2026 Journal of Engineering, Technology and Social Sciences
Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Volume 12 Special Issue: GTiMME
International Conference on Green Technology in Mechanical and Marine Engineering

IMPROVEMENT OF INDOOR AIR QUALITY IN REDUCING THE AMOUNT OF CO_2 (CARBON DIOXIDE) USING INDOOR FLOATING GARDEN

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ARTICLE INFO

Article history:
Received
14 July 2025
Received in revised form
18 September 2025
Accepted
03 October 2025
Published online
02 January 2026

Keywords:
Indoor Floating Garden; Carbon Dioxide (CO_2); Indoor Air Quality

ABSTRACT

This study aims to evaluate the effectiveness of an Indoor Floating Garden (IFG) system in improving indoor air quality by reducing carbon dioxide (CO_2) concentration, in alignment with the principles of green engineering in the field of Mechanical Engineering. The IFG system was designed as a modular, water-based floating plant installation with existing aquarium placed in a indoor space measuring 20 m². CO_2 concentrations were monitored over a 7-day period using anemometer, with measurements recorded every 3 hours within 8:00 am to 5:00pm respectively. A control room without the IFG system was used for comparative analysis. The results showed that the IFG system successfully reduced average CO_2 concentrations by 23.4% compared to the control room, with a maximum daily reduction of up to 227 ppm. Plants such as Epipremnum aureum was identified as key contributors to CO_2 absorption through active photosynthesis on the water surface. Overall, the use of IFG as a passive approach to indoor CO_2 control presents significant potential in green engineering applications. This innovation not only contributes to the sustainable enhancement of indoor air quality but also offers integration possibilities in modern building designs to reduce reliance on energy intensive mechanical ventilation systems.

1.0 Introduction

Indoor air quality (IAQ) is increasing recognised as a critical determinant of health, comfort and productivity, particularly in urbanised and tightly populated environments. Most significant among these pollutants have been carbon dioxide (CO_2), which is not toxic at typical indoor levels but is a critical indicator of the adequacy of ventilation and has been shown to impact cognitive function, mood and overall well-being (Chuang et al., 2023). Conventional indoor air purification methods rely on mechanical ventilation and heating, ventilation and air conditioning (HVAC) systems. While they are effective, they use a lot of energy and contribute significant to CO_2 emissions in the building sector.

In recent years, green engineering solutions have emerged to address these challenges by integrating natural processes into building environments. Among these, the use of indoor plants has gained traction depend to their potential to passively absorb CO_2 through photosynthesis. Several studies have validated the CO_2 reducing capability of plant species under varying environmental conditions. Weerasinghe et al. (2023) clearly showed that *Spathiphyllum* had high CO_2 absorption rates under controlled lighting. Similarly, Manokeaw et al. (2022) used predictive modelling to show that *Sansevieria* is effective at reducing CO_2 levels. Vertical gardens and other spatial plant systems have also been shown to offer both air quality improvement and energy saving benefits (Yungstein & Helman, 2023).

In this context, simple systems like floating gardens or plant filters are getting more attention because they help plants clean the air more effectively. Rezaie and Choi (2024) introduced a cyanobacterial artificial plant system achieving up to 90% CO_2 removal, highlighting the potential for hybrid bio-botanical solutions. Similarly, Hashim et al. (2019) found that active plant based filters reduced CO_2 more effectively than passive ones showing the importance of good system design.

Although there is growing evidence that plants can help purify air, water-based systems like the Indoor Floating Garden (IFG) are still not widely studied or used. Most previous studies have focused on potted plants, green walls or active filter systems. However, there is little data on how well passive water based plant systems work indoors. As the need for low energy and sustainable indoor air quality (IAQ) solutions grows, it is important to assess other systems that combine eco-friendly ideas with practical design.

While some studies have examined how plants absorb CO_2 under varying lighting and soil conditions (Gubb et al., 2019) and others have explored mobile plant systems (Hashim et al., 2019), there remains a lack of comprehensive testing on the effectiveness of IFG systems in typical indoor settings. Few studies have looked at how the combination of water plants and reflective water surfaces can improve indoor CO_2 absorption through photosynthesis. There are also not many field studies comparing these systems with rooms that have no plants. For example, Tangahu et al. (2024) found that CO_2 levels stayed stable but did not drop significantly.

This study aims to evaluate the effectiveness of an Indoor Floating Garden (IFG) system in reducing indoor CO_2 concentrations within a controlled $20m^2$ indoor environment. By conducting a comparative analysis against a control room and leveraging real-time CO_2 monitoring over a 7-day period, the research seeks to validate the IFG as a passive, sustainable solution for improving IAQ. The findings will contribute to the field of green engineering by exploring how aquatic plant systems can be seamlessly integrated into building designs to reduce reliance on conventional mechanical ventilation.

2. Methodology

2.1 Selection of Plant Species

Epipremnum aureum as illustrated in Figure 1 (commonly known as golden pothos) was selected as the primary plant species for the Indoor Floating Garden (IFG) system based on its proven efficiency in indoor CO_2 absorption, robust growth in low-light environments, and suitability for hydroponic conditions. Previous studies, such as Raghda et al. (2018), have highlighted its effectiveness in improving air quality in office settings while its vigorous photosynthetic activity on water surfaces makes it particularly suitable for water-based installations. Additionally, Epipremnum aureum requires minimal maintenance and demonstrates high adaptability to varied humidity and temperature conditions, aligning well with the passive green engineering goals of this study.

Figure 1: *Epipremnum aureum*

2.2 System design and setup

The IFG system was constructed using an existing rectangular plastic indoor aquarium measuring 90 cm × 45 cm × 40 cm (L × W × H), which served as a water reservoir for the floating garden. A modular floating raft built from plastic storage box, was positioned on the water surface. Circular plant holders were embedded within the raft to secure the roots of the Epipremnum aureum cuttings, allowing their stems and leaves to remain above water while the roots absorbed nutrients directly from the water below.

The experimental room measuring 20 m², was selected to reflect the dimensions of a typical small room. The room was unventilated during the observation hours to minimise external airflow effects. The system included an attached lighting setup, but natural daylight from windows was still the main light source, offering indirect light to support plant photosynthesis. It also included an exhaust fan to help improve air circulation and support consistent CO_2 exchange within the indoor space. The IFG unit was placed central within the room to optimise air interaction and spatial influence.

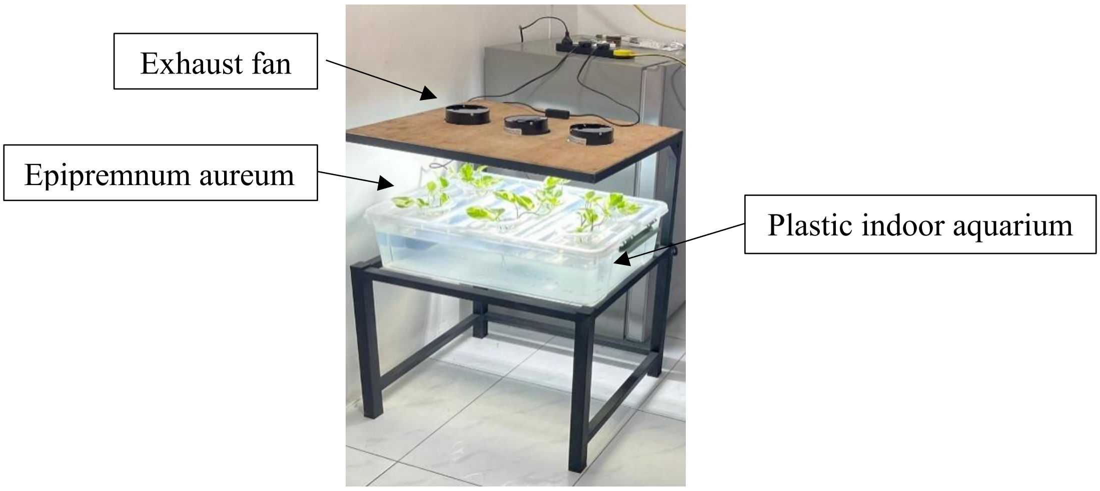

Figure 2: Model of Indoor Floating Garden

2.3 Control Room

A baseline for comparison was established using an adjacent room with similar size, construction materials and occupancy conditions, but without the IFG system. This control room contained standard furnishings but no indoor plants or artificial air purifiers. Both rooms experienced the same ambient external conditions to ensure consistency in comparative assessment.

2.4 Experimental Procedure

The experiment was conducted over a continuous 7-day period. CO_2 concentration levels were monitored using a calibrated digital anemometer equipped with a CO_2 sensor. Readings were recorded at hourly intervals from 8:00 am to 5:00 pm each day, capturing fluctuations during active daytime occupancy periods. The sensor was placed at breathing height (approximately 1.2 metres above ground level) at the room's centre to provide representative indoor air quality data.

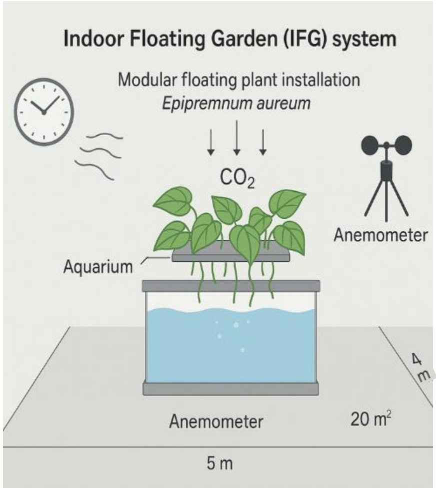

Figure 3: Experimental setup in IFG room

3.0 Result and Discussion

From the Table 1, over the 7-days observation period, the Indoor Floating Garden (IFG) system demonstrated a consistent reduction in carbon dioxide (CO_2) concentration compared to the control room. The average CO_2 level in the IFG room was 23.4% lower than in the control room. On some days, reductions of up to 227 ppm were recorded during peak photosynthetic activity hours, typically between 11:00 AM and 2:00 PM. These results confirm the system's ability to lower indoor CO_2 without the use of mechanical ventilation or air purification devices.

Table 1: Result of percentage reduction of average CO_2 level

Time Taken	Average Control Room Reading within 7 days (ppm)	Average IFG Room Reading within 7 days (ppm)	Percentage Reduction (%)
8:00 am	790	617	21.9
11:00 am	850	634	25.4
2:00 pm	920	693	24.7
5:00 pm	980	769	21.5
Total Average	885	678	23.4

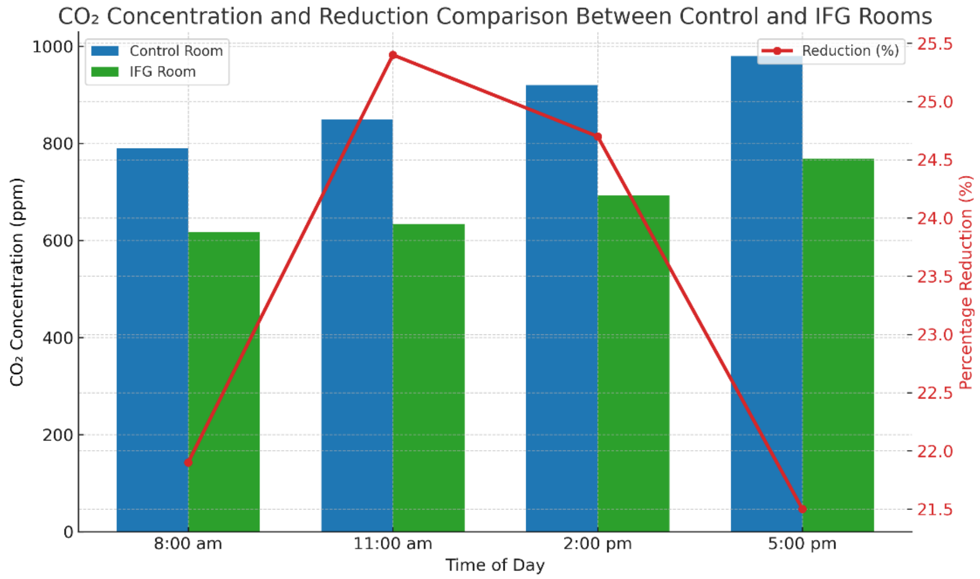

Figure 4: CO_2 concentrations and reduction comparison between control and IFG room within 7-days observation.

From Figure 4, the graph illustrates a consistent reduction in CO_2 concentration across all measured times in the room equipped with the Indoor Floating Garden (IFG) system compared to the control room. The CO_2 levels in the control room range from 790 to 980 ppm, while the IFG room maintains lower values between 617 and 769 ppm. The highest reduction (25.4%) occurs at 11:00 am, possibly depend to increased photosynthetic activity under stronger daylight conditions. This indicates that the IFG system, through the integration of aquatic plants and water surfaces enhances natural air purification, supporting the use of plants as passive CO_2 absorbers through photosynthesis.

The system's effectiveness can be attributed to biological uptake of CO_2 by plants, improved microclimate regulation through evaporation from the water surface, and better airflow supported by the exhaust fan. These combined mechanisms create a more stable and energy efficient environment for air purification. The relatively steady percentage reduction throughout the day, with an overall average of 23.4%, reinforces the practicality of IFG as a sustainable design approach, particularly in indoor environments where conventional systems are energy intensive or less feasible.

4. Conclusion

The IFG system developed in this study effectively reduced indoor CO_2 concentrations by an average of 23.4%, validating its potential as a passive, low-energy solution for indoor air quality enhancement. By integrating water-based plant systems into indoor environments, the study contributes to the growing field of sustainable green engineering solutions and provides a scalable model for future application in building design.

Acknowledgements

Special thanks to the Air-conditioning and Refrigeration Jabatan Kejuruteraan Mekanikal, Politeknik Ungku Omar Workshop for providing the laboratory facilities.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the author(s) used OpenAI's ChatGPT to assist in improving the readability and language of the text. All content generated by ChatGPT was subject to thorough review, editing, and revision by the author(s) to ensure its accuracy, completeness, and alignment with the research objectives. The author(s) take full responsibility for the integrity and content of the published work. This declaration complies with ICGESD 2025 guidelines on the use of generative AI in scientific writing.

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