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Phytoremediation Potential of Indoor Plants in Reducing Air Pollution in Libraries: A Review

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Abstract: ***Library is the key to knowledge. It bridges the gap between the user and the information and supports the academic interests of its users. Thereby, it is considered to be the heart of the institution as well as a pillar of society. In the process of acquiring and disseminating information, library professionals need to go through various steps that can cause the alteration in the indoor environment, leading to different health issues, which in turn affect the quality of performance. In this study, the authors tried to point out different sources of indoor air pollutants, namely physical, chemical, and biological pollutants, and what are the potential health risks caused by them. The study also tried to suggest a few Indian indoor plants as an alternative remedy to this situation and how they are helpful. The concept of a green wall is also discussed. As the health of the professionals is related to their performance and also to the satisfaction of the users, so it is necessary to observe and protect the environment they are working in.***

Keywords: IAQ, Indoor Air Pollution, Phytoremediation, health hazards, green walls.

1. Introduction

When speaking of libraries, an image always pops up in our mind, and that is a huge storehouse full of stacks of books. So basically, libraries are the homes of books, journals, magazines, atlases, pamphlets, etc. Mostly the insiders of libraries are made of papers, but now there are also CDs, DVDs, microfiches, chips, computers, printers, scanners etc. All these materials need maintenance and preservation for long-term use. And for preservation, libraries use different methods and different chemicals as well as herbal substances. All the activities inside the library and these substances used for preservation, along with the natural air pollutants, contribute to the degradation of indoor air quality (IAQ) of libraries and that in turn affects the health status of the people working in and using libraries. The term Indoor Air Quality (IAQ) can be defined as the quality of air in a closed building or structure in relation to the pollutant concentration and thermal conditions, which can negatively affect the health and performance of the occupants (Sam Kubba 2017). Phytoremediation is a relatively new term that generally refers to the use of plants to absorb or reduce contaminants in the environment. This method is cost-effective. Plants in general can absorb carbon dioxide from the atmosphere and store it inside them as biomass (through the process of photosynthesis), thereby reducing one of the greenhouse gases and, in turn, slowing the process of global warming. Plants also release oxygen and water vapour into the air, which contributes to making the environment cool and pollution-free (Greipsson 2011). Some indoor plants are very useful in removing various toxic gases from the atmosphere and making the environment comfortable for living and/ or working, along with a charm of aesthetics (Ravindra and Mor 2022).

Indoor Air Pollution in Libraries

Particles or agents present in the air inside a building, causing the air quality to degrade, can be termed as indoor air pollutants. Indoor air pollutants can be categorized as i) Physical pollutants, such as radiation, particulate matter, and temperature, etc., ii) Chemical pollutants, which include nitrogen dioxide (NO_2), carbon monoxide (CO), VOCs, etc., and iii) Biological pollutants such as bacteria, fungi, etc. These are harmful and have negative effects on human health. The most common indoor air pollutants are listed below:

Table1: Different Indoor Air Pollutants

S. No.	Physical Pollutants	Chemical pollutants	Biological Pollutants
1	Temperature	Nitrogen dioxide(NO_2)	Bacteria
2	Humidity	Sulphur dioxide(SO_2)	Fungi
3	Lighting	Carbon dioxide(CO_2)	
4	Particulate Matter (PM2.5, PM10)	Carbon monoxide(CO)	
5	Emissions of electronic devices	Formaldehyde(HCHO)	
6	Radon radiation	Ozone(O_3), Total Volatile Organic Compounds (TVOCs), Lead (Pb), Asbestos, Pesticides	

Physical pollutants:

Temperature is the basic parameter of indoor air quality, as an increase or decrease in temperature can be sensed immediately by the occupants and causes them discomfort. Also, higher temperature is favourable for bacterial growth, thus contributing to the indoor air pollution. Humidity also influences the growth of viruses and bacteria by reducing the air circulation and trapping them in the air (WHO 2022). Use of poor artificial light can cause an unpleasant environment for the occupants, and the excessive use of artificial light can

increase the temperature, causing light pollution (EPA 2024). Particulate matter (PM), also known as particle pollution, is a mixture of solid carbonaceous particles with liquid droplets suspended in the air. They are mainly of two types depending on the size: a) PM_{10} with a diameter of 10 micrometre or less, and b) $PM_{2.5}$ with a diameter of 2.5 micrometre or less. Particulate matter with less than 10 micrometrein diameter is inhalable and affects the lungs deeply. With that concern, $PM_{2.5}$ has the greatest risk of causing serious health problems as it can affect the lungs, even get into the bloodstream, damaging the heart. Although the main source of PM in the library is the outdoor environment, it can also be generated inside from the cleaning activities, carpets, paints, Xerox machines, printers, etc. (Vinh Van Tran et al. 2020). Various electronic equipment, such as reprographic machines, computers, printers, etc., that are used inside the library emit Volatile organic compounds (VOCs) and particulate matter, which in turn degrade the air quality, causing health hazards (Cacho et al. 2013). The main source of Radon is the soil, while the other sources are from buildingmaterials and tap water. It contaminates the air significantly (Jassim and Isaifan 2018).

Chemical pollutants:

There are various common chemical pollutants that originate inside the library and also come from the outdoors and get trapped in the indoor air. Oxides of Nitrogen (NO and NO_2) are potential indoor air pollutants, sources of which might be from the aging wooden furniture, lights, heaters, or from the outdoor air. In high concentration NO_2 can damage health. The sources of Carbon Monoxide (CO) are quite the same as with NO_2, and the presence of both is identified as a hazardous risk factor. CO concentration can cause health problems like headaches, dizziness, and hypoxia. Carbon dioxide (CO_2) is another indoor air pollutant that may come from the respiratory activity of the people inside the library and from the outside air, the adverse effect of which may cause hyperventilation, headache, and loss of consciousness, etc. (Albert 1994). The source of SO_2 is mainly from fuel combustion, and it is present in larger amounts in the outdoor air than indoors. It is also produced indoors by the use of heaters (Nidhi et. al. 2023). Volatile Organic Compounds (VOC) include different chemical substances in gaseous forms that have higher concentrations in indoor air than outside. Sources of VOCs are generally paints, preservatives, pesticides, room fresheners, correction ink, copier etc.

Formaldehyde is one of the VOCs that can be readily measured. Sources of formaldehyde are mainly building materials. Formaldehydes are also present as a component in adhesives and paints. In libraries, formaldehyde mainly comes from the pressed wood products like cabinets, shelves, and drawer fronts, etc., that contain UF resin.

Ozone is an atmospheric pollutant that can infiltrate into the indoor air from outdoors, and as an indoor air pollutant, it can also be produced indoors from the Xerox machines, laser printers, etc. (Heather et al. 2009).

Asbestos is commonly used in building materials for roofs, vinyl floor tiles, old stoves, and heaters, etc. Lead is an environmental pollutant, the major source of which is mainly from automobile emissions. Lead finds its way to the indoor, and it is also produced by the activities inside. This heavy metal can be deposited in the indoor air through dust and can have adverse effects on humans through inhalation or dermal contact (Tan et al. 2016).

Pesticides are used inside the library to keep the books and other materials free from pests and mites. So the indoor air contains a high concentration of pesticide spray.

Biological pollutants:

There are airborne as well as human activity-generated bacteria and fungi, which are also influenced by the climatic conditions and poor ventilation. As microbes, they are harmful. (Burrell 1991).

Potential health hazards caused by indoor air pollution:

Indoor air pollutants have negative impacts on health and can cause severe illness, even leading to death. Various studies have reported on different diseases caused by physical, chemical, and biological indoor air pollutants, ranging from the most common allergic reactions to fatal diseases like COPD and lung cancer.

Table 2: Diseases due to indoor air pollution

S. No	Disease	Cause
1	Allergic reactions	Biological pollutants may cause allergy
2	Breathing problems, headache	Aldehydes
3	Coughing, throat irritation, Chest tightness	Ozone
4	Asthma	Exposure to NO2
5	Chronic Obstructive Pulmonary Disease (COPD)	Nitrogen oxides and particulate matter
6	Airway infection	Exposure to VOC
7	Lung infection/Lung cancer	Asbestos, Sulphur oxides
8	Blood and nerve disorders	Pesticide, Lead
9	Sick building syndrome	Due to discomfort inside the building

A poor indoor air quality leads to indoor air pollution which in turn can cause health problems as well as harmful diseases and loss of performance. According to 'WHO' a medical condition where the residents or workers of a building feel sick or unwell that increases with the time of exposure inside the building is known as sick Building Syndrome (Ref:Parulair). Exposure to a high concentration of NO_2 can have adverse effect on pulmonary function and cause lung damage. Different studies have reported that there are significant changes in the lung function in patients with asthma and COPD with exposure to NO_2. Ozone toxicity occurs primarily through inhalation. The harmful effects of ozone exposure include pulmonary inflammation (Heather et al. 2009). Health effects caused due tothe exposure to Volatile Organic compounds (VOC) include dyspnea or shortness of breath, eye nose and throat irritation, headache, fatigue, dizziness etc. Formaldehydes can cause difficulty in breathing, watery eyes, coughing and wheezing etc. High concentrations of formaldehydes can sometimes trigger attacks of asthma (WHO 2023). Exposure to SO_2 can cause breathing difficulties, asthma, nose and throat irritation etc. And a long exposure to asbestos through breathing can lead to lung cancer.Lead contamination is toxic and being exposed to lead can damage different organs and systems in our body. It can cause hypertension, cerebrovascular diseases. It also

affects the kidney, liver and our central nervous system (Assi et al. 2016). Pesticides are toxic substances and its exposure can cause allergic reactions, headache, dizziness, breathing difficulties etc. depending on the amount and period of exposure (Shi et al. 2020). The indoor air contaminated with bacteria and fungi can cause health hazards such as allergic reactions, asthma, conjunctivitis etc. (Hayleeyesus and Manaye 2014).

Use of common Indian Indoor Plants to Maintain Indoor air Quality:

Dracaena group of plants (about 120 species of plants in the Asparagaceae family) are very capable of removing benzene from indoor air. It can also remove formaldehyde and improve indoor air quality (Treesubsuntron C and Thiravetyan, P. 2012).

Table 3: Common Indoor plants in India and their effects

Plants	Common name	Family	Effects
Dracaena fragrans	Dracaena	Asparagaceae	Reduce VOCs, Reduce CO_2, remove bad smell
Spathiphyllum wallisii	Peace Lily	Araceae	Do
Anthurium andraeanum	Anthurium	Araceae	Reduces formaldehyde, ammonia and hydrocarbon
Epipremnum aureum	Money Plant	Araceae	Reduces Benzene and formaldehyde
Aloe Vera	Aloe Vera	Asphodelaceae	Do
Chlorophytum comosum	Spider Plant	Asparagaceae	Reduce Ozone, formaldehyde and Hydrocarbon
Ficus benjamina	Weeping fig	Moraceae	Reduce formaldehyde and hydrocarbon
Dypsis lutescens	Areca Palm	Arecaceae	Reduces formaldehyde
Polystichum munitum	Sword fern or Boston fern	Dryopteridaceae	Do

Table Ref: air purification by house plants/Pieter de Visser)

Table Ref: role of plants in indoor air remediation/Parulchauhan, IJETSR)

Peace Lily, as an indoor plant, has the capacity to purify air by absorbing contaminants such as benzene, CO, etc. It reduces VOCs and adds moisture to the indoor air, thereby making it comfortable for breathing. It also absorbs some airborne allergens, as well as acetone and alcohol products produced from varnishes, paints, and other similar materials, promoting calmness. It also has an aesthetic use as home décor (Casalena 2022).

Anthurium plants can purify the air by removing formaldehyde, benzene, xylene, etc. It also removes microbes and spores from the air, allowing allergy-prone people to relax and feel stress-free.

Money Plant is a powerful indoor air purifier that removes formaldehyde, benzene, etc. It also produces oxygen. As it removes toxins from the air, it promotes good health. The leaves of this plant absorb the radiation from electronic devices such as laptops, computers, televisions, etc., thereby keeping us safe from the harmful effects, and are also good for the eyes.

Aloe Vera also has the air filtration capability by expelling formaldehyde, benzene, dust, and microbes. This plant also has anti-inflammatory and antimicrobial properties. It also helps to improve air quality by absorbing some common indoor chemicals found in paints and glue (Inbathamizh et al. 2020).

Spider plant removes benzene, xylene, carbon monoxide, etc. It also removes formaldehyde produced from wood works, adhesives, pesticides, etc. It also increases humidity in the surrounding air (Rawat 2019).

The Areca palm removes toluene, xylene, and formaldehyde. It reduces stress and is good for people suffering from allergies (Sharma et al. 2019).

Boston fern absorbs formaldehyde emitted from air fresheners, adhesives, paints, etc., and provides a soothing effect in the surroundings. It also acts as a humidifier and helps to retain the moisture in the air, which is good for dry skin problems in cold weather and in air conditioned room (Rawat 2019). Weeping fig filters the air by removing formaldehyde and hydrocarbons. It is a natural humidifier. It also has antimicrobial properties.

Table 4: Other Indian Indoor Plants with Air Purifying Properties

Sl. No.	Plant name	Scientific name	Family
1.	Tulsi	*Ocimum tenuiflorum*	Lamiaceae
2.	Windows Thrill	*Kalanchoe blossfeldiana*	Crassulaceae
3.	Radiator plants or Peperomia	*Peperomia pellucida*	Piperaceae
4.	Snake Plant	*Dracaena trifasciata*	Asparagaceae
5.	Lucky bamboo	*Dracaena sanderiana*	Asparagaceae

There are a few other common Indian indoor plants that also have some health benefits and air purifying properties. Tulsi is the most common household plant that acts as a natural air purifier by absorbing CO and SO_2. It can continuously produce fresh oxygen and is good for skin as well as respiratory issues.

Lucky bamboo can remove harmful toxins from the air and is believed to reduce stress. Snake plant also filters the air by removing toxic substances like formaldehyde. It promotes mental health and well-being. In addition to the purification of air, Windows' thrill reduces stress and boosts our moods (Rankel 2024). Peperomia has anti-inflammatory properties and is good for the eyes (Ho et al. 2022).

Application of Green Walls:

Green wall, also known as a bio-wall or vertical garden, can be incorporated in the architecture of the library building as a solution to sustainability and a better environment. It can improve air quality and reduce temperature. It also contributes to the psychological well-being as well as aesthetics. A green wall is a system that includes the implementation of greenery on vertical surfaces or walls with selected species of indoor plants. The idea can be applied either by hanging the plants along the wall or by integrating the greenery covering a large surface and allowing it to grow continuously (Manso and Castro- Gomes 2015).

2. Conclusion

Indoor air in libraries is often contaminated with different harmful agents that degrade the air quality, highly impacting the health and performance of the occupants. Various environmental and airborne pollutants and germs, along with those generated by the activities inside, contribute to this situation. The physical, chemical, and biological agents altogether take a toll on human health by affecting body function and causing diseases. Depending on the severity of the concentration of the toxin and the time of exposure, the effect might be lethal sometimes. As an alternative strategy, we can use some indoor plants that are proven to have the air purifying capacity as well as potential health benefits. A relatively new concept of green wall can also be implemented to take a step towards sustainability.

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References

[1] ALBERT (WM). Indoor air pollution: NO, NO_2, CO, and CO_2. *The Journal of Allergy and Clinical Immunology*. 94,2; 1994; 289-295.

[2] ASSI (MA), HAZMEE (MNM), HARON (AW), SABRI (MYM) & RAJION (MA). The detrimental effects of lead on human and animal health. 9, 6; 2016; 660-671. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4937060/

[3] BURRELL (R). Microbiological agents as health risks in indoor air. Environmental health perspectives. Vol. 95, 1991; 29-34. https://ehp.niehs.nih.gov/doi/abs/10.1289/ehp.919529

[4] CACHO (C), SILVA (GVA), MARTINS (A) & KOTZIAS (D). Air pollutants in office environments and emissions from electronic equipment: A review. Fresenius environmental bulletin 22, 9; 2013; 24-48.

[5] CASALENA (E). Peace Lily. By A-Z Animals Staff.December 28, 2022. **https://a-z-animals.com/blog/peace-lily-benefits-and-other-facts/**

[6] EZZATI (M). Indoor air quality in developing Nations. Encyclopedia of Energy. 2004; 343-350.

[7] GREIPSSON (S). Phytoremediation. Nature Education Knowledge 3,10; 2011; 7-10. https://www.nature.com/scitable/knowledge/library/phytoremediation-17359669/

[8] HAYLEEYESUS (SF) & MANAYE (AM) Microbiological quality of indoor air in university libraries. 4,1; 2014; S312-S17. https://www.sciencedirect.com/science/article/pii/S2221169115302884

[9] HEATHER (L), PAPINCHAK (E), JAY (H), TEODORA (O) & DENNIS (R). Effectiveness of Houseplants in Reducing the Indoor Air Pollutant Ozone.19,2; 2009; 286-290. https://journals.ashs.org/horttech/view/journals/horttech/19/2/article-p286.xml

[10] HO (KL), YONG (PH), WANG (CW), KUPPUSAMY (UR), NGO (CT), MASSAWE (F) & NG (ZX). *Peperomia pellucid* (L.) Kunth and eye diseases: A review on phytochemistry, pharmacology, and toxicology. 20,4; 2022; 292-304. https://pubmed.ncbi.nlm.nih.gov/35153134/

[11] INBATHAMIZH (L), APARNA (K). & HARINI (AS). Indoor medicinal plants: beneficial biocatalysts for air filtration and bioremediation – A review. *International journal of green pharmacy*. 14,2; 2020; 130-137. https://www.greenpharmacy.info/index.php/ijgp/article/view/2875/1104

[12] IRENA (I). UNSD, World Bank, WHO. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution—Non Commercial 3.0 IGO (CC BY-NC 3.0 IGO) 2022. Available from: https://trackingsdg7.esmap.org/downloads.

[13] JASSIM (M) & ISAIFAN (R). A review of the sources and impacts of Radon Indoor air pollution. Indoor Air Pollution, 2018.

[14] KIERSTEN (R). Benefits of having a Milky Widow's Thrill. Greg, 2024. https://greg.app/milky-widows-thrill-benefits/

[15] KUBBA (S). Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes, Second Edition, 2017. https://www.sciencedirect.com/topics/engineering/indoor-air-qualityviewed on 1/2/2024

[16] MANSO (M) & CASTRO- GOMES (P). Green wall systems: A review of their characteristics. *Renewable and sustainable energy.* 41,78-88; 2015; 863-871. https://www.researchgate.net/publication/266078897_Green_wall_systems_A_review_of_their_characteristics

[17] MAXWELL (NI). Environmental injustices of energy facilities. Encyclopedia of Energy. 2004; 503-515.

[18] RAJORIA (N), JHAMARIA (C), SHARMA (S), SINGH (N), AMERIYA (T) &. GUPTA (A). Sources and effects of indoor air pollutants: a review. Annals of forest research 66,1; 2023; 1035-1047. https://e-afr.org/article/view-2023/pdf/1035.pdf

[19] RAVINDRA (K) & MOR (S). Phytoremediation potential of indoor plants in reducing air pollutants. Front Sustain.Cities. Vol.4, 2022. https://www.frontiersin.org/articles/10.3389/frsc.2022.1039710/full

[20] RAWAT (A). Spider plant benefits that will make your Jaw drop. Ferns n Petals. 2019. https://www.fnp.com/article/spider-plant-benefits-that-will-make-your-jaw-drop
[21] SHARMA (P), PUSHPA (C) & CHAPADGAONKAR (S). Phytoremediation of indoor pollution – A mini review. World Journal of Pharmaceutical Research. 8,7; 2019; 2136-2143.
[22] SHI (Y), WANG (G), CAI (X), DENG (J), ZHENG (L), ZHU (H), YANG (B) & CHEN (Z). An overview of COVID-19. Journal of Zhejiang Univ Sci B. 21, 5; 2020; 343–360.
[23] SOREANU (G). Biotechnologies for improving indoor air quality. Start-up creation, The smart Eco-Efficient Built Environment. 2016; 301-328.
[24] TAN (SY), PRAVEENA (SM), ABIDIN (EZ) & CHEEMA (MS). A review of heavy metals in indoor dust and its human health-risk implications. Rev Environ Health, 31,4; 447–456. https://www.degruyter.com/document/doi/10.1515/reveh-2016-0026/html
[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 Environ Res public health*. 17,8; 2020; 27-29. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7215772/
[26] TREESUBSUNTRON (C) & THIRAVETYAN (P). Removal of benzene from indoor air by *Dracaena sanderiana*: Effect of wax and stomata. Atmospheric Environment. Vol. 57. 2012; 317-321.**https://www.sciencedirect.com/science/article/abs/pii/S1352231012003469**
[27] WARWICKER (B). Materials for energy efficiency and thermal comfort in buildings. Woodhead Publishing Series in Energy. 2010; 365-383.
[28] WATSON (AFR). Indoor air quality in industrial nations. Encyclopedia of energy. 2004; 351-363.