



Impact of Indoor Plants on Human Health: A Review

**Smriti Pathania^{a*}, Homraj Sahare^a, Sarath Jayakumar^a,
Rasika Ashok Sarje^a, Ritika Gupta^a and B. Vidya Sree^a**

^a *Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, 144411, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/ijecc/2024/v14i64216>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/117939>

Review Article

Received: 02/04/2024

Accepted: 05/06/2024

Published: 10/06/2024

ABSTRACT

One of the goals of a construction was to have a sustainable and healthy interior, something that engineers took seriously when creating and utilizing it. Physical approaches can be used to design arrangements, such as in the layout arrangements, lighting, and air reflections. Still, there has been a fierce pushback against the natural approach paradigm. This paper addresses the greening of interior spaces as a means of preserving and improving the quality of interior spaces. The sick-structure pattern, disinclinations, nasal and ocular vexations, and respiratory dysfunction, including unseasonable fatalities, have all been linked to poor IAQ. The use of phytoremediation is a novel method to lessen air adulterants and improve IAQ by absorbing, adsorbing, assimilating, or transferring them. Thus, the current review's goal is to investigate the role that inner sources play in perfecting inner air quality, including their sanctification capabilities. There's adding substantiation that colorful factory species or their corridor can reliably reduce the attention of multitudinous air adulterants in the inner medium and promote mortal good. still, the inner air adulterant junking effectiveness depends on the species of the factory, and colorful factory characteristics like splint

*Corresponding author: E-mail: smritipathania944@gmail.com;

Cite as: Pathania, Smriti, Homraj Sahare, Sarath Jayakumar, Rasika Ashok Sarje, Ritika Gupta, and B. Vidya Sree. 2024. "Impact of Indoor Plants on Human Health: A Review". *International Journal of Environment and Climate Change* 14 (6):145-54. <https://doi.org/10.9734/ijecc/2024/v14i64216>.

size, consistency, area, photosynthetic exertion, and light intensity. One of the cheapest and most reliable ways to create a healthier inner terrain is by using inner shops. If more focus is put on developing a biophilic environment and increasing the usage of inner stores, more public health can be maintained at a lower cost and with less load on the health care system. As of yet, no standards have been set for fashionable interior stores or how they affect vibrant elements like internal ventilation, moisture content, and temperature. Thus, further experimental exploration is demanded that simulates the interior terrain to cover the impacts of inner shops on factors like moisture, temperature, and ventilation., in perfecting the medium of unrestricted space.

Keywords: IAQ; phytoremediation; light intensity; interior ventilation; temperature; respiratory disfunction.

1. INTRODUCTION

Houseplants Reduce Harmful Indoor Air Pollutants particle board furniture, paints and plenty of cleansing substances have VOCs, additionally called unstable natural compounds, which might be chemical compounds that might be launched as gases from not unusual place family products. VOCs, which include benzene, formaldehyde, and trichloroethylene, could have poor fitness outcomes which include an accelerated chance of developing some malignancies, allergies and other respiratory conditions, migraines, CNS damage, and more. Houseplants are a practical and affordable solution to minimize volatile organic compounds (VOCs) and improve the health of your home, even if placing air purifiers and windows can also improve indoor air quality and minimize chemical emissions. Chang, T et al., [1]. An estimated fifteen to eighteen houseplants are required to considerably reduce volatile organic compounds (VOCs) in a residence, as per a study on the subject [55-56]. Another analysis found that dracaena can remove 94% of airborne acetone in a comparable period as bromeliads, which can remove over 80% of typical volatile organic compounds from the air in just twelve hours. All plants can purify indoor air, although some are more effective than others at doing so. The majority of people are aware of how effective connecting with the herbal world is at relieving stress. Hunter, P. [2]. Working with houseplants has been shown in a study to significantly reduce signs of stress and abnormal places, including elevated cortisol levels, blood pressure, and pulse rates. Repotting indoor plants or watering them might be easy ways to reduce mental chatter and slow down breathing rates. For those who are unable to access the outdoors or the natural world, placing a houseplant on a sunny windowsill can help calm anxious minds and promote relaxation. Kaewrat J. et al.,[3]. Although vivid flowers and lush greenery can

bring charm and coziness to bedrooms, the oxygen-boosting properties of plants can also aid in encouraging sound sleep. Through the process of photosynthesis, plants absorb carbon dioxide and convert it to oxygen, which is then released into the surrounding environment. Recent research suggests that exposure to high oxygen levels at night can promote deeper, more restorative sleep, which is why many doctors and scientists recommend having houseplants in your bedroom. Taking care of houseplants has been shown to help reduce stress's symptoms and signs, but it can also improve your mood by reducing the signs and symptoms of chronic conditions including PTSD, depression, and anxiety. Keeping good care of indoor plants can be "definitely distracting" and help generate a sense of cause, but the benefits of indoor plants on brain fitness go much farther. According to a 2007 study, serotonin is released when certain bacteria, called *Mycobacterium vacate*, are present in both indoor and outdoor soil. This process enhances both mental and emotional well-being.

2. MATERIALS AND METHODOLOGY

1. The primary benefits of indoor plants for human comfort and health [39]. An extensive overview of the impact of indoor plants on human comfort and health based on the following four criteria: transpiration, cleansing, psychological consequences, and photosynthesis Amoatey P et al., [4]. The basic processes that keep the carbon and oxygen cycles in nature intact in plants are photosynthesis and transpiration. They could serve as inspiration for human endeavours that are frequently disregarded. Carslaw N et al.,[5]. Furthermore, it has been demonstrated that indoor vegetation indirectly influences stress levels, health, and task performance through subconscious mental processes.

Indoor vegetation has been extensively explored for its potential to reduce indoor pollution and minimize human exposure. It can function as an effective indoor air cleaner. Archary P et al., [6]. Indoor vegetation has roles in a variety of domains, including sensing, solar energy, acoustics, and human comfort and fitness [38]. Utilizing all of a plant's properties improves human comfort and health (Toyoda M et al.,2020).

2. **Indoor Plants Effect on Self-Reported Perceptions.** Indoor flora influences how one views oneself [35]. In particular, indoor plants have the power to increase positive emotions, lessen negative emotions, and ease physical discomfort to greatly improve mental perceptions. It is advised to expose people to several flower or foliage pots, each with a small or mild length, at distances of no more than three meters for about twenty minutes [36]. The beneficial effects of indoor vegetation provide sensible guidelines for policymakers, environmental planners, and the general population. Moslehian et al., [7]. Because human beings nowadays spend the maximum of their time interior and are confronted with an increasing number of excessive bodily and mental fitness and health problems, using indoor flora to offer bodily and intellectual fitness blessings merits extra attention [8] This isn't always best dependent on public fitness but additionally on economic, societal, and environmental sustainability [37].
3. Interaction with indoor vegetation may also lessen mental and physiological strain by suppressing autonomic frightened gadget hobbies in younger adults [33]. Compared to mental labour, this study indicates that engaging in physical engagement with indoor plants can lessen physiological and psychological stress. Hassan et al., [9] This is achieved by lowering diastolic blood pressure and sympathetic nervous system activity while fostering calm, at ease, and organic emotions. Goldstein et al., [10].
4. A scoping overview of epidemiological research on indoor plant life and intellectual health [44]. Most studies were conducted in past years during the COVID-19 pandemic. Despite the numerous publicity metrics and intellectual fitness outcomes, all protected research had been aligned to the concept that indoor vegetation may want to advantage intellectual fitness with the aid of lowering stress, depressive symptoms, and terrible emotions, this demonstrated the small sample size and high degree of variation found in epidemiological studies on indoor plants and mental health. Pérez-Urrestarazu L et al.,[11]. While many studies have demonstrated the beneficial effects of indoor plants, there is limited epidemiological evidence linking indoor plants to improvements in mental health, including decreased stress, depressive symptoms, and negative emotions. This evidence is primarily related to the COVID-19 pandemic. Du W. & Wang, G. [12].
5. **Effect of indoor flora in paintings surroundings on intellectual stress** [43]. The presence of vegetation precipitated a massive extrude in mind activity, relative to that determined inside the absence of vegetation Thatcher et al., [13]. According to EEG data, having indoor plants increased both the high alpha and high beta activities in comparison to when there were no indoor plants, which had a beneficial effect on mental stress [40]. The higher levels of alpha waves in our study were suggestive of higher degrees of relaxation when working with indoor plants [14].
6. **Feasibility have a look at intellectual health-care results of plant installations in workplace spaces** [41]. The impacts of plant installations in office spaces on mental health care include the relaxing of visible weariness and the emotions of drowsiness of organizations of work-associated fatigue emotions [42]. The type of plant and industry having an impact on these effects are the determining factors. Cocârță D et al.,[15].
7. An assessment of indoor inexperienced flowers was conducted to enhance the indoor environment Ali MU et al.,[26]. Effects of indoor pollutants, such as CO2 concentration and volatile organic compounds (VOCs), on the interior thermal environment, Although the effectiveness of using green plants was discussed in terms

- of learning or production, patients' overall post-operative recovery and emotional state [16].
8. Improving the IAQ for Learning Efficiency with Indoor Plants [34]. The total amount of CO₂ breathed out exceeded the legal limit of 1000 parts per million, yet the participants were unaware of the elevated levels of CO₂ indoors. Tsai, W. T. [17]. It is analytically demonstrated that maintaining the indoor plant leaf area density at roughly 14.68% of the floor area might reduce the CO₂ concentration by respiration by 50%. Li C et al.,[18]. When it comes to the positioning of plants, people believe that indoor air is 40% crispier and 140% more palatable. Additionally, there was a 108% improvement in the complaints of SBS symptoms and a roughly 120% improvement in the ability to concentrate on studying. The placement of indoor plants will rise as people become more conscious of sustainability. Jung C et al.,[16]. Indoor plants today not only filter indoor air but also provide a visible green effect to improve human comfort [45].
 9. The look of indoor flora and their impact on people's perceptions of indoor air high-satisfactory and subjective well-being Corlan RV et al., [28]. The plant's outward look significantly influenced the participants' responses, aesthetic preferences, and perceptions of the plant's benefits for humidity, indoor air quality, and subjective well-being. The physical characteristics of the plant can be utilized to forecast how people would perceive its effects on SWB and IAQ [8]. The terms "beautiful," "interesting," "uplifting," and "relaxing" were shown to be the most reliable indicators of benefits for SWB. With the largest SWB benefit, the most suggested plants are Ficus sphere, palm, Ficus column, and Epipremnum. To optimize the health benefits for building inhabitants, designers and installers had to select wholesome indoor plants that people find appealing and captivating [19].
 10. An assessment of common indoor plants' ability to enhance studio apartment indoor air quality. Ventilation plus a biofilter can lower CO₂, TVOCs, HCHO, PM_{2.5}, and PM₁₀ levels by 76%, 87%, 75%, 52%, and 51%, respectively [29]. concluded that a variety of indoor potted plants offer a sustainable, cost-efficient, self-regulating, and effective way to improve indoor air quality and, in turn, people's health and productivity in small, confined spaces (Maung T et al.,2021).
 11. Utilizing indoor plants as a substitute tactic to enhance indoor air quality. Reduced air quality below the established threshold is indicative of indoor air pollution Chen RY et al., [27]. The quality of indoor air is determined by the ambient air quality as well as by a toxic material produced by home activities. Ali et al., [20] In addition to causing lung cancer, asthma, chronic obstructive pulmonary disease (COPD), and sick-building syndrome, indoor air pollution is also linked to over two million deaths in developing nations. Balmes et al.,[21]. The use of indoor plants is one of the fascinating research topics to address the issue of indoor air pollution. Despite the lack of established guidelines for the best indoor plant, a number of research have identified the ability of a certain indoor plant to remove harmful compounds. Luo et al., [22]. This gives evidence-based insight into the utility of indoor plants as a substitute for indoor air remediation and contains key information concerning indoor air pollution. (Sharma et al.,2019).
 12. Using tobacco smoke to help detect harmful metals by using indoor flora as bio monitors. Houseplants and biomonitoring agents include *Dieffenbachia amoena*, *Dracena marginata*, *Ficus elastica*, *Spathiphyllum wallisii*, and *Yucca massengena* [30]. A small amount of toxic metal accumulation can be easily seen in houseplants. Lead (Pb), cadmium (Cd), and chromium (Cr) were chosen due to significant emissions from cigarette smoke [31]. They ascertained this by utilizing inductively coupled plasma-optical emission spectrometry (ICP-OES) to analyse the plant species' leaves. In all species, tobacco use was associated with greater amounts of Cd, Cr, and Pb (Pb > Cr > Cd) than non-tobacco use. (Ghoma et al.,2022).
 13. Human Relations, Indoor Air Pollution, and Current Trends in the Management and

Enhancement of Indoor Air Quality [32]. An analysis and assessment of the main causes of significant pollutant emissions, fitness consequences, and issues related to illnesses predominantly based on IAP, including sick building syndrome (SBS) and building-related illness (BRI) [23]. Furthermore, the methods and strategies for controlling and undervaluing pollutant concentrations are highlighted, along with

the most recent advancements in attempts to address and enhance IAQ and their associated benefits and potentials. Pichlhöfer A et al.,[24]. The development of new materials for sensors, IAQ monitoring systems, and smart homes is anticipated to be a viable strategy for IAQ manipulation and improvement in the future. Tran V et al.,[25].

Table 1. Environmental factors affecting indoor air quality

Sr. No.	Environmental Factors	Recommended Species	References
1	Indoor Air Quality (IAQ)	Golden pothos, Sword fern, English ivy, Dracaena, Lady palm	Fraser Torpy, Michael Zavattaro [2018]
2	Carbon Emission (CO2)	Snake plant, Spider plant, Jade plant, Money plant, Areca palm	Mehmet Cetin, Hakan Sevik [2016]
3	Particulate Matter (PM)	Rubber plant, Aloe vera, Chinese evergreen Philodendron, Fittonia	Stapleton, E.; Ruiz-Rudolph, [2018] Fraser Torpy, Michael Zavattaro [2018]
4	Volatile Organic Compound (VOC)	Areca palm, Bmboo palm , Rubber plants, Peace lily , Dracena	Yu Gong et al (2019)

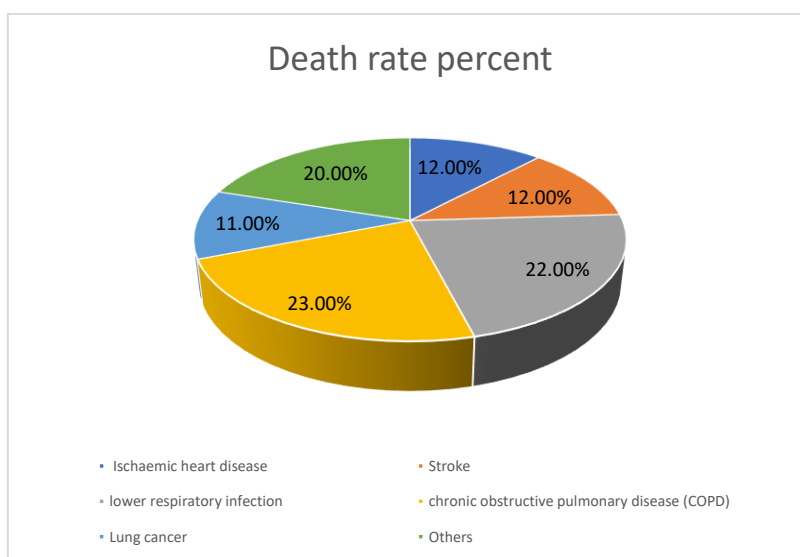


Fig. 1. Death rate due to indoor air pollution (WHO, 2023)

Table 2. Health components affected by indoor plants

Sr. No.	Health Factors	Recommended Species	References
1	Mental Stress	Peace lily, Snake plant , Common ivy , Money plant , Jade plant	Han, K.-T. (2018)
2	Respiratory Disease	Spider plant, Areca palm, Pothos, Aloe vera, Rubber plant	Ahu Aydogan, Ryan Cerone [2021]
3	Lung Cancer	Spider plant, Snake plant , Areca palm, Pothos , Aloe vera	Vuokko, A., Selinheimo, S., Sainio, M., Suojalehto, Virtanen, M & Karvala, K. (2015).

Table 3. Aesthetic components in indoor environment

Sr. No.	Aesthetic Components	Recommended Species	References
1	Terrariums	Air plant , Sword fern , Polka dot plant ,Dracaena , Fittonia	Dr. Imad M. Assali, [2017]
2	Vertical Frames	Money plant, Philodendron, Aglonema, Begonia, Dracena	Raji, B., & van den Dobbelsteen, A. (2015)
3	Dish gardens	Devil's ivy, Jade plant, Lucky bamboo ,Begonia , Peace lily	Nejati, A., Shepley, Lee, C., Varni, J. (2016)

Table 4. Plant recommended for indoor environment

Sr. No.	Botanical Name	Common Name
1	<i>Epipremnum aureum</i>	Money plant
2	<i>Dracaena fragrans</i>	Dracaena
3	<i>Dracaena trifasciata</i>	Snake plant
4	<i>Sansevieria trifasciata</i>	Sansevieria
5	<i>Syngonium podophyllum</i>	Syngonium
6	<i>Bambusa vulgaris</i>	Bamboo plant
7	<i>Aglaonema commutatum</i>	Aglonema



Fig. 2. Photographs of indoor plants

3. TEMPERATURE AND HUMIDITY REQUIRED FOR INDOOR PLANTS

3.1 Temperature

Temperatures that are too high or too low can harm foliage, cause leaf loss, stunt growth, or even kill plants. Maximum indoor plants, however, can withstand frequent temperature changes [56].

- The majority of indoor flowering plants choose the same variety during the day,

but they flourish at night-time temperatures of 55° to 60°F; • A precise rule of thumb is to keep the night-time temperature to 10 to 15°F lower than the daytime temperature to induce physiological recovery from moisture loss, intensify flower color, and prolong flower life; and Indoor plants are sensitive to drafts and heat from registers, especially flowering types. Keep them safe from abrupt temperature changes. Never again find your indoor flowers near sources of heat or air conditioning [46].

3.2 Humidity

Particularly in the winter, most indoor spaces are too dry for healthy indoor plants.

- All indoor plants, except cacti and succulents, benefit from treatments that increase the surrounding humidity [52].
- There's some debate as to whether spraying plants will boost humidity. If you choose to accomplish this, use tepid water and stop misting plants with fuzzy leaves, such as African violets. Early in the day, mist the leaves to help them dry before dusk [54].
- One way to increase humidity throughout the space is to set pots on a tray filled with water and rocks.
- When you place plants in a room together, the humidity level in that space will increase [55].

4. LIGHT HOURS REQUIRED FOR INDOOR PLANTS

- Seedlings: 16 to 18 hours daily.
- Hydroponically grown herbs and lettuce: 12–14 hours daily.
- Houseplants with foliage: 12–14 hours.
- 14–16 hours for houseplants to bloom.

Bright Light: A sunny, mildly lit window facing the south or west that receives direct sunlight throughout the day. It must get not less than 5 to 6 hours of daylight every day, ideally more. Plant care can now and then be tougher for winters face up to the temptation to transport your plant toward the window [50]. Most flora that wants shiny mild will now no longer be capable of dealing with the bloodless drafts that grow the nearer you pass towards a window. e.g. Snake plant, Spider plant, Aglaonema, Dracaena etc [48]

Indirect Light: Indirect mild may be discovered in locations with an east-dealing window, or in an indoors of a room that gets completely mild from a south- or west-dealing window [49]. This can also mean there for instance. e.g. Jade plant, Parlour palm, Sword fern, Devils ivy etc [47].

Low Light: Especially in the winter, a lot of rooms can be considered low light. Low-mild conditions may apply to rooms with north-facing windows or partially shaded residential windows.

It's probably poor light if you find it tough to examine a newspaper [51]. With the addition of artificial light, plants can still thrive in low-light environments. For instance. Peace lily, English ivy, philodendron, and golden pathos [53].

5. CONCLUSION

One of the main ways that plants help people live longer and in better health is by boosting their immune systems' ability to fight disease. Living in a healthy atmosphere and eating a well-balanced, nutritious diet could help achieve this. Plants were a key detail inside the human surroundings that at once and in a roundabout way enhanced human health . By presenting human beings with oxygen and food, plant extractions were broadly used inside the pharmaceutical enterprise as useful resources in ailment prevention and treatments. While circuitously via way of means of enhancing the surroundings via air-purifying and elimination of air pollutants. Indoor plants such as aloe vera can be used as home remedies to aid in managing various diseases . Also, flora has a mental impact that affects human productivity and destressing which influences humans. Indoor plants have been known to add aesthetic value to their surroundings as well as to home decor. However, indoor plants such as rubber trees, English ivy, and spider plants increase the performance in human psychology. The presence of indoor scented and unscented plants enhances human comfort. It has been demonstrated that plant photosynthesis improves air quality by producing negative ions. In addition to eliminating pollutants and volatile organic materials, plants have also been discovered to control humidity and temperature. In general, having indoor plants improves air quality and has numerous positive effects on people's physical and mental health. Indoor plants help to affect many environmental factors such as indoor air quality, carbon emission, particulate matter and volatile organic components as well as health factors such as mental stress, respiratory disease, lung cancer etc.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Chang T, Wang J, Lu J, Shen Z, Huang Y, Sun J, Cao J. Evaluation of indoor air pollution during decorating process and inhalation health risks in Xi'an, China: A case study. *Aerosol and Air Quality Research*. 2019;19(4):854-864.
- Hunter P. The health toll of air pollution: Despite global efforts to clean up the air, outdoor and indoor air pollution still have a drastic negative effect on public health. *EMBO Reports*. 2020;21(8):e51183.
- Kaewrat J, Janta R, Sichum S, Kanabkaew T. Indoor air quality and human health risk assessment in the open-air classroom. *Sustainability*. 2021;13(15):8302.
- Amoatey P, Omidvarborna H, Baawain MS, Al-Mamun A, Bari A, Kindzierski WB. Association between human health and indoor air pollution in the Gulf Cooperation Council (GCC) countries: A review. *Reviews on Environmental Health*. 2021;35(2):157-171.
- Carlsaw N, Shaw D. Secondary product creation potential (SPCP): A metric for assessing the potential impact of indoor air pollution on human health. *Environmental Science: Processes & Impacts*. 2019;21(8):1313-1322.
- Archary P, Thatcher A. Affective and cognitive restoration: Comparing the restorative role of indoor plants and guided meditation. *Ergonomics*. 2022;65(7):933-942.
- Moslehian AS, Roös PB, Gaekwad JS, Van Galen L. Potential risks and beneficial impacts of using indoor plants in the biophilic design of healthcare facilities: A scoping review. *Building and Environment*. 2023;233:110057.
- Berger J, Essah E, Blanusa T, Beaman CP. The appearance of indoor plants and their effect on people's perceptions of indoor air quality and subjective well-being. *Building and Environment*. 2022; 219:109151.
- Hassan A, Chen Q, Liu Y, Jiang T, Guo L, Mingyan J, Liu S. Do plants affect brainwaves? Effect of indoor plants in work environment on mental stress. *Eur. J. Hortic. Sci.* 2020;85(4):279-283.
- Goldstein AH, Nazaroff WW, Weschler CJ, Williams J. How do indoor environments affect air pollution exposure? *Environmental Science & Technology*. 2020;55(1):100-108.
- Pérez-Urrestarazu L, Kaltsidi MP, Nektarios PA, Markakis G, Loges V, Perini K, Fernández-Cañero R. Particularities of having plants at home during the confinement due to the COVID-19 pandemic. *Urban Forestry & Urban Greening*. 2021;59:126919.
- Du W, Wang G. Indoor air pollution was nonnegligible during COVID-19 lockdown. *Aerosol and Air Quality Research*. 2020;20(9):1851-1855.
- Thatcher A, Adamson K, Bloch L, Kalantzis A. Do indoor plants improve performance and well-being in offices? Divergent results from laboratory and field studies. *Journal of Environmental Psychology*. 2020;71: 101487.
- Cetin M, Abo Aisha AES. Variation of AI concentrations depending on the growing environment in some indoor plants that used in architectural designs. *Environmental Science and Pollution Research*. 2023;30(7):18748-18754.
- Cocârță DM, Prodana M, Demetrescu I, Lungu PEM, Didilescu AC. Indoor air pollution with fine particles and implications for workers' health in dental offices: A brief review. *Sustainability*. 2021;13(2):599.
- Jung C, Awad J. Improving the IAQ for learning efficiency with indoor plants in university classrooms in Ajman, United Arab Emirates. *Buildings*. 2021;11(7):289.
- Tsai WT. An overview of health hazards of volatile organic compounds regulated as indoor air pollutants. *Reviews on Environmental Health*. 2019;34(1):81-89.
- Li C, Bai L, He Z, Liu X, Xu X. The effect of air purifiers on the reduction in indoor PM_{2.5} concentrations and population health improvement. *Sustainable Cities and Society*. 2021;75: 103298.
- Ramya A, Nivetha A, Dhevagi P. Overview of indoor air pollution: A human health perspective. *Spatial Modeling and Assessment of Environmental Contaminants: Risk Assessment and Remediation*. 2021;495-514.
- Ali MU, Yu Y, Yousaf B, Munir MAM, Ullah S, Zheng C, Wong MH. Health impacts of

- indoor air pollution from household solid fuel on children and women. *Journal of Hazardous Materials*. 2021;416:126127.
21. Balmes JR. Household air pollution from domestic combustion of solid fuels and health. *Journal of Allergy and Clinical Immunology*. 2019;143(6):1979-1987.
 22. Luo Y, Zhong Y, Pang L, Zhao Y, Liang R, Zheng X. The effects of indoor air pollution from solid fuel use on cognitive function among middle-aged and older population in China. *Science of the Total Environment*. 2021;754:142460.
 23. Yang DL, Zhang ZN, Liu H, Yang ZY, Liu MM, Zheng QX, Xiang P. Indoor air pollution and human ocular diseases: Associated contaminants and underlying pathological mechanisms. *Chemosphere*. 2023;311:137037.
 24. Pichlhöfer A, Sesto E, Hollands J, Korjenic A. Health-related benefits of different indoor plant species in a school setting. *Sustainability*. 2021;13(17):9566.
 25. Tran VV, Park D, Lee YC. Indoor air pollution, related human diseases, and recent trends in the control and improvement of indoor air quality. *International Journal of Environmental Research and Public Health*. 2020;17(8):2927.
 26. Ali MU, Lin S, Yousaf B, Abbas Q, Munir MAM, Rashid A, Wong MH. Pollution characteristics, mechanism of toxicity and health effects of the ultrafine particles in the indoor environment: Current status and future perspectives. *Critical Reviews in Environmental Science and Technology*, 2022;52(3):436-473.
 27. Chen RY, Ho KF, Hong GB, Chuang KJ. Houseplant, indoor air pollution, and cardiovascular effects among elderly subjects in Taipei, Taiwan. *Science of the Total Environment*. 2020;705: 135770.
 28. Corlan RV, Balogh RM, Ionel I, Kilyeny S. The importance of indoor air quality (IAC) monitoring. In *Journal of Physics: Conference Series*. IOP Publishing. 2021; 1781: 012062
 29. Deng H, Xu X, Wang K, Xu J, Loisel G, Wang Y, Gligorovski S. The effect of human occupancy on indoor air quality through real-time measurements of key pollutants. *Environmental Science & Technology*. 2022;56(22):15377-15388.
 30. Ghoma WEO, Sevik H, Isinkaralar K. Using indoor plants as biomonitors for detection of toxic metals by tobacco smoke. *Air Quality, Atmosphere & Health*. 2022;15(3):415-424.
 31. González-Martín J, Kraakman NJR, Pérez C, Lebrero R, Muñoz R. A state-of-the-art review on indoor air pollution and strategies for indoor air pollution control. *Chemosphere*. 2021;262:128376.
 32. Gopalakrishnan P, Kavinraj M, Vivekanadhan V, Jeevitha N. Effect of indoor air quality on human health-A review. In *AIP Conference Proceedings*. AIP Publishing. 2021;2408(1).
 33. Ipek Ö, Ipek E. Effects of indoor air pollution on household health: evidence from Turkey. *Environmental Science and Pollution Research*. 2021;28(47):67519-67527.
 34. Kelly FJ, Fussell JC. Improving indoor air quality, health and performance within environments where people live, travel, learn and work. *Atmospheric Environment*. 2019;200, 90-109.
 35. Kumar P, Singh AB, Arora T, Singh S, Singh R. Critical review on emerging health effects associated with the indoor air quality and its sustainable management. *Science of The Total Environment*. 2023;872:162163.
 36. Li S, Xu J, Jiang Z, Luo Y, Yang Y, Yu J. Correlation between indoor air pollution and adult respiratory health in Zunyi City in Southwest China: situation in two different seasons. *BMC Public Health*. 2019;19:1-14.
 37. Ma Y, Zhang Y, Cheng B, Feng F, Jiao H, Zhao X, Yu Z. A review of the impact of outdoor and indoor environmental factors on human health in China. *Environmental Science and Pollution Research*. 2020;27:42335-42345.
 38. Mannan M, Al-Ghamdi SG. Indoor air quality in buildings: A comprehensive review on the factors influencing air pollution in residential and commercial structure. *International Journal of Environmental Research and Public Health*. 2021;18(6):3276.
 39. Mansouri A, Wei W, Alessandrini JM, Mandin C, Blondeau P. Impact of climate change on indoor air quality: A review. *International Journal of Environmental Research and Public Health*. 2022;19(23):15616.
 40. Maung TZ, Bishop JE, Holt E, Turner AM, Pfrang C. Indoor air pollution and the health of vulnerable groups: A systematic review focused on particulate matter (PM),

- volatile organic compounds (VOCs) and their effects on children and people with pre-existing lung disease. *International Journal of Environmental Research and Public Health*. 2022;19(14):8752.
41. Mujan I, Anđelković AS, Munćan V, Kljajić M, Ružić D. Influence of indoor environmental quality on human health and productivity-A review. *Journal of Cleaner Production*. 2019;217:646-657.
 42. Nandan A, Siddiqui NA, Singh C, Aeri A. Occupational and environmental impacts of indoor air pollutant for different occupancy: A review. *Toxicology and Environmental Health Sciences*. 2021;13(4):303-322.
 43. Pillariseti A, Ye W, Chowdhury S. Indoor air pollution and health: Bridging perspectives from developing and developed countries. *Annual Review of Environment and Resources*. 2022;47:197-229.
 44. Qiu Y, Yang FA, Lai W. The impact of indoor air pollution on health outcomes and cognitive abilities: empirical evidence from China. *Population and Environment*. 2019;40:388-410.
 45. Raju S, Siddharthan T, McCormack MC. Indoor air pollution and respiratory health. *Clinics in Chest Medicine*. 2020;41(4):825-843.
 46. Rosário Filho NA, Urrutia-Pereira M, d'Amato G, Cecchi L, Ansotegui IJ, Galán C, Peden DB. Air pollution and indoor settings. *World Allergy Organization Journal*. 2021;14(1):100499.
 47. Roth S. The effect of indoor air pollution on cognitive performance: Evidence from the UK. Manuscript, London School of Economics; 2020. Available: <https://personal.lse.ac.uk/roths/JMP.pdf>
 48. Sahoo G, Wani AM, Swamy SL, Rout S, Gupta S. Indoor pollution and human health. In *AIP Conference Proceedings*. AIP Publishing. 2022;2385(1).
 49. Samudro H, Samudro G, Mangkoedihardjo SP. Prevention of indoor air pollution through design and construction certification: A review of the sick building syndrome conditions. *Journal of Air Pollution and Health*. 2022;7(1):81-94.
 50. Sarigiannis DA, Gotti A, Karakitsios SP. Indoor air and public health. In *Management of emerging public health issues and risks*. Academic Press. 2019;3-9.
 51. Sharma D, Jain S. Impact of intervention of biomass cookstove technologies and kitchen characteristics on indoor air quality and human exposure in rural settings of India. *Environment International*. 2019;123:240-255.
 52. Toyoda M., Yokota Y, Barnes M, Kaneko M. Potential of a small indoor plant on the desk for reducing office workers' stress. *Hort Technology*. 2020;30(1):55-63.
 53. Yoo SY, Kim YJ, Lee TH, Lee BK, Kim MJ, Han SH, Park HB. Membrane system for management and utilization of indoor CO₂. *Journal of Industrial and Engineering Chemistry*. 2023;122:161-168.
 54. Zhao T, Markevych I, Buczyłowska D, Romanos M, Heinrich J. When green enters a room: A scoping review of epidemiological studies on indoor plants and mental health. *Environmental Research*. 2023;216:114715.
 55. Kabinesh V, Vennila S, Baranidharan K, Ravi R.P.H., Krishnamoorthi S, Thirunavukkarasu M. Sustainable Spaces - The Evolution of Biophilic Design in Modern Architecture: A Review. *Asian Journal of Environment & Ecology*. 2024;23(5):64-77. Available: <https://doi.org/10.9734/ajee/2024/v23i5548>
 56. Deng L, Deng Q. The basic roles of indoor plants in human health and comfort. *Environmental Science and Pollution Research*. 2018;25(36):36087-101.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<https://www.sdiarticle5.com/review-history/117939>