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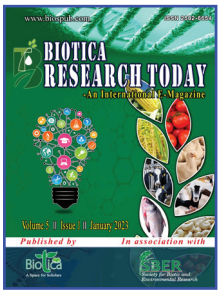

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Indoor Plants for Air Pollution Abatement

C. Prabakaran

Dept. of Natural Resource Management, Horticultural College and Research Institute for Women, Tiruchirappalli, Tamil Nadu (620 027), India

Abstract

Indoor pollutants include particulate matter, CO and other toxins. In developing countries like India, it is gaining importance because of the use of more traditional fuels. Short-term exposures to SPM 2.5 µm (upto 24 h) exacerbate existing health issues like chronic bronchitis, respiratory symptoms, asthma, ER visits and days with limited activity. To reduce pollution and to ensure better living conditions activities like air circulation, filtration, sunlight, ventilation and indoor plants (greenery) should be ensured while designing the buildings. The indoor plants *viz.* Pothos (*Epipremnum aureum*), Rubber plant (*Ficus elastica*), Snake plant (*Sansevieria trifaciata*), Aloe (*Aloe vera*), Peace lily (*Spathiphyllum wallisii*), Spider plant (*Chlorophytum comosum*), Parlor palm (*Chamaedorea elegans*), Reed palm/ bamboo palm (*Chamaedorea seifrizii*) and Areca palm (*Dypsis lutescens*) are the promising plant for indoor pollution abatement.

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Corresponding Author
C. Prabakaran
e-mail: prabakaran.c@tnau.ac.in

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Indoor plants, Indoor pollution, Particulate matter, VOC

Introduction

Indoor air pollution (IAP) is created by the release of harmful pollutants within the building. Indoor air pollutants include fine particulate matter, CO, and various other toxins. Indoor air pollution is gaining importance in developing countries like India, where people often burn fuels indoors for cooking and heating.

Indoor Air Quality

Indoor air quality (IAQ) is defined as the air quality within and around buildings and structures arising from chemical, biological and physical contaminants in the air. The IAP is one of the leading health risks very relevant to developing countries. Concern over the negative health impacts of poor indoor air quality is growing. According to WHO, in 2020, household air pollution caused roughly 3.2 million deaths (Prabakaran, 2007). Although the vast majority of houses and buildings appear to have no issues, non-industrial IAP accounts for a variety of symptoms and illnesses.

Indoor Air Pollutants

Pollutants in indoor air emanate from a variety of sources like aero-biologicals and irritants. Biological contaminants include dust mites, pet dander and saliva, mould, pollen, infectious agents due to stagnant water, mattresses, carpets and humidifiers. The incomplete combustion by-products of biomass fuels include formaldehyde, carbon monoxide, polyaromatic hydrocarbons, suspended particulate matter and oxides of S, As and F, which are produced when coal is burnt and are harmful to human health. Resins, waxes, polishing agents, cosmetics and binders contribute to the production of pollutants such as aldehydes, volatile and semi-volatile organic compounds, which significantly contaminate indoor air. Concern over harmful chemical compounds discharged into

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E-mail: bioticapublications@gmail.com

interior spaces by home furnishings and building materials has grown in recent years (Suzuki *et al.*, 2019). Also, strong, short-lived climate pollutants (SLCPs) include black carbon (sooty particles), methane released by inefficient stove combustion and off-gases released by building materials.

Indoor Air Pollution in India

India tops the list of nations with the largest population that have less access to clean fuel for cooking, since nearly 80% of households in villages still depend on biomass fuel. About 1.3 million mature deaths occur in India due to poor indoor air quality. Airborne suspended particulate matter (SPM) consists of a complex mixture of solids and aerosols, including dry solid particles, liquid-coated solid cores and minute inhalable liquid droplets, all of which can harm health (Udayasoorian *et al.,* 2007). Short-term exposures to SPM 2.5 µm (upto 24 h) exacerbate existing health issues like chronic bronchitis, respiratory symptoms, asthma, ER visits and days with limited activity. These unfavorable health impacts are observed in individuals of all ages. According to the Global Burden of Disease Project of WHO, PM 2.5 µm is the common air particle that is most strongly linked to ill-health caused by air pollution. Particles with a diameter of 10 µm (PM10) are predominantly known to impact the upper respiratory tract causing allergic rhinitis and related comorbidities, which are a cause of major concern in India.

Health Problems Associated with Indoor Air Pollution

Indoor air pollution (IAP) has multi-system health impacts that are visible from early pregnancy through old age. It has been demonstrated that exposure to IAP, depending upon the severity of the exposure to pollutants during pregnancy, has both short-term and long-term health consequences. The pollutants are absorbed into the bloodstream through the lung parenchyma, causing multiple coagulopathy syndromes and depositing in the placenta, interfering with foetal nutrition, causing stillbirth, pre-mature birth, small for gestation babies, who are born with fixed airway obstruction leading to chronic lifelong lung problems along with other non-pulmonary diseases, including memory and behavioral problems. IAP causes 4,00,000-5,50,000 premature deaths in India from acute lower respiratory infections and chronic pulmonary obstruction disease. Exposures during pregnancy also affect the epigenome and cause congenital abnormalities. The cardiovascular system, endocrine system and brain system are affected as well. Cancer has also been linked to IAP.

WHO Global Air Quality Guidelines for Air Pollution Prevention

WHO has released guidelines for safeguarding public health against the threats posed by selected indoor pollutants, which mentions that annual average $PM_{2.5}$ concentrations should not be more than 5 g m^{-3}, and 24-h average exposures must not be higher than 15 g m^{-3} on more than 3-4 days $year^{-1}$. Households employ a variety of domestic fuels and technologies for heating cooking and lighting like firewood, LPG, cow-dung cakes, coal and kerosene, all of which contain compounds like formaldehyde, poly-organic materials and hydrocarbons. Out of the 0.2 billion people in India who use fuel for cooking include 49, 28.6, 8.9, 2.91.50.4, 0.1, 0.5% firewood, LPG, cow-dung cake, kerosene, coal, lignite/ charcoal, biogas, electricity and other alternatives, respectively. Also, over 750 million families are unable to access electricity, which forces them to use hazardous lighting sources like kerosene lamps, exposing them to extremely high levels of fine particulate matter. At the household level, women and children disproportionately experience the highest health burden in terms of IAP, as they spend more time exposed to toxic smoke from polluting stoves and fuels while cooking.

Sources and Effects

Indoor air quality (IAQ) in workplaces impacts productivity and well-being. Outside the homes, considerable time is spent by people in indoor spaces in their workplaces, schools, and other commercial and industrial buildings. Combustion by-products, radon and organic chemicals that are volatile or semi-volatile are among the pollutant types with significant indoor sources. Particulate matter and ozone are the two outdoor contaminants that warrant particular attention. Additionally, outdoor particulate matter levels from nearby construction sites, tobacco smoke, carpets and anthropogenic activities have all been linked to an increase in indoor PM levels. Concrete additives are known to cause higher indoor ammonia concentrations. Indoor radon is the dominant source of health-relevant radiation exposure to public health. Exposure to high levels of indoor radon has a significant lung cancer risk factor. Another health impact from IAP is sick building syndrome (SBS), which is associated with a set of nonspecific symptoms experienced by occupants due to time spent in a building with poor IAQ. One of the important causes of SBS is inadequate ventilation.

Hospitals, the most essential component of public infrastructure, contribute to nearly 4.4% of the carbon footprint, including IAP. Each department of a hospital sources pollutants, *e.g.*, anaesthesia (nitrous oxide and waste anaesthetic gases - halogenated anaesthetic agents), laboratory fumes (hazardous air pollutants, HAPs), refrigerators (hydrofluorocarbons), sterilization units (VOCs, especially ethylene oxide), nebulization in the ER and ICU, and the cleaning agents used. Large, enclosed, air-conditioned public gathering places like hospitals represent a health concern owing to dangers from IAP and the transmission of airborne diseases. According to the Pollution Control Board, the primary Indian Air Law did not mandate IAQ.

The Indian National Green Tribunal took note of the issue and determined it to be a significant legal issue, urging regulation of IAQ in public areas (Singh and Dewan, 2022). Poor hospital IAQ may induce sick hospital syndrome (SHS), which can cause headaches, exhaustion, eye and skin irritations, and other symptoms. More gravely, poor hospital IAQ management may result in nosocomial infections and occupational disorders. Also, hospitals without ventilation contribute to four times more infection rates.

In developing and underdeveloped countries, there is still a deficiency of IAQ-focused research and a shortfall of literature that examines the implications of climate change on IAQ that might affect public health. Research is needed on indoor environmental quality monitoring to combat the health risks caused by various indoor air pollutants. Additional research is necessary to assess the exposure levels of indoor pollutants and to strengthen the evidence for their association with health outcomes.

Government Initiatives

Rural populations are aware of the dangers of breathing in smoke from conventional cooking methods. However, the affordability and availability of an alternate cooking energy source is a disadvantage for these populations. In India, to prevent, control and reduce air pollution, the government has implemented a variety of legislative measures like the National Clean Air Programme (NCAP) and a Comprehensive Action Plan. Persistent and collaborative efforts from several industries like housing, energy, environment, health and rural development are needed to mitigate IAP. While formulating policies, India should follow reasonable and logical principles that consider the ground conditions. Concurrently, effective interventions, beginning with education, a shift in fuel usage and suitable urban architectural methods are required.

Prevention and Control

To reduce pollution and to ensure better living conditions activities like air circulation, filtration, sunlight, ventilation and indoor plants (greenery) should be ensured while designing the buildings. Green buildings and sustainable architecture are known to improve IAQ compared to conventional buildings. It is imperative to take quick action to improve IAQ, as most people spend a maximum amount of time indoors.

Indoor Plants for Pollution Abatement

The indoor plants *viz*. Pothos (*Epipremnum aureum,* Figure 1) Rubber plant (*Ficus elastic*, Figure 2), Snake plant (*Dracaena trifaciata*, Figure 3), Aloe (*Aloe vera*, Figure 4), Peace lily (*Spathiphyllum wallisii*, Figure 5), Spider plant (*Chlorophytum comosum*, Figure 6), Parlor palm (*Chamaedorea elegans*, Figure 7), Reed palm/ bamboo palm (*Chamaedorea seifrizii*, Figure 8) and Areca palm (*Dypsis lutescens*, Figure 9) are the promising plants for indoor pollution abatement. The plants *viz.*, Parlor palm and Areca palm are low-maintenance plants. They differ in their leaf shape. A parlor palm's leaves are delicate lanceolate shapes, (growing up to 8 inches long). An Areca palm's leaves are larger and ovoid, growing up to several feet (multiple stems arise from one base) in clusters. The areca palm has an arching habit. The parlor palm grows upright in clusters and is sturdier.

Figure 1: *Epipremnum aureum* (Pothos)

Figure 2: *Ficus elastica* (the rubber plant)

Figure 3: *Dracaena trifasciata* (Snake plant)

Figure 4: Aloe (*Aloe vera*)

Figure 5: *Spathiphyllum wallisii* (Peace lily)

Figure 6: *Chlorophytum comosum* (Spider plant)

Figure 7: *Chamaedrea elegans* (Parlour palm)

Figure 8: *Chamaedorea seifrizii* (Bamboo palm/ reed palm)

Figure 9: *Dypsis lutescens* (Areca palm)

Conclusion

A houseplant, sometimes known as a pot plant, potted plant, or indoor plant, is an ornamental plant that is grown indoors. As such, they are found in places like residences and offices, mainly for decorative purposes. Indoor plants bestow clean, healthier air for human beings to breathe, improving our well-being and comfort. They make our surroundings more pleasant, and they make us feel calmer. Interior plants have been associated with reduced stress, increased pain tolerance, and improved productivity in people. Ornamental indoor plants absorb VOCs, control the particulate matter and it will also give oxygen by absorbing carbon monoxide and Other VOCs. While selecting indoor plants care should be taken that they should grow under the shade with little maintenance and should have a high growth rate. Moreover, it should not toxic to children and pets.

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