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Designing Fresh Air – Future Strategies for Built Environments

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Summary

This report explores specific biophilic design strategies and their role in enhancing indoor environment quality through the integration of vegetation and sustainable building practices. As urbanisation increases there is a growing responsibility to address the poor air quality, volatile organic compounds (VOC's), and limited exposure to nature that impact humans physical and psychological health. The assessment of case studies and research evaluate biofiltration techniques and exemplars of green design that highlight the effectiveness of vegetation in improving indoor air quality in commercial office spaces and learning environments.

A key focus of this report is The Revitaliser, a biophilic indoor solution designed by Eco Effective Solutions and Eco Environ-

ment, which incorporates vegetation, biofilters and sustainable interior elements to improve indoor air quality and create a productive workspace.

The Revitaliser was built for the International Healthy Buildings Conference and installed in the conference lobby space at the Brisbane Entertainment and Conference Centre, Australia. Findings from case studies such as a German BMW Manufacturing facility and Australian classroom trials, confirm the benefits of integrating vegetation in indoor environments. They include lower indoor temperatures, enhanced cognitive function and improved psychological well-being. The Revitaliser's carefully designed bio filters and materials with specific plants greatly reduce VOC's, stabilise CO2 levels and boost indoor levels. Combined with hygienic space management via commercial cleaning and plant management, effective decision making and learning can be boosted with increased occupant well-being.

This report aims to emphasise the significance of prioritising natural and vegetation solutions in design and planning to transition the built environment towards more sustainable and productive workspaces and built environments. By collaborating with scientific researchers, built environmental consultants and legislators, current knowledge and technologies can be brought on to foster safer and healthy indoor spaces, adopting innovative new ecoservices.

INTRODUCTION

Concerns about indoor air quality and general environmental health are growing as urbanisation increases. Reduced access to nature, high concentrations of volatile organic compounds (VOCs) and poor air quality all have a detrimental impact on human productivity and health. Fresh air is considered good for people as it does not contain dirt, pollutants or dangerous substances. Typically, in urban environments fresh air is confused with Outdoor air, sourced for office and living environments. Breathing in pollutants causes symptoms such as, but not limited to, headaches, fatigue, dizziness, respiratory disease, asthma, runny nose, etc. In the workplace this is vital for the productivity and safety of occupants who spend their working and living hours inside. The integration of vegetation in an indoor environment can aid in improving air quality, noise reduction and occupant well-being. Utilising vegetation to improve indoor spaces can be optimised with biofiltration plant design, often changing the composition of the air. The benefits of biofilters include a reduction of office stress levels via the psychological benefits of plants in the workplace, absorption, diffraction and reflection of noise resulting in improved space acoustics, the reduction of carbon dioxide levels, absorption of electromagnetic radiation, and an improvement of humidity levels through leaf transpiration. The Revitaliser was a built demonstration of indoor environment quality which was designed in collaboration with Eco Environment (1) with specific biophilic principles. The utilisation of natural elements, especially vegetation, to improve indoor spaces is emphasised by biophilic design principles. This paper discussed how vegetation can be strategically

used to improve air quality, temperature control, noise reduction, and occupants' well-being in workplaces and built environments.

Exemplars

A comprehensive review of studies and case examples was conducted to evaluate the impact of indoor vegetation on the environment and its occupants.

Real-time testing methods were employed to access information such as temperature, air quality and occupation conditions.

Fig. 1 shows the green spaces created at BMW manufacturing. Indoor air quality improvements based on the absorption of CO2 and VOCs by plants.

Figure 1. Indoor space at BMW Manufacturing created for temperature regulation through plant use in office spaces

Fig. 2 shows the use of green space in Manly Hotel, Brisbane, Australia. The structure has a west-facing wall with a green façade that helped to lower the indoor temperature by up to 5°C.

Figure 2. The structure at Manly Hotel in Brisbane has a west facing wall; the integration of a green façade helped to lower the indoor temperature by up to 5°C.

At the Waste Administration Centre in Logan, Queensland, a greenhouse is strategically placed to provide airflow in to the building through a fernery (**Fig. 3**).

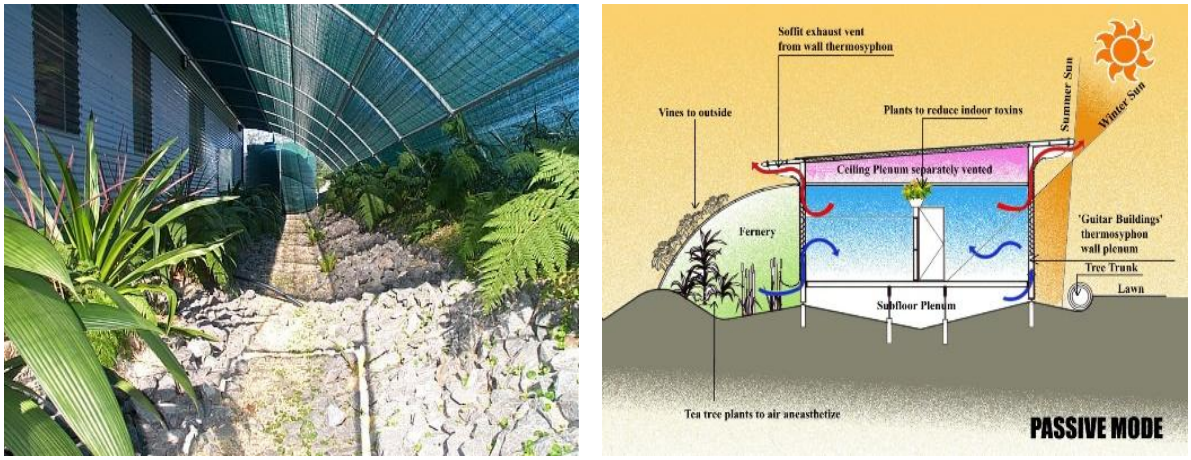

Figure 3. A greenhouse strategically designed to provide air flow through a fernery at the Logan Waste Administration Centre in Queensland.

EVIDENCE-BASED PRACTICES

The Impact of CO2

At Berkeley Lab, USA researchers found that even moderately elevated levels of indoor carbon dioxide resulted in lower scores on six of nine scales of human decision-making performance (The Australian 2012). (**Fig. 3).** When occupants struggle to be productive that will affect work efficiency as well.

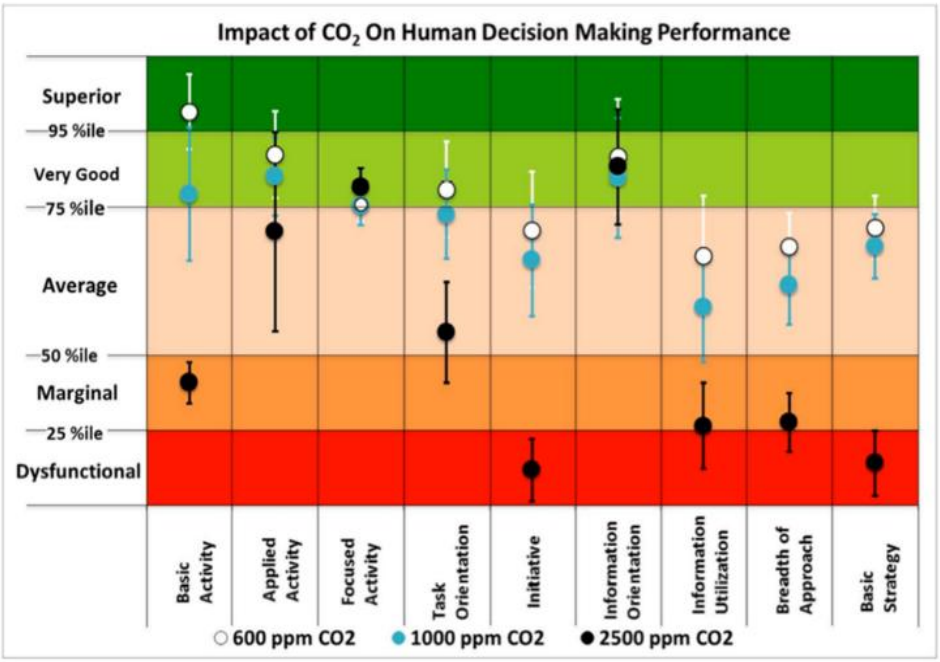

Figure 4. Effect of elevated carbon dioxide content in workspace on nine scales of human decision making.

Plants as a treatment

Psychological benefits of plants in the office environment include reduction in stress, anxiety, and fatigue, as measured in studies conducted by the University of Technology Sydney. A 50% reduction in stress and a 65% reduction in negative emotions among occupants were recorded (Burchett et al., 2010).

Indoor Biophilic Trials – Queensland School Trials

A study performed by John Daly and Professor Margret Burchett was aimed at investigating the effects of indoor plants on classroom performance in the composite classes of Year 6 and 7 students in three independent schools in the Brisbane region. Students were tested with standard tests before plant placements and retested every 4 weeks for 6 months of plant presence or absence. The data collected showed that plants in the classroom can improve student performance (**Fig 5 – 7**).

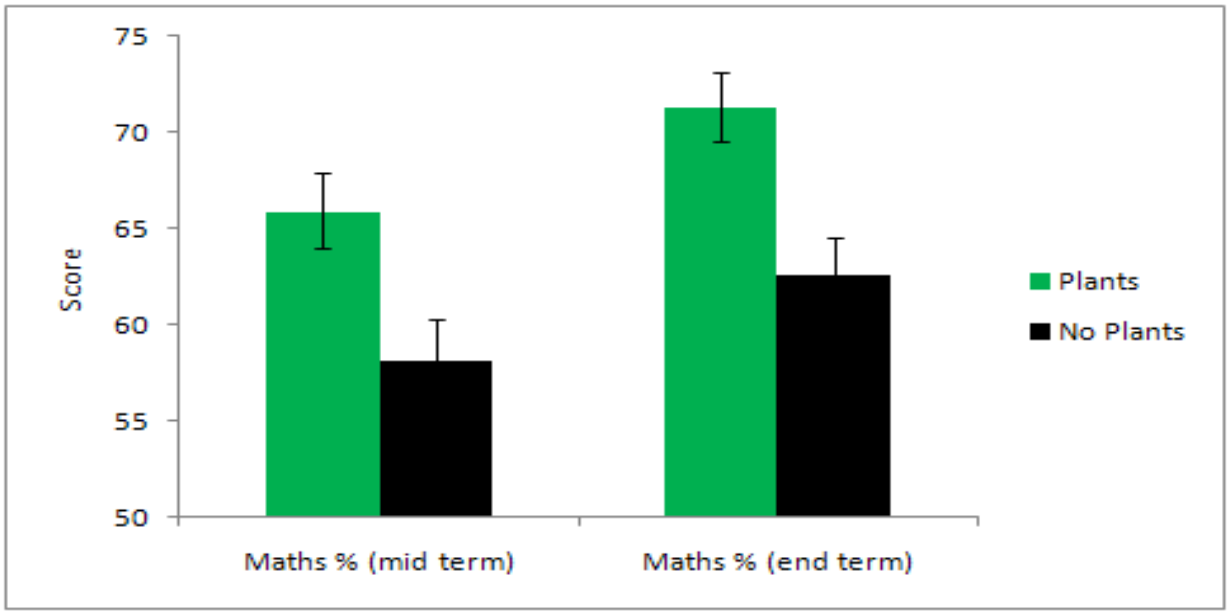

Figure 5. Comparison of changes in mid-term and end of term maths scores, in classes with and without plants in School A (All Saints Albany Creek) (Means and SE; n = 69–72).

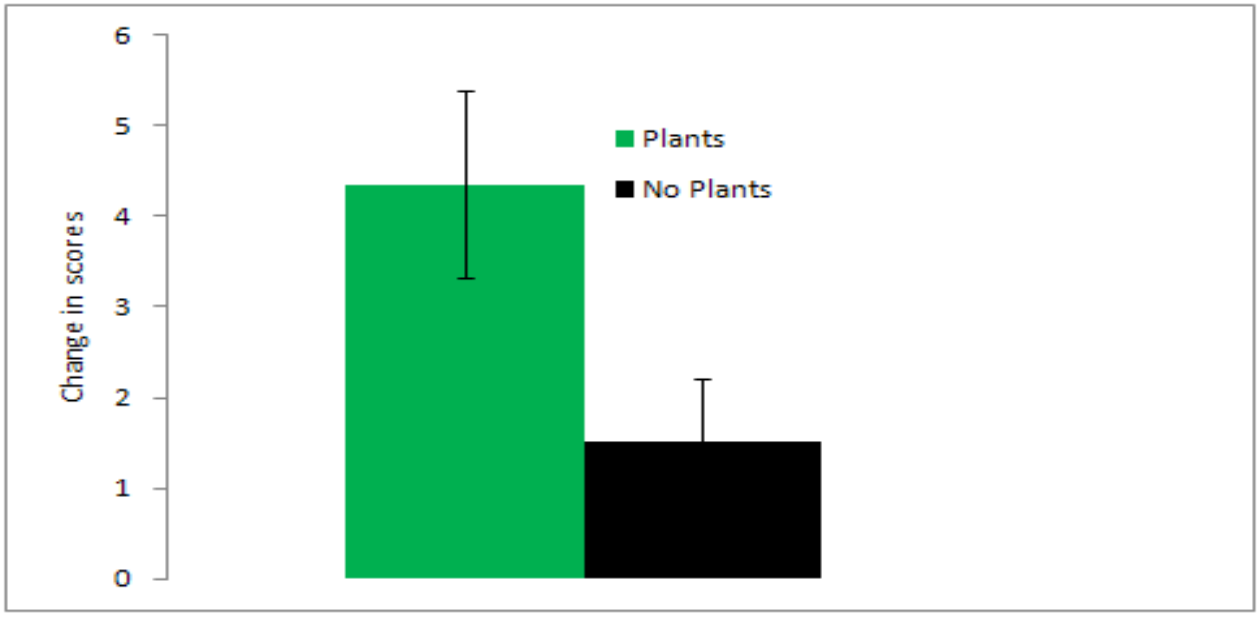

Figure 6. Comparison of changes in mid-term and end of term spellings scores in classes with and without plants in School A (All Saints Albany Creek) (Means and SE; n = 69–72).

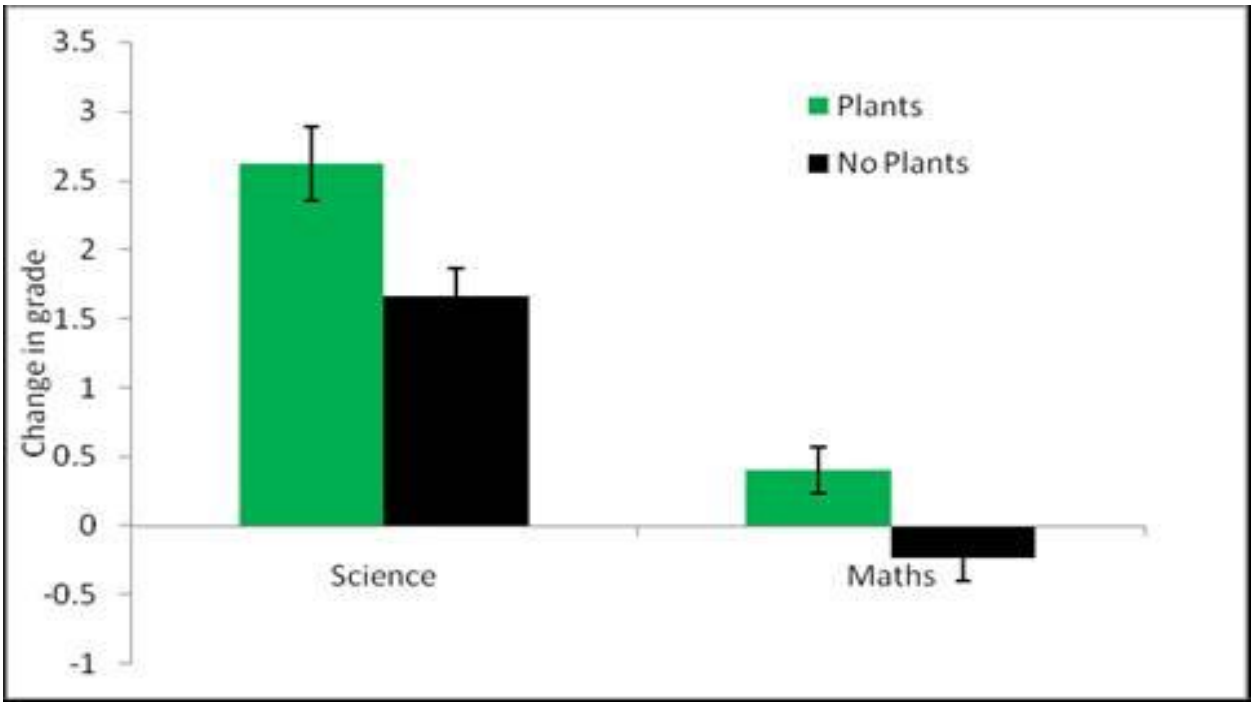

Figure 7. Comparison of end of term science and maths grades in classes with and without plants in School B (All Saints Anglican Gold Coast). (Means and SE, n = 149).

The results indicated that the integration of plants in the classroom led to consistently improved performance. The improvements ranged from 10-14% in every subject. According to this research two or three plants per 100 m^2 in an office can significantly reduce levels of CO2 and VOC's (Daly et al. 2024).

THE REVITALISER

The Revitaliser is an innovation in interior design to improve occupants' decision-making performance and learning environments. Designed by Eco Effective Solutions, under the supervision of Mark Thomson, the Revitaliser combines vegetation, bio filters, and contemporary fit-out elements while incorporating biophilic principles to deliver healthier and more productive workspaces (**Fig. 8**).

Figure 8. Interior design to improve air quality and staff performance using plants.

The principles are:

1. Healthy vegetation can improve fresh air
2. Construction techniques can reduce VOCs
3. Interior design can improve productivity
4. Particular furniture and fittings can reduce VOCs
5. Acoustics, ergonomics and lighting are critical
6. Workspaces are processes not products

Principle One

Improving air quality through vegetation requires a strategic approach that involves correct soil management, plant selection, positioning and maintenance. Indoor soil mixes need to be designed and managed by specialists to ensure optimal plant health and filtering properties. Maintaining regular rotation and management of plants will aid in their ability to purify airborne pollutants. Selecting plant species with high oxygen generation

and VOC absorption will further improve indoor air quality. Additionally, the positioning and maintenance of plants should be designed and managed to ensure adequate airflow around them, maximising circulation and the ability to eliminate pollutants.

Principle Two

In order to reduce VOCs in construction, sustainable maintenance methods, effective building techniques, and cautious material selection are required. Selecting durable materials and suitable repair techniques is crucial to reducing emissions over time. By lowering occupant exposure to dangerous chemicals, the use of low-toxic adhesives and zero-VOC paints enhances indoor environmental quality. Additional advantages of offsite prefabrication offer reduced on-site VOC and indoor air quality. Effective cleaning and waste management, including the use of low VOC cleaning agents and regular air duct cleaning are critical. Additionally, by lowering exposure to pollutants at crucial points, and adhering to a carefully planned construction sequence improves both safety and indoor environmental quality. To maintain sustainability future disassembly and repurposing of materials should also be considered to minimise long-term environmental impact.

Principle Three

Interior design can be crucial in enhancing productivity by creating functional, comfortable and sustainable workspaces. An experienced eco-interior designer should lead the design team to ensure an environmentally responsible and efficient approach. Integrating multiple desktop computer screens has been shown to increase occupant productivity by up to 30%, providing a more efficient workflow. The use of adaptable, modular, and mobile furniture is essential for creating flexible work environments that accommodate changing needs. Sourcing furniture from ISO14001-certified manufacturers ensures sustainability and reduced environmental impact. A holistic design approach that considers ergonomics, aesthetics and sustainability fosters a well-balanced and productive workspace, ultimately improving employee well-being and efficiency.

Principle Four

Selecting the right furniture and fittings aids in reducing VOCs and improving indoor environmental quality. Using third-party environmentally certified furniture ensures that materials meet strict sustainability and health standards. Opting for zero or low-formaldehyde bonding agents in substrates minimises harmful emissions. Additionally, applying zero-VOC paints and powder coated surfaces further enhances air quality by eliminating toxic off gassing. By reducing VOC exposure, workspaces become safer and more comfortable, leading to improved employee productivity and overall well-being.

Principle Five

Acoustics, ergonomics and lighting are critical elements in creating a comfortable and productive workspace. The use of recycled plastic interior linings provides excellent acoustic absorption and durability, helping to reduce noise levels and enhance concentration. Ergonomically approved chairs and furniture improve occupant comfort, reducing strain and increasing overall productivity. A dual lighting concept, incorporating both

overhead and task lighting, minimises computer screen glare and enhances visual comfort. By integrating these design elements, workspaces can foster a healthier, more efficient and user-friendly environment.

Principle Six

Workspaces should be viewed as processes rather than products, requiring continuous evaluation and adaptation to maintain optimal environmental quality and occupant well-being. Annual National Australian Built Environment Rating System (NABERS) indoor environmental tests should be conducted to assess air quality, lighting and overall comfort. Regular occupant surveys help monitor trends and identify areas for improvement, ensuring that the workplace evolves to meet user needs.

Collecting data on energy, water, waste management, and indoor environmental quality provides valuable insights for sustainable operations. Effective communication between facilities managers and office management is essential for implementing improvements, while proper induction programs ensure that occupants understand workplace practices and contribute to maintaining a healthy efficient environment.

Revitaliser conceptual diagram by Eco Effective Solutions is given in **Fig. 9.** Revitaliser was installed at the Brisbane Convention and Exhibition Centre for the 10th International Healthy Buildings Conference in 2012 (Ecoeffective, 2025).

Figure 9. Conceptual diagram of Revitaliser by Eco Effective Solutions.

The Revitaliser's specifically selected pants, bio filters and materials dramatically reduce VOCs, stabilise CO2 levels, and boost oxygen to create a space that is safe for occupants and improve their cognitive function in the workspace.

Measurement of Ultrafine Particulates

Ultrafine particulate concentrations inside and outside the Revitaliser over a period were monitored. It was observed that the concentration of ultrafine particles inside the Revitaliser is generally lower than outside, with the outside measurements showing to be higher (**Fig. 10**). This confirms that the Revitaliser reduced particulate levels in air.

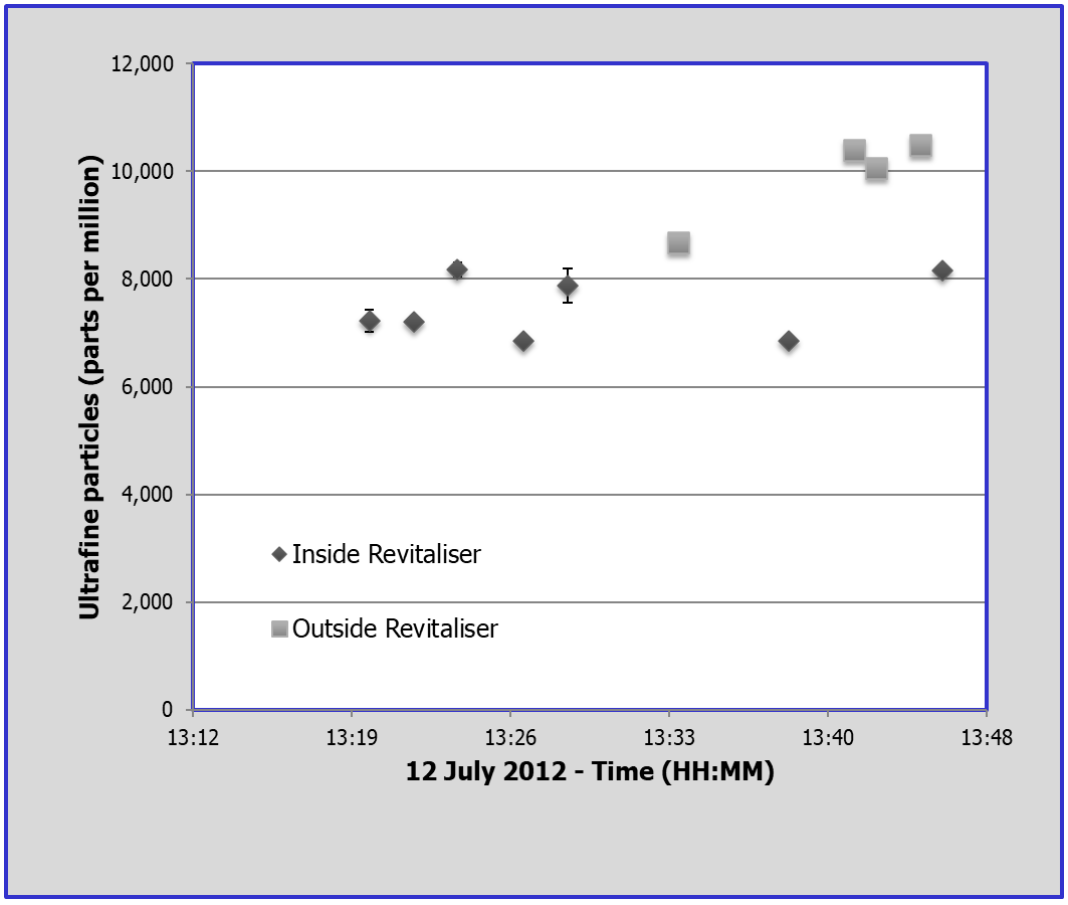

Figure 10. Ultrafine particulate concentration inside and outside Revitaliser over 35 minutes.

Volatile Organic Compounds (VOCs)

VOC concentrations were measured over a period of time with and without plants. Thereafter the Revitaliser was switched on. The level of VOCs that were lower when plants were present, further reduced dramatically when the Revitaliser was switched on (**Fig.11**).

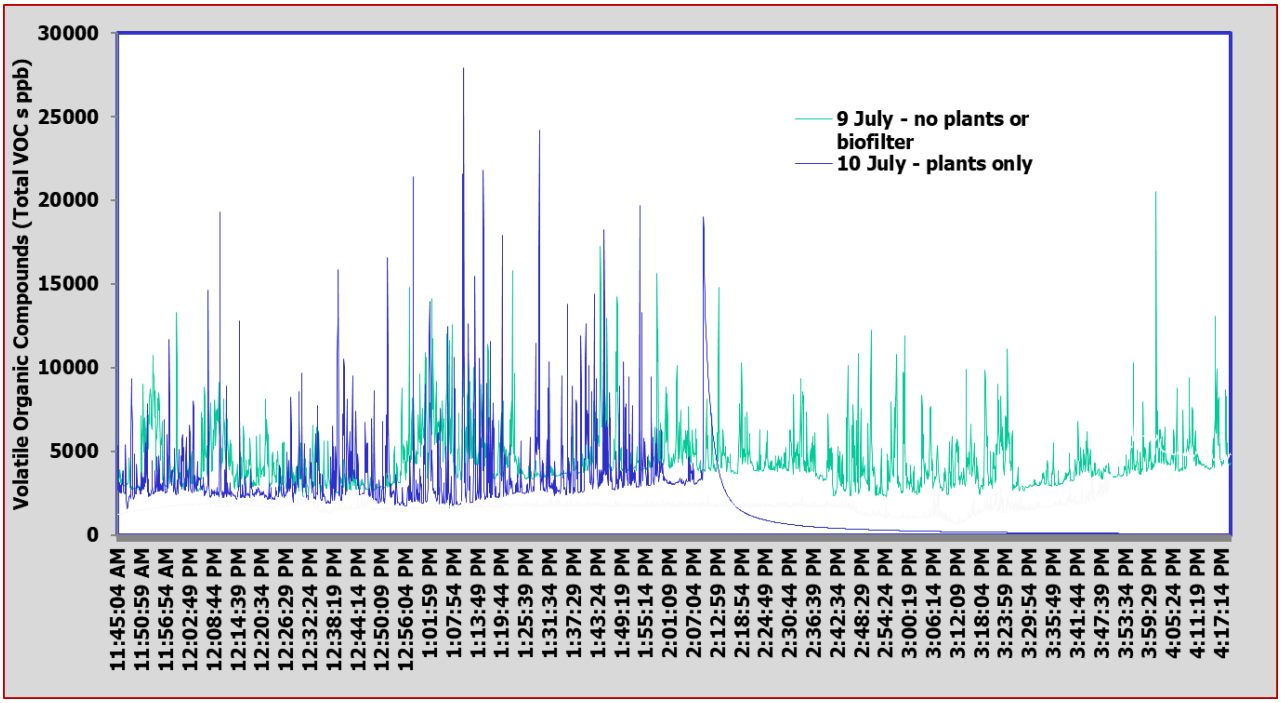

Figure 11. The total VOCs concentration over time on two different days.

Day one – 9th July which is the green line shows the concentration with no plants or biofilter, and the 10th of July which is the blue line showing the concentration with plants only. The VOC levels on day two - 9Th July (no plants) were significantly higher through-out the measuring period, whereas the VOC levels on 10th July (day two with plants) were considerably lower with a further decline in VOC levels once the Revitaliser was engaged at 2.12pm. This indicates that the presence of plants had a strong effect in reducing airborne VOCs.

Indoor Air Quality

Indoor air quality measurements taken within the Revitaliser during the Healthy Buildings Conference in July 2012 are presented in **Fig. 12.**

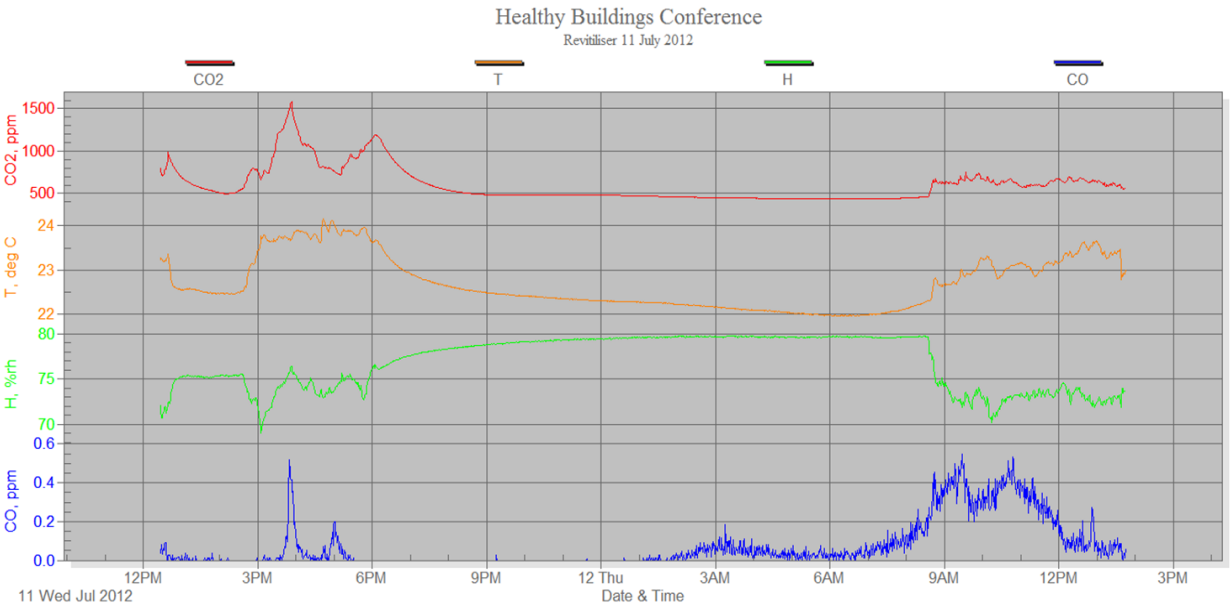

Figure 12. Environmental parameters during the Healthy Buildings Conference on the 11th July 2012. CO (ppm, blue), CO2 (ppm, red), Temperature (Celsius, orange), and humidity (%RH, green) were measured within the Revitaliser.

LIVING WITH NATURE

In the global assessment report on biodiversity and ecosystems services key findings were that the health of our environment is decreasing. It is noted that Australian cities are expanding, damaging biodiversity and ecosystems which are impacting our health and wellbeing. Our cities need more green spaces, and due to the significance of this issue The Brisbane Green Factor Tool was introduced into the Brisbane City Council's City Plan (Greenfactor, 2025). The Green Factor tool is a measure that captures the ratio between green areas and its total area. The aim for Brisbane using Green Factor is that it provides urban development practitioners with a method to optimise landscape designs and maximise the ecosystem services by assessing the quality of green infrastructure in new developments. This can be used for residential areas, hotels, retail centres, public spaces, community buildings, industrial and service stations (Greenfactor, 2025).

New Landscape Approval Requirements for Brisbane City Council, Australia

Legislation plays a considerable role in influencing our built environment. Brisbane City Council's new landscape development approval requirements emphasise the importance of sustainable and healthy designed urban development. The use of the Brisbane Green Factor Tool provides practitioners with measurements to optimise green infrastructure and ecosystem services such as deep planting areas, wind studies, and maintenance plans. By enforcing these requirements and regulations, the Council seeks to mitigate urban heat and enhance biodiversity.

Brisbane City Council has established requirements for landscape development to ensure it aligns with city planning and environmental standards. The key requirements include:

- Green Factor Ratio Area to be scheduled, areas calculated and signed off.
- Deep Planting to be 15% of Site Area and a minimum area of 4m x4m.
- Shade and Aspect studies to be conducted for each site.
- Wind report in meters/second for container planting locations.
- Weekly water consumption calculated every month by a certified Designer.
- Details of Structural assessment by RPEQ Engineer for green element planters including material selection and fixing specifications.
- Maintenance Plans for Body Corporate / Community Management adoption
- As built drawings of installations with minimum falls in substrates with 1.20 details plus plans and elevations.

With these requirements there is the opportunity to further urban development within the city and provide green spaces to restore lost biodiversity and address increasing issues such as urban heat and storm water quality. Indoor Air Quality legislation in Australia have proven ineffective during times of extreme heat and external pollution. Indoor Air Guidelines exist, although the design, building and development industries rely on Australian Standards for Air Quality delivery. Australian Standards typically identify the minimum standard to be achieved, whilst healthy built environments require higher standards to achieve productivity and wellbeing benefits. Best Practice Air Quality solutions have received attention since the COVID 19 pandemic, when minimum air quality standards were proven ineffective in curtailing the spread of the COVID 19 virus in Australia.

Healthy Vegetation in Built Environments is now understood to be a best practice ingredient, to deliver productivity benefits, improved occupant well-being and healthier living and working environments. The Revitaliser demonstration created valuable insights to understand the ingredients of healthy working environments.

CONCLUSION

The findings in this report demonstrate the significance of integrating vegetation within the indoor environment and in turn improves air quality, reduce pollutants, and enhances occupant well-being. The Revitaliser and other biophilic design strategies show quantifiable advantages from lowering VOC levels and stabilising CO2 which improves cognitive function and reduces stress. The research further confirms the significance of strategic implementation of biofiltration and sustainable construction practices and methods to creating healthy workplaces and urban areas. While indoor environments are vital to occupants, the Brisbane City Council's updated landscape development approval requirements support the necessity of incorporating green spaces into proposed urban development. In the future, fostering collaboration between architects, scientists, urban planners and legislators will be crucial in developing built environments into healthy and

self-sustaining ecosystems. This collaboration will reinforce human and environmental health while paving the way for a sustainable urban future with proven good indoor air quality and increased indoor wellbeing for building occupants.

Acknowledgements

(1) Eco Environment- specialist consulting firm founded by John Daly, Brisbane, Australia.

(2) BMW manufacturing case study -interview with Architect Dieter Schemp, LOG ID Turbingen Germany, 2005 by Mark Thomson (photos used with Architects permission).

(3) Manly Hotel Brisbane (TVS Architects) Project Architect: Mark Thomson, Landscape Architect: Nial Fraser.

(4) Eco Environment – John Daly Research.

(5) Revitaliser data undertaken by Octief Laboratories under the supervision of Dr. Claire Bird, founder of LITMAS laboratories.

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