Indoor Air Pollutant

Title	**The phytoremediation of indoor air pollution: a review on the technology development from the potted plant through to functional green wall biofilters**
Author Name	P. J. Irga . T. J. Pettit . F. R. Torpy
Journal Name	Rev Environ Sci Biotechnol
Year	2018
Volume and Issue	17
Abstracts	Poor indoor air quality is a health problem of escalating magnitude, as communities become increasingly urbanised and people's behaviours change, lending to lives spent almost exclusively in indoor environments. The accumulation of, and continued exposure to, indoor air pollution has been shown to result in detrimental health outcomes. Particulate matter penetrating into the building, volatile organic compounds (VOCs) outgassing from synthetic materials and carbon dioxide from human respiration are the main contributors to these indoor air quality concerns. Whilst a range of physiochemical methods have been developed to remove contaminants from indoor air, all methods have high maintenance costs. Despite many years of study and substantial market demand, a well evidenced procedure for indoor air bioremediation for all applications is yet to be developed. This review presents the main aspects of using horticultural biotechnological tools for improving indoor air quality, and explores the history of the technology, from the humble potted plant through to active botanical biofiltration. Regarding the procedure of air purification by potted plants, many researchers and decades of work have confirmed that the plants remove CO_2 through photosynthesis, degrade VOCs through the metabolic action of rhizospheric microbes, and can sequester particulate matter through a range of physical mechanisms. These benefits notwithstanding, there are practical barriers reducing the value of potted plants as standalone air cleaning devices. Recent technological advancements have led to the development of active botanical biofilters, or functional green walls, which are becoming increasingly efficient and have the potential for the functional mitigation of indoor air pollutant concentrations.
Keywords	Biofiltration ; Indoor air; Indoor plants; Air pollution; Purification

Title	Towards practical indoor air phytoremediation: A review
Author Name	T.Pettit, P.J.Irga & F.R.Torpya
Journal Name	Chemosphere
Year	2018
Abstracts	Indoor air quality has become a growing concern due to the increasing proportion of time people spend indoors, combined with reduced building ventilation rates resulting from an increasing awareness of building energy use. It has been well established that potted-plants can help to phytoremediate a diverse range of indoor air pollutants. In particular, a substantial body of literature has demonstrated the ability of the potted-plant system to remove volatile organic compounds (VOCs) from indoor air. These findings have largely originated from laboratory scale chamber experiments, with several studies drawing different conclusions regarding the primary VOC removal mechanism, and removal efficiencies. Advancements in indoor air phytoremediation technology, notably active botanical biofilters, can more effectively reduce the concentrations of multiple indoor air pollutants through the action of active airflow through a plant growing medium, along with vertically aligned plants which achieve a high leaf area density per unit of floor space. Despite variable system designs, systems available have clear potential to assist or replace existing mechanical ventilation systems for indoor air pollutant removal. Further research is needed to develop, test and confirm their effectiveness and safety before they can be functionally integrated in the broader built environment. The current article reviews the current state of active air phytoremediation technology, discusses the available botanical biofiltration systems, and identifies areas in need of development.
Keywords	Green wall; Botanical biofilter; Indoor air quality; Living architecture; VOC; Potted plant

Title	**Phytoremediation of VOCs from indoor air by ornamental potted plants: A pilot study using a palm species under the controlled environment**
Author Name	HakimehTeiri, Hamidreza Pourzamani & Yaghoub Hajizadeh
Journal Name	Chemosphere
Year	2018
Volume and Issue	197
Abstracts	Volatile organic compounds (VOCs) in indoor air have recently raised public concern due to their adverse health effects. One of hazardous VOC is Formaldehyde which can cause sensory irritation and induce nasopharyngeal cancer. The aim of this study was to investigate potted plant-soil system ability in formaldehyde removal from indoor air. We applied one of common interior plant from the palm species, *Chamaedorea elegans*, inside a chamber under the controlled environment. Entire plant, growing media and roots contribution in formaldehyde were evaluated by continuously introduction of different concentrations of formaldehyde into the chamber (0.66–16.4 mg m^{-3}) each over a 48-h period. Our findings showed that the plant efficiently removed formaldehyde from polluted air by 65–100%, depending on the inlet concentrations, for a long time exposure. A maximum elimination capacity of 1.47 mg/m2. h was achieved with an inlet formaldehyde concentration of 14.6 mg m^{-3}. The removal ratio of areal part to pot soil and roots was 2.45:1 (71%: 29%). The plants could remove more formaldehyde in light rather than dark environment. Concentrations up to 16.4 mg m^{-3} were not high enough to affect the plants growth. However, a trivial decrease in chlorophyll content, carotenoid and water content of the treated plants was observed compared to the control plants. Thus, the palm species tested here showed high tolerance and good potential of formaldehyde removal from interior environments. Therefore, phytoremediation of VOCs from indoor air by the ornamental potted plants is an effective method which can be economically applicable in homes and offices.
Keywords	Phytoremediation; Formaldehyde; Potted plant; Indoor air pollution

Title	**Green wall technology for the phytoremediation of indoor air: a system for the reduction of high CO_2 concentrations**
Author Name	FR Torpy, M Zavattaro & PJ Irga
Journal Name	Air Quality, Atmosphere & Health
Year	2017
Volume and Issue	10, 5
Abstracts	Along with the growing requirement to reduce building carbon emissions, a need has arisen to find energy efficient means of improving the quality of indoor air. Indoor plants have been shown to be capable of reducing most air pollutants; however, practical numbers of potted plants will not have the capacity to control many forms of air pollution, especially CO_2. Green walls are space-efficient means of increasing the density of indoor plants. We assessed an active green wall for its potential to reduce CO_2 in chambers and a test room. Chlorophytum comosum and Epipremnum aureum were both effective cultivars for CO_2 removal at light densities greater than 50 µmol m^{-2} s^{-1}. Substrate ventilation increased the rate of CO_2 draw down from chambers, possibly due to increased leaf gas exchange rates. Green walls were then tested in a 15.65-m^3 sealed simulation room, allowing the calculation of clean air delivery rate (CADR) and air changes per hour (ACH) equivalents based on CO_2 draw down. Rates of CO_2 draw down were modest under typical brightly lit indoor conditions (50 µmol m^{-2} s^{-1}); however, when light intensity was increased to relatively bright levels, similar to indoor conditions next to a window or with the addition of supplementary lighting (250 µmol m^{-2} s^{-1}), a 1-m^2 green wall was capable of significant quantifiable reductions of high CO_2 concentrations within a sealed room environment. Extrapolating these findings indicates that a 5-m^2 green wall containing C. comosum could balance the respiratory emissions of a full-time occupant.
Keywords	Carbon dioxide; Indoor environment; Biofiltration; Phytoremediation; Sustainable buildings; Active green walls

Title	**Investigation of A Potted Plant (Hedera helix) with Photo-Regulation to Remove Volatile Formaldehyde for Improving Indoor Air Quality**
Author Name	Ming-Wei Lin, Liang-Yü Chen, Yew-Khoy Chuah
Journal Name	Aerosol and Air Quality Research
Year	2017
Volume and Issue	17
Abstracts	Formaldehyde is the most common volatile organic compound (VOC) emitted from household materials and is associated with many health risks, including sick building syndrome. A potted Hedera helix was used as an air purifier to remove the gaseous formaldehyde. Development of a test platform is necessary to evaluate the indoor performance of air cleaning protocols. The box modulation with a novel volatile pollutant-emitting source was applied in an air quality monitoring experiment to mimic a non-ventilated workplace. The environmental conditions and the pollutant concentrations in the air were measured in real time, and the monitoring data was uploaded to cloud storage media by a wireless technique. Compared with natural dissipation, our results demonstrate a 70% decrease in the required time to achieve 1.0 ppm of gaseous formaldehyde using the biological purifier. In addition, the effect of photo-regulation was not significant in the use of potted plants to remove gaseous formaldehyde. Our study provides an accurate and available platform for the public to determine the health risks of VOCs in their buildings.
Keywords	Phyto-degradation; Ornamental plant; Gas sensor; Air cleaning; Photoreaction

Title	**Removal ratio of gaseous toluene and xylene transported from air to root zone via the stem by indoor plants**
Author Name	K. J. Kim, H. J. Kim, M. Khalekuzzaman, E. H. Yoo, H. H. Jung & H. S. Jang
Journal Name	Environmental Science and Pollution Research
Year	2016
Volume and Issue	23, 7
Abstracts	This work was designed to investigate the removal efficiency as well as the ratios of toluene and xylene transported from air to root zone via the stem and by direct diffusion from the air into the medium. Indoor plants (Schefflera actinophylla and Ficus benghalensis) were placed in a sealed test chamber. Shoot or root zone were sealed with a Teflon bag, and gaseous toluene and xylene were exposed. Removal efficiency of toluene and total xylene (m, p, o) was 13.3 and 7.0 $\mu g \bullet m^{-3} \bullet m^{-2}$ leaf area over a 24-h period in S. actinophylla, and was 13.0 and 7.3 $\mu g \bullet m^{-3} \bullet m^{-2}$ leaf area in F. benghalensis. Gaseous toluene and xylene in a chamber were absorbed through leaf and transported via the stem, and finally reached to root zone, and also transported by direct diffusion from the air into the medium. Toluene and xylene transported via the stem was decreased with time after exposure. Xylene transported via the stem was higher than that by direct diffusion from the air into the medium over a 24-h period. The ratios of toluene transported via the stem versus direct diffusion from the air into the medium were 46.3 and 53.7 % in S. actinophylla, and 46.9 and 53.1 % in F. benghalensis, for an average of 47 and 53 % for both species. The ratios of m,p-xylene transported over 3 to 9 h via the stem versus direct diffusion from the air into the medium was 58.5 and 41.5 % in S. actinophylla, and 60.7 and 39.3 % in F. benghalensis, for an average of 60 and 40 % for both species, whereas the ratios of o-xylene transported via the stem versus direct diffusion from the air into the medium were 61 and 39 %. Both S. actinophylla and F. benghalensis removed toluene and xylene from the air. The ratios of toluene and xylene transported from air to root zone via the stem were 47 and 60 %, respectively. This result suggests that root zone is a significant contributor to gaseous toluene and xylene removal, and transported via the stem plays an important role in this process.
Keywords	Indoor air; Toluene; Xylene; Plants; Removal; Ratio transportation