

## GREEN BREATH: HARNESSING INDOOR PLANTS TO PURIFY WORKSHOP ENVIRONMENTS IN SUSTAINABLE MANUFACTURING

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**ABSTRACT:** On the global scale, indoor air pollution in industrial workshops constitutes a significant occupational and environmental concern. Sustainable manufacturing approaches, including biophilic interventions such as the integration of indoor plants, have been explored for their capacity to enhance air quality in a natural manner. This systematic review reflects empirical evidence on the effectiveness of indoor plants in purifying air and boosting health and comfort in built environments, with a particular emphasis on their applicability in manufacturing workshops. Peer-reviewed studies published between 2019 and 2025 were identified across multiple databases, and those meeting the inclusion criteria were analyzed. Findings suggest that certain plant species, including “Spider Plant” (*Chlorophytum comosum*), “Snake Plant” (*Sansevieria trifasciata*), and “Golden Pothos” (*Epipremnum aureum*), effectively suppress concentrations of volatile organic compounds (VOCs), carbon dioxide (CO<sub>2</sub>), and particulate matter. In addition, psychological benefits such as stress reduction among workers and improved job satisfaction were consistently observed. Although indoor plants have been widely studied, their application in workshop environments remains underexplored. The review concludes that indoor plants have considerable potential to play a supporting role in sustainable manufacturing, especially in small and medium enterprises, but should be accompanied by traditional air handling systems.

*Keywords:* biophilic design, indoor air quality, indoor plants, phytoremediation, sustainable manufacturing

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### 1 INTRODUCTION

Indoor air quality (IAQ) is a vital component of occupational health, yet it remains an underexplored aspect in manufacturing environments. According to Zhang et al. (2019), industrial workshops frequently accumulate a range of pollutants such as volatile organic compounds (VOCs), particulate matter (PM), and elevated carbon dioxide (CO<sub>2</sub>) primarily due to inadequate ventilation and emissions from machinery, solvents, and adhesives. Concurrently, sustainable manufacturing practices are increasingly embracing human-centered design, with biophilic interventions such as indoor plant integration being explored to enhance well-being and air quality (Chen et al., 2021).

Phytoremediation, which involves the use of plants to absorb and neutralize indoor air pollutants, presents a promising, low-cost, and eco-friendly strategy. While numerous studies have validated the air purifying capabilities of plants in office and residential settings, their effectiveness in workshop-scale industrial environments remains largely uninvestigated (Smith, 2024). Therefore, this systematic review aims to identify current evidence on the air purification capacities of indoor plants, highlight plant species with demonstrated effectiveness, and assess their applicability and limitations in workshop settings.

## 2 METHODOLOGY

### 2.1 Search Strategy

This study is based on a qualitative literature review on integrating indoor greenery to enhance air purification in eco-friendly manufacturing settings. Both national and international literature were reviewed to evaluate the use of indoor plants in the manufacturing sector. The study was conducted as a formal systematic review following PRISMA guidelines.

To ensure comprehensive coverage, five academic databases—Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar—were searched using combinations of keywords including “biophilic design,” “indoor air quality,” “indoor plants,” “phytoremediation,” and “sustainable manufacturing.” Peer-reviewed articles published between 2019 and 2025 were selected to enhance the originality of the overall report.

### 2.2 Inclusion and Exclusion Criteria

The inclusion criteria comprised empirical studies that measured pollutant levels in the presence of indoor plants, were conducted in indoor environments (residential, office, industrial), were written in English, and employed measurable IAQ indicators (e.g., VOCs, particulate matter-PM 2.5, CO<sub>2</sub>). Further, the exclusion criteria included studies without quantitative data, experiments conducted in greenhouse or outdoor settings, review articles, commentaries, and studies lacking sufficient methodological detail.

### 2.3 Data Extraction and Synthesis

Relevant data were extracted including plant species, environmental settings, air pollutants measured, methodologies employed, and outcomes. A thematic synthesis was used to organize findings into key areas including pollutant removal efficiency, plant characteristics, psychological benefits, and applicability to industrial settings.

## 3 RESULTS AND DISCUSSION

### 3.1 Results

#### 3.1.1 Pollutant Removal Capabilities

Numerous studies have confirmed that specific indoor plants can significantly reduce airborne toxins. For example, *Chlorophytum comosum* and *Epipremnum aureum* have consistently demonstrated high formaldehyde and benzene removal rates in controlled environments (Yoo et al., 2022). Additionally, Zhang et al. (2019) found that dense indoor plant arrangements in experimental environments reduced PM 2.5 levels by 20-30%. Mayura et al. (2023) highlighted the crucial role of rhizospheric soil microbes in VOC degradation, reinforcing the importance of potting medium composition in enhancing phytoremediation.

#### 3.1.2 Psychological and Workplace Benefits

Exposure to indoor greenery has been associated with positive psychological outcomes. Toyoda et al. (2020) reported that workers surrounded by plants experienced lower stress levels, enhanced focus, and improved mood. Similarly, Chen et al. (2021) observed marginal increases

in productivity and overall workplace satisfaction in biophilic environments, although they noted that causality was difficult to isolate.

### 3.1.3 Applicability to Workshop Environments

Despite their proven benefits, only a limited number of studies have evaluated plant-based interventions in industrial settings. Zhang et al. (2019) conducted a field study in a semi-enclosed carpentry workshop and reported up to 35% VOC reduction using plant-based filters. However, challenges such as dust accumulation on leaves, irregular maintenance, and limited space were frequently cited as barriers to effectiveness.

## 3.2 Discussion

The review confirms that indoor plants can effectively enhance indoor air quality (IAQ) through phytoremediation, particularly species such as *Spider Plant*, *Snake Plant*, and *Golden Pothos*. These plants have demonstrated significant reductions in common indoor pollutants like VOCs, CO<sub>2</sub>, and PM 2.5. Table 1, summarizes the key plant species and their pollutant removal efficiencies. For example, according to the Table 1, *Chlorophytum comosum* has shown formaldehyde removal rates up to 70% in controlled conditions (Yoo et al., 2022), while *Epipremnum aureum* can eliminate over 60% of benzene under favorable conditions (Mayura et al., 2023).

**Table 1.** Summary of Pollutant Removal Efficiency by Plant Species

Plant Species	Primary Pollutants Removed	Average Removal Efficiency	Notable Study
Spider Plant ( <i>C. comosum</i> )	Formaldehyde, CO <sub>2</sub>	65–70% (in 24 hrs)	Yoo et al., 2022
Snake Plant ( <i>S. trifasciata</i> )	CO <sub>2</sub> , Toluene, PM 2.5	30–45%	Smith, 2024
Golden Pothos ( <i>E. aureum</i> )	Benzene, Xylene	60–66%	Mayura et al., 2023

Despite their potential, implementation of indoor plants in industrial workshops is limited by challenges such as dust accumulation, maintenance needs, and pollutant variability. These environments often require hybrid strategies for example, combining plant-based solutions with mechanical filtration to cope with higher pollutant loads (Smith, 2024). Additionally, biophilic design offers psychological benefits, including reduced stress, enhanced mood, and improved satisfaction among workers (Toyoda et al., 2020; Chen et al., 2021). Even if pollutant removal is moderate, these human-centered benefits make indoor plant integration valuable.

Future work should focus on long-term studies in industrial contexts, exploring modular systems like wall-mounted plant units and conducting cost-benefit assessments to support broader adoption in sustainable manufacturing settings.

## 4 CONCLUSION

This review confirms that indoor plants hold considerable potential for enhancing indoor air quality and promoting psychological well-being in manufacturing workshops. Species such as *Chlorophytum comosum* (Spider Plant), *Sansevieria trifasciata* (Snake Plant), and *Epipremnum aureum* (Golden Pothos) have shown measurable reductions in VOCs, CO<sub>2</sub>, and PM 2.5- especially when plant density, light, and airflow conditions are optimized (Yoo et al., 2022; Mayura et al., 2023; Zhang et al., 2019). Additionally, plants contribute to worker satisfaction, stress reduction, and cognitive benefits (Toyoda et al., 2020; Chen et al., 2021).

Nonetheless, practical barriers remain in industrial applications, such as dust exposure, limited space, and maintenance challenges. Zhang et al. (2019) and Smith (2024) stress the importance of combining plant systems with traditional air-handling methods to overcome these issues. While the pollutant-removal effect alone may be moderate in complex industrial environments, the psychological and aesthetic advantages strengthen the case for biophilic design integration. Moving forward, future investigations should prioritize longitudinal studies in real-world workshop environments, assess maintenance feasibility, and explore scalable green infrastructure. Integrating indoor plants into sustainable manufacturing offers a human-centered, environmentally responsible approach to occupational health and productivity.

## 5 ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the Industrial Engineering Training Institute, Katubedda, Moratuwa, Sri Lanka, for the opportunity and support provided throughout this study. Special thanks go to my colleagues and mentors for their valuable insights and encouragement. Their guidance was instrumental in shaping the direction of this research. I also appreciate the collaborative spirit that fostered a productive research environment. This work reflects a shared commitment to sustainability in manufacturing practices.

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