarpus lutescens*	CO_2, Benzene, Toluene, Carbon monoxide, Formaldehyde, Xylene, Trichloroethylene	Bhargava et al. 2020
Song of India	*Dracaena reflexa*	Xylene, Toluene, Trichloroethylene, and Formaldehyde	Kavathekar et al. 2022
Peace lily	*Spathiphyllum wallisii*	Toluene, CO_2, and Volatile Organic Compounds (formaldehyde, benzene etc.)	Dominici et al. 2021, Kulkarni et al. 2018
Dumb cane	*Dieffenbachia seguine*	CO_2, Formaldehyde, and Toluene	Tan et al. 2022
Weeping fig	*Ficus benjamina*	Octane, Terpene, Formaldehyde and CO_2	Deng et al. 2018, Tan et al. 2022
Aloe vera	*Aloe barbadensis miller*	Formaldehyde, CO_2 and Benzene	Shishegaran et al. 2020
English ivy	*Hedera Helix*	Formaldehyde, Octane CO_2, Benzene, Toluene, Terpene, and Trichloroethylene	Lin et al. 2017, Deng et al. 2018
Spider plant	*Chlorophytum comosum*	Formaldehyde, CO_2, benzene, Toluene, Terpene, ozone and VOCs	Moya et al. 2018
Bird nest fern	*Asplenium Nidus*	CO_2 and Formaldehyde	Su et al. 2015
Snake plant	*Sansevieria Trifasciata*	Benzene, Formaldehyde, Toluene and CO_2	Pajare et al. 2015, Kavya et al. 2017
Golden pothos	*Epipremnum Aureum*	Formaldehyde, Toluene, PM 2.5, PM 10, Xylene, Ozone, Ketones, and CO_2	Taemthong et al. 2022, Deng et al. 2018
Dracaena	*Dracaena Compacta*	CO_2, Carbon monoxide, TVOCs	Tan et al. 2022

E. Bird Nest Fern

Bird's Nest Fern, scientifically known as *Asplenium Nidus*, is a tropical plant in the Polypodiaceae family. One of the biggest fern species is found in the Polypodiaceae family, which exhibits great morphological and systematic variety (Tan et al. 2022). It is found in the tropical rainforests of Southeast Asia and Africa. The Bird Nest Fern has the ability to reduce CO_2 levels by 0.3 ppm per hour (Su et al. 2015). Bird nest fern can continue photosynthesis under artificial lighting at night, and the photosynthesis was more successful at removing gas pollutants after having done so during the day, indicating that bird nest fern may be capable of long-term and continuous removal of gas pollutants. The findings show that bird nest fern can successfully remove indoor CO_2 and HCHO, therefore cleaning the air. According to the experimental findings in (Su et al. 2015), bird nest fern may lower CO_2 levels from 2000 ppm to a safe 800 ppm at an average rate of 1.984 ppm/h (per pot). HCHO concentrations, on the other hand, were lowered from 2 ppm to the safe threshold of 0.1 ppm, at an average of 0.003 ppm/h (per pot).

F. Snake plant

Snake Plant, also known scientifically as *Sansevieria trifasciata*, is a popular indoor and outdoor plant all around the world. It is recognised as a medicinal plant in addition to being an attractive plant. It is one of the greatest houseplants for absorbing airborne pollutants, such as formaldehyde, nitrogen oxide, benzene, xylene, and trichloroethylene. It converts a lot of CO_2s to O_2 at night, making it ideal for having several in the room. The snake plant needs an atmosphere with an air temperature of 24 °C, a relative humidity of 40%, and a light intensity of 1500 lux (Tan et al. 2022). Snake Plant is one of the few plants that can absorb carbon dioxide and release oxygen not only during the day, but also at night through a process called Crassulacean Acid Metabolism (CAM) photosynthesis (Kavya et al. 2017). Snake Plant can absorb the most carbon dioxide in parts per million per square centimetre of leaf area, at 0.201 ppm/sq.cm. Snake plant showed almost double the photosynthetic potential of dracaena, as well as higher oxygen-releasing potential in both light and dark circumstances, and hence might be a better candidate indoor plant for pot transplanting in cold climates to enhance indoor air quality.

G. Golden Pothos

Golden Pothos, scientifically known as Epipremnum Aureum, is an Araceae family member (Tan et al. 2022). It is also known as devil's ivy. It can tolerate environmental stress and survive in the target region for a while. It is highly effective in removing air pollutants like benzene, trichloroethylene, xylene, and formaldehyde and maintaining fresh air by providing oxygen thanks to its evergreen vines and little green heart-shaped leaves (Kulkarni et al. 2018). Without soil, golden pothos may be grown in pots filled with water. Golden Pothos grows in the combined circumstances of 300 Lux of light intensity, 22–27°C of temperature, and 50–70% relative humidity (Deng et al. 2018). (Taemthong et al. 2022) discovered that the most effective rate of CO2 reduction was 1.74 ppm/min when green walls with Golden pothos were placed perpendicular to windows and allowed for maximum light exposure. It can lower formaldehyde by 81-96% in 24 hours (Deng et al. 2018), shown in table 3. Golden pothos can lower 85% of total suspended particles, 75.2% of PM 2.5, and 71.9% of PM10, according to (Ibrahim et al. 2018).

Table 3: Effectiveness of indoor plants in eliminating formaldehyde and CO2

Plant Name	CO2	Formaldehyde	Reference
Areca palm	88.5%	88.16%	Bhargava et al. 2020, Hashim et al. 2019
Peace lily	83.8%	-	Hormann et al. 2017
Dumb cane	90.2%	81-96%	Sarker et al. 2022, Deng et al. 2018
Aloe vera	78%	90–95%	Sarker et al. 2022, Deng et al. 2018
English ivy	26.7%	100%	Hashim et al. 2019, Lin et al. 2017
Bird nest fern	60%	95%	Su et al. 2015
Snake plant	81%	99.75%	Sarker et al. 2022, Ullah et al. 2021
Golden pothos	93.76%	81-96%	Tan et al. 2022, Aydogan et al. 2011

CONCLUSION

This paper investigates the ability of frequently used indoor plants to enhance the indoor air quality by eliminate major indoor air pollutants like carbon dioxide and formaldehyde. In addition to reducing CO2 and formaldehyde, indoor plants can help maintain relative humidity and minimise other pollutants such PM 2.5, PM 10, carbon monoxide, toluene, and trichloroethylene. Through the photosynthetic process and the root microbial matrix, indoor plants decrease CO2 and formaldehyde. After analysing the effectiveness of the listed small-scale botanicals in improving IAQ, Golden Pothos, Snake Plant, and Areca Palm are the most popular and effective indoor plants because they can lower most indoor pollutants (Formaldehyde, Toluene, PM 2.5, PM 10, Xylene, Ozone, Ketones, and CO2) and outperform other indoor plants. Aloe vera is the best indoor plant for the night since it emits oxygen and provides optimum indoor air quality. Thus, we conclude that cultivating indoor plants is the most effective and cost-effective way to enhance indoor air quality than utilizing other equipment such as air purifiers.

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