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Active Botanical Biofiltration in Built Environment to Maintain Indoor Air Quality

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The implementation of sustainable solutions for maintaining indoor air quality has become a particular concern to the building community. Research on green technologies for indoor air has highlighted the potential of active botanical biofiltration (ABB) systems, where the air is circulated through the plant root zone as well as the growing medium for maximum phytoremediation effect. ABB has been found beneficial for pollutant removal along with the potential for increasing humidity and air cooling. Assessment in laboratory condition revealed the removal efficiency of ABB systems ranged from 54 to 85% for total suspended particulate matters where gaseous pollutants such as formaldehyde and toluene removal efficiencies were 90% and over 33%, respectively, in real environment. Moreover, the esthetic value of ABB acts as an added benefit for positive mental effects. However, very limited data is available to date that demonstrates the pollutant removal efficiency of ABB systems in realistic indoor environments, and the mechanisms behind this emerging technology are still poorly understood. The purpose of this mini review study is to present a quantitative assessment of the recent advancement of ABB systems and indoor air quality. Finally, the limitations of ABB systems and research gaps are highlighted for future improvement.

Keywords: active living wall, indoor air quality, air filters, building environment, biofiltration

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INTRODUCTION

According to the Environmental Protection Agency, indoor air pollution is considered one of the top five environmental health risks. Moreover, 2.7% of the global burden of disease has been linked to indoor air pollution in a report published by the World Health Organization (WHO) (WHO Global Health Risks, 2009; Mannan and Al-Ghamdi, 2021). Commonly listed health impacts of indoor air pollutants include asthma, headache, nausea, fatigue, eye irritation, reduced lung function, cough, and lung cancer (Park et al., 2001; Swanson, 2001; USEPA, 2003; Dorothy Shimer and Phillips, 2005; Fisk et al., 2007). To minimize indoor air pollutants concentration below the threshold levels in different indoor environments, several methods have been adopted so far, such as source reduction, dilution, and the use of air cleaning devices. Portable air cleaning devices, also known as air purifiers or sanitizers, and HVAC and other duct-mounted air cleaning devices are two types of general air cleaning devices available that commonly use fibrous air filters, electrostatic precipitators, and ionizers to remove particles from indoor air (USEPA, 2018).

Along with the advancement of mechanical devices for indoor air pollution control, in the long run, building professionals are showing great interest in indoor plant-based air purification systems for several potential mechanisms of leaf surface, stomata, and plant roots. These include adsorption and absorption capacity of gaseous air pollutants and particulate material (PM); degradation capacity of gaseous air pollutants; CO_2 removal and O_2 supply; increase in humidity; and reduction in bioaerosols (Newman and Reynolds, 2004; Orwell et al., 2004; Kohlrausch et al., 2006; Liu et al., 2007; Llewellyn and Dixon, 2011). However, the limitations of the potted plant and green wall approaches initiated the research for more advanced green wall–based air purification systems, which allow the intimate contact of polluted air with the microorganisms in the rhizosphere zone of the plants to maximize the phytoremediation process by creating an airflow through mechanical devices. This approach was defined as active botanical biofiltration (ABB) by Pettit et al. (2018a) where Liewellyn and Dixon (2011) stated the system as the botanical indoor air biofilter (BIAB) (Llewellyn and Dixon, 2011; Pettit et al., 2018a). Moreover, researchers used several other nomenclatures to refer this same system such as an active living wall (ALW) or active green wall (AGW) system when they applied this technology to the existing living wall or green wall systems (here living wall and green wall both indicate the similar vertical greening system) (Irga et al., 2017a; Pettit et al., 2019a). So far, research has been carried out dealing with different aspects of ABB to reduce overall air pollutants, such as the impact of plant quantity and type; temperature and airflow; media substrates; plant nutrition and irrigation; and lighting. However, very limited data is available to date that demonstrates the pollutant removal efficiency of ABB or ALW systems in realistic indoor environments, and the mechanisms behind this emerging technology are still poorly understood for specific areas. **Figure 1** represents the schematic of BIAB and ALW systems.

The purpose of this short review study is to present a quantitative assessment of the recent advancement of ABB systems, especially ALW systems, for improved indoor air quality (IAQ). To achieve this, the authors have conducted a literature search for peer-reviewed articles with a special focus on the application of ABB or ALW systems for indoor spaces for a period of the last 10 years. The literature search included mainly peer-reviewed journals along with conference papers and other scientific reports. The databases that have been searched mostly for relevant publications are Science Direct, Springer Link, and Wiley Online Library. The article's selection was based on several criteria, including the construction of the systems, the efficiency of pollutant removal, system assessment condition, and impact of the ABB or ALW systems on other indoor environmental quality. Finally, the limitations of these systems and research gaps are highlighted for future improvement. The selected articles have been classified and presented in this review in two categories, mainly the air filtration systems in laboratory conditions and realistic indoor environments. Based on these two classifications, the application of ABB or ALW systems have been carefully evaluated and described in the following section. Hence, this mini review aims to:

- Review the recent advancement of ABB systems to identify the indoor pollutant removal efficiency in quantitative manner
- Review the construction strategy of the ABB or ALW systems along with the condition of the experiment environment (e.g., size of the room) to benefit the system's future development
- Highlight the research gaps and future outlook

ACTIVE BOTANICAL BIOFILTRATION FOR BETTER INDOOR AIR

This section reviews the application of the ABB system for indoor spaces from different perspectives to present the most

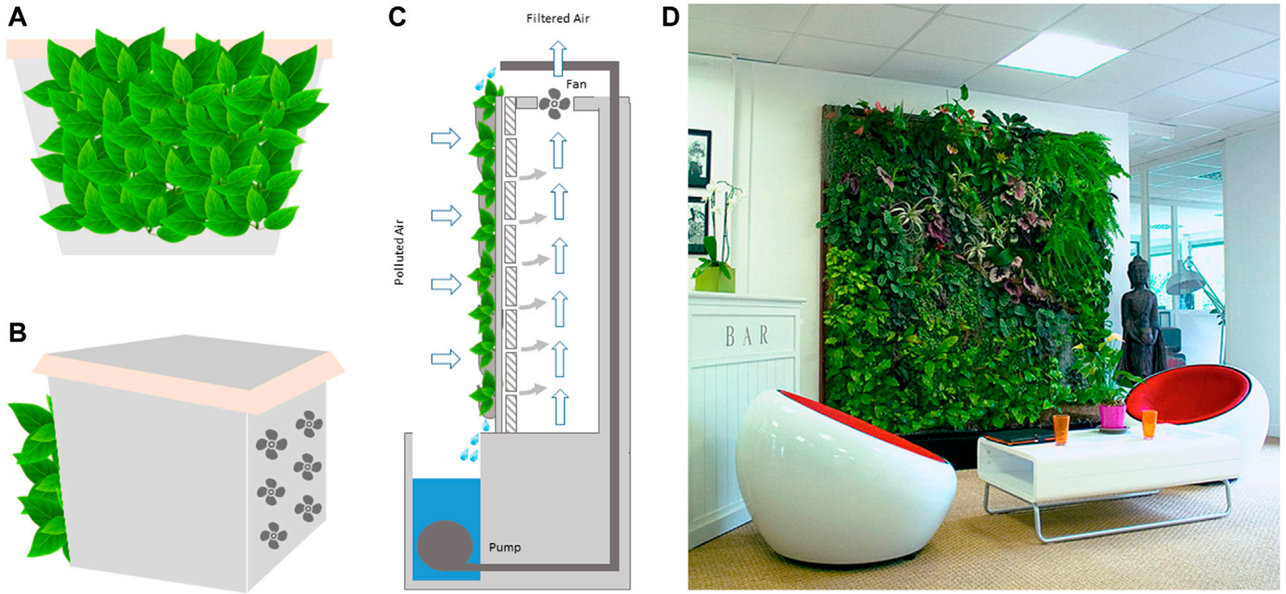

FIGURE 1 | Schematic of BIAB and ALW systems. Section **(A, B)** represents the front and side view of BIAB system where section **(C)** presents the cross-sectional view of ALW system **(D)** represents how an indoor living wall system would look like. (Ibrahim et al., 2018; Mannan and Al-Ghamdi, 2020).

TABLE 1 | Summary of ALW systems. Analysis of the ALW/ABB studies performed in real and laboratory environment based on construction and operation conditions and pollutant removal capacity.

Study type	Objective	Construction of filter	Laboratory/ realistic indoor condition	Vegetation used	Summary of investigation	References
Real office condition and laboratory condition	To assess the single pass efficiency of ABB system for both water insoluble and soluble VOC's	Filter bed dimension: 1.8 m × 0.6 m × 0.15 m (L × W × D); substrate: Activated carbon and porous shell pebble; axial flow fan	Office dimension: 16.4 m × 5.4 m × 3 m (L × W × H); 265 m^3 Office condition: 22°C and 15% RH Laboratory chamber dimension: 4.84 m × 3.63 m × 3.05 m (L × W × H); 54.4 m^3 Laboratory condition: 23°C and 60% RH	8 Golden Pothos (*Epipremnum aureum*)	Formaldehyde and toluene removal efficiency 90% and over 33% in the first 4 days, respectively for both long and short term assessment. The filtration capacity was equal to 20% outside air supply which can save 10–15% energy in cold climate along with 20% rise in RH.	Wang and Zhang (2011)
Real building environment	To assess the removal capacity of PM and TVOCs	Residential AGW Dimension: 1.5 m^2; Substrate: Coconut husk, two 240-V AC fans Classroom AGW dimension: 9 m^2,. three 12-V DC fan	Residence: Floor area of 8.75 m^2 and a total volume of 22.70 m^3 Residence condition: No HVAC, only ceiling fan, ambient temperature: 20–24°C Class: Floor area of 40.07 m^2 and a volume of 120.2 m^3 Class condition: HVAC system	*Chamaedorea elegans, Epipremnum aureum, Ficus lyrate, Neomarica gracillis, Peperomia obtusifolia, Spathiphyllum wallisii, Schefflera arboricola, Nephrolepis exaltata and Syngonium podophyllum*	Residential: TVOC and PM concentration 72.5% lower than the control Classroom: Reduced TVOC concentration by ~ 28% and reduced PM by 42.6% compared to HVAC system	Pettit et al. (2019a)
Real building environment	To assess the impact of ALW on room temperature and humidity	ALW dimension: 8 m^2 Galvanized steel structure, prismatic steel tank, polyamide and polypropylene substrate, PVC pipes, submersible pump, four axial fans, metal halide reflector	Hall room dimension: 12 × 9 × 3.25 m (L × W × H); no HVAC system	*Asparagus sprengeri Regel, Chlorophytum comosum (Thunb.) Jacques, Epipremnum aureum (Linden ex André) G.S.Bunting, Ficus pumila L., Monstera deliciosa Liebm. Nephrolepis exaltata (L.) Schott, Soleirolia soleirolii (Req.) Dandy and Spathiphyllum wallisii hort*	0.8 to 4.8°C drop in temperature Recommended that the cooling process can be more efficient when the initial conditions of the room are warmer and drier Recommendation for future work: optimization of ALW size, change in air flow direction	Pérez-Urrestarazu et al. (2016)
Real office environment and laboratory condition	To assess whether the ALW makes a detectable contribution to the abundance and diversity of airborne culturable indoor fungal concentrations	ALW dimension: 50 cm × 50 cm × 13 cm; axial impeller	Office dimension: 14 m^2 in floor area, 32.2 m^3 volume Office condition: 22.5 ± 1.5°C, HVAC system Laboratory chamber dimension: 216 L Perspex test chamber, temperature 22–24°C, Fluorescent tube lighting	*Chlorophytum comosum and Epipremnum aureum*	Negligible impact of ALW to the diversity or density of airborne fungi was observed in the assessment site	Irga et al. (2017a)
Laboratory condition	To assess filtration efficiency for PM	ALW dimension: 50 cm × 50 cm × 13 cm; axial impeller	Chamber condition: Fully sealed, air-tight Perspex test	*Chlorophytum comosum* (Spider plant)	At most efficient air flow rate (11.25 L s^{-1} found) removal efficiencies	Irga et al. (2017b)

(Continued on following page)

TABLE 1 | (*Continued*) Summary of ALW systems. Analysis of the ALW/ABB studies performed in real and laboratory environment based on construction and operation conditions and pollutant removal capacity.

Study type	Objective	Construction of filter	Laboratory/ realistic indoor condition	Vegetation used	Summary of investigation	References
			chambers, light intensity 10 ± 2 µmol m^{-2} s^{-1}; average temperature 23.0 ± 0.1°C, and RH 55 ± 10%		were 53.35 ± 9.73% for TSP, 53.51 ± 15.99% for PM_{10}, and 48.21 ± 14.71% for $PM_{2.5}$	
Laboratory condition	To assess filtration efficiency for PM	ALW dimension: 38 cm × 38 cm × 34 cm; 0.05 m^3 Substrate: Kenaf fiber, Axial brushless fan, cooling pad: corrugated paper type, submersible water pump	Chamber dimension: Sealed tight acrylic Perspex test chamber (0.6 m × 0.6 m × 0.6 m; 216 L)	*Epipremnum aureum* (Golden pothos)	Removal efficiency: 85% (TSP), 75.2%. ($PM_{2.5}$), and 71.9% PM_{10})	Ibrahim et al. (2018)
Laboratory condition	To assess the single-pass VOC removal efficiency using MEK	ALW dimension: 150 cm × 100 cm; substrate: Inorganic growing media plus activated carbon, integral electric fan	Chamber dimension: 4.0 m × 3.0 m × 2.5 m; 30 m^3 volume Chamber condition: Temperature 21.5 ± 2°C and RH 37.5 ± 2.5%, LED floodlight (40 µmol s^{-1} m^{-2})	*Philodendron scandens, Philodendron scandens "Brazil", Asplenium antiquum, and Syngonium podophyllum*	Single pass removal efficiency 57% (average)	Torpy et al. (2018)
Laboratory condition	To assess CO_2 and CH_2O purification efficiency	ALW dimension: 57 cm × 22 cm × 67 cm (L × W × H) and volume 0.2 m^3, light intensity for plant 90 ± 5 µ mol·m^{-2} s^{-1} PPF	Chamber dimension: 100 cm × 70 cm × 200 cm; 1.4 m^3 volume Chamber condition: Closed fumigation box; temperature 25 ± 2°C	*Nephrolepis exaltata Schott*	33% more formaldehyde removal efficiency compared to the non-exhausted condition and concluded the similar purification ability of ALW and commercial air purifier	Hung et al. (2019)
Laboratory condition	To assess NO_2 purification efficiency	Biofilter materials: PVC pipe (120 mm × 88 mm), coconust husk substrate, high density polyethylene cloth	Closed loop flow reactor: 0.9 m^3, 9.95 µmol m^{-2}·s^{-1} photosynthetic flux density, temperature 22°C	*Spathiphyllum wallisii (peace lily), Syngonium podophyllum (arrowhead vine)*	NO_x removal efficiency depends on type of plants species and lighting. Exponential decay of NO_2, NO, and O^3 was observed	Pettit et al. (2019b)
Laboratory condition	To assess PM, VOC's and CO_2 removal efficiency	AGW dimension: 500 mm × 500 mm × 130 mm, coconut fiber based substrate, axial impeller	Chamber dimension: Perspex chamber (sealed; 0.6 m^3)	Australian native species (6 plant species)	Compared with the common ornamental indoor plants, Australian native plants are less effective for PM and CO_2 removal, however, they are found to have same removal capacity for benzene	Paull et al. (2019)
Laboratory condition	To assess the capacity of ALW growing media	Cassettes dimension: 85 mm × 85 mm, 482.1 cm^3 coconut husk and activated carbon based substrates	Chamber dimension: 0.6 m × 0.6 m × 0.6 m; 1.4 m^3 volume Chamber condition: Sealed Perspex chamber	*Nephrolepis exaltata bostoniensis*	No influence of coconut husk particle size on removal efficiency, however substrate mixture of coconut husk and activated carbon enhances the gaseous pollutants removal	Pettit et al. (2018b)

(Continued on following page)

TABLE 1 | (*Continued*) Summary of ALW systems. Analysis of the ALW/ABB studies performed in real and laboratory environment based on construction and operation conditions and pollutant removal capacity.

Study type	Objective	Construction of filter	Laboratory/ realistic indoor condition	Vegetation used	Summary of investigation	References
					efficiency. Activated carbon inhibits the removal efficiency of particulate matter	
Laboratory condition	To assess growing media or substrates of ALW system	Wind tunnel test: Galvanized metal structure, PVC pipe (20 mm dia), axial pump, centrifugal fan	NA	Pothos (Scindapsus aureus Engl.)	Polyamide and polypropylene performed best, while polyester based substrate/growing media performed worst	Franco et al. (2012)
Laboratory condition	Assessment of ALW to achieve more appropriate and effective airflow	Rectangular plastic box (500 mm × 500 mm × 130 mm), substrate: Coconut husk and fiber, axial fan	NA	*Schefflera arboricola, Chlorophytum comosum‘variegatum*	Compared to the dry substrate, more air passed through saturated wet substrate	Abdo et al. (2019)

recent developments, challenges, and opportunities of ABB for better IAQ. **Table 1** summarized the reviewed studies based on the construction and operation condition and pollutant removal capacity. Here, all the terms related to ABB systems (e.g., the terms ABB/ALW/AGW) have been used based on how they have defined in each specific research studies, although having the same mechanism for air filtration.

Active Botanical Biofiltration in Realistic Conditions

The investigation of an ABB prototype has been performed for both soluble and insoluble volatile organic compounds (VOCs) and was developed based on three basic principles: the degradation of VOCs through plant root microorganisms, pollutant adsorption through activated carbon, and pollutant absorption by water (Wang and Zhang, 2011). This prototype was assessed in a typical office environment as well as in a full-scale stainless-steel test chamber. 5–32 vol% was found as the optimum water content range in the root bed for maximum VOC removal. Experimentation in real office conditions for 300 days indicated satisfactory single-pass removal efficiency for formaldehyde and toluene (90% and over 33%, respectively, for the first four days). Moreover, this ABB system successfully reduced the indoor air temperature by 0.5°C in the realistic environment, while the reduction of temperature was 1°C in laboratory conditions. The relative humidity (RH) increase for realistic and laboratory conditions was 17.7 and 9–13%, respectively. Furthermore, a reduction of 20% of the supply of outdoor air can be achieved using the ABB system and thus can save energy required by the building given that the concentrations of toluene and formaldehyde dictated the standard ventilation rate for this case. However, different climate zones should be investigated (including hot and cold) to justify the applicability of indoor ABB systems along with the energy-saving potential. Two pilot-scale AGWs were tested in both residential housing and a classroom to assess the removal capacity of both total volatile organic compounds (TVOCs) and PM (Pettit et al., 2019a). Analysis of the investigated data confirmed the reduction of TVOC and PM concentrations to a level that the classroom’s current HVAC system could not achieve in normal conditions. In the residential space, a 72.5% lower TVOC concentration was found compared to the control system when the AGW system was applied; the same occurred for residential PM. Although significant improvement was observed here, this study highlights the need for long-term experimentation and empirical validation assuring AGW systems’ efficiency in improving IAQ.

Apart from pollutant removal capacity, a prototypic ALW was tested in realistic conditions to observe the impact of ALW on indoor temperature and humidity (Pérez-Urrestarazu et al., 2016). Acting as natural evaporative coolers, ALW systems can reduce indoor temperature as well as increase humidity, thus lowering the cooling energy requirements in buildings (Rodgers et al., 2013). Analysis of the sensor results revealed temperature drops ranging from 0.8 to 4.8°C for different positions around the ALW. The differences in the impact of the ALW on different positions in the assessment hall indicate the requirement of further investigation into topics such as ALW size optimization and airflow direction. Moreover, the effects on indoor temperature and humidity should also be investigated during normal weekdays when the assessment location experiences normal activities. The contribution of an ALW to indoor fungal spread was assessed in both a realistic environment and laboratory conditions in Sydney, Australia (Irga et al., 2017a). Analysis of the testing data concluded the ALW system had a negligible impact on airborne fungal concentration; however, this study emphasizes the importance of long-term assessment to realize the potential of fungal growth in indoor spaces.

Active Botanical Biofiltration in Laboratory Conditions

The efficiency of ABB in the removal of PM was assessed exclusively in a static chamber where general observation recorded that PM removal efficiency increased with an increase in airflow rate (Irga et al., 2017b). Experiments were conducted at five different airflow rates to assess the single-pass efficiency of the ABB system for the filtration of total suspended particles (TSPs), $PM_{2.5}$, and PM_{10}. However, airflow rate over 11.25 L s^{-1} reduced the filtration efficiency during the experiment with the botanical system, whereas systems without the botanical part did not show the same characteristics. Approximately 53, 54, and 48% removal efficiencies were achieved for TSPs, PM_{10}, and $PM_{2.5}$, respectively. Based on the collected data and further analysis, this study estimates that for four occupants in an office environment, 1 m^2 of an ABB system could sufficiently supply the required ventilation. Further assessment of this system *in situ* is marked as the next step so that in the near future, the ABB system could operate as a standalone system or an integral part of an HVAC unit to provide standard ventilation for indoor spaces. A similar investigation was conducted where the single-pass filtration efficiency of a BIAB system was assessed for PM levels (TSPs, $PM_{2.5}$, and PM_{10}) (Ibrahim et al., 2018). Compared to the available systems on the market, this BIAB system added an evaporative cooling pad to enhance the principle of PM removal efficiency through absorption. With this advancement in BIAB design, this system successfully removed 85% of TSPs, 71.9% of PM_{10}, and 75.2% of $PM_{2.5}$. Nonetheless, the long-term efficiency of BIAB systems, along with the simultaneous removal of CO_2 and VOCs with PM, are still to be investigated extensively.

For methyl ethyl ketone, the filtration efficiency of an AGW was investigated in a 30 m^3 chamber representative of a realistic room (Torpy et al., 2018). A combination of inorganic growing media and activated carbon was applied for the reduction of indoor VOCs, which showed a 57% VOC reduction on average for single-pass removal efficiency. Recommendations are made to further investigate plant type, growing medium, and moisture content to enhance VOC removal efficiency. CO_2 and formaldehyde purification with the assistance of an ALW was assessed, and thereafter, test results were compared with the pollutant removal efficiency of two commercial air filters (Hung et al., 2019). The fumigation tank experiment indicated a similar air cleaning capacity for the ALW as for the selected two commercially available portable air cleaners; the ALW and the two commercial air cleaners are also economically comparable. A closed-loop flow reactor assessment was performed to check the ability of AGW systems to reduce NO_2 in green buildings (Pettit et al., 2019b). Both O_3 and NO were also monitored in this study for two specific vegetation systems and two lighting conditions. In ambient conditions, this system demonstrated exponential decay for all the targeted air pollutants; however, the study indicates a requirement for *in situ* long-term assessment. The use of native Australian plants and their efficiencies in an ALW system was assessed; the performance of native and ornamental plants was compared (Paull et al., 2019). Single-pass removal efficiency revealed the less effective nature of the native Australian plants for the removal of PM and CO_2 when compared with the common ornamental plants. Further comparison indicated a similar ability to remove benzene in both types of plants.

Investigation about growing media (granulated activated carbon and coconut coir) in a functional green wall was conducted for a range of indoor air pollutants, especially for PM and VOCs, as the growing media or substrates not only act as a support system for vegetation but also promote primary pollutant removal mechanisms (Pettit et al., 2018b). Although coconut coir's particle size was found to have no influence on pollutant removal efficiency, the increased removal efficiency was observed when activated carbon was mixed with coconut coir substrates, particularly for gaseous air pollutants. Oppositely, the growing media activated carbon was found to have a negative impact on PM removal efficiency. Equal concentrations of both coconut husk and activated carbon showed the best VOC removal conditions. This study strongly suggests selecting the growing media based on target indoor air pollutants along with assessing different vegetation conditions when using those substrates in future studies. Likewise, three different synthetic substrates (polyamide-polypropylene, polyester, and polyurethane) were assessed by open-circuit wind tunnel from four different perspectives, namely saturation efficiency, water volume retained, water consumption, and pressure drop (Franco et al., 2012). Considering all the given parameters, polyamide-polypropylene was found to be the best option, as it exhibited low water consumption tendency, average water retention capacity, and high saturation efficiency.

An airflow assessment for an ALW system was performed where both unplanted and planted modules were investigated in wet and dry conditions (Abdo et al., 2019). The preliminary observation indicated a substantially increased airflow rate through the saturated wet substrate compared with the dry substrate. This study recommends performing computational fluid dynamics analysis and large eddy simulation, which can verify the effectiveness of ALW system modification. The impact of four different vegetation systems on an ALW system was monitored, which highlighted the influence of plant species on specific VOCs' removal processes in different percentages and recommended assessing the impact of mixed plants in future studies (Irga et al., 2019).

CONCLUSION AND FUTURE DIRECTIONS

As the quality of buildings' indoor air contributes to human health problems on a large scale, the implementation of sustainable solutions for maintaining IAQ has become a particular concern to the building community. ABB has been found beneficial for pollutant removal along with the potential for increasing humidity and air cooling. It has also been well studied that these systems do not promote fungal spread if kept in a well-monitored condition (Fleck et al., 2020). Moreover, the esthetic value of ABB acts as an added benefit for positive mental effects.

Although ABB systems have been assessed from different perspectives, investigations still need to be performed in real indoor environments to acquire conclusive results in the long run. Most studies thereby highlight the requirement for *in situ* experimentation for an extended time. Moreover, the optimization of the systems and advanced simulation analysis have been indicated as future work in this research field. As many studies have been performed that focus on specific pollutants, more investigations are required that focus on combining all the common indoor pollutants and observing how the advanced botanical system works in such conditions. Area- and weather-specific investigation can also benefit the development of ABB systems.

Although most of the studies performed in both realistic condition and laboratory condition have specified the ABB or ALW system dimensions (such as length, width) with the dimension of the indoor space or static chamber where the experiments have been performed, however, still now no clear equation or relationship has been drawn for optimum size of ABB or ALW system for any specific indoor space. Hence, simulation studies can be implemented as future studies to find such equations/relations. The temperature was set to 22–25°C in most cases for the experimental procedure; thereby, it is still unknown how the ABB or ALW systems will perform inside buildings where the temperature reaches far more than this specific temperature range during the pick summer season or opposite in the winter.

Along with the performance assessment of the ABB systems, it is also needed to evaluate the economic viability of these systems. Hung et al. (2019) has compared the ALW system with two commercially available air filters systems both from pollutant removal efficiency and economic perspective, however, most of the studies have excluded the economic factor. Moreover, with the progress of ABB systems, it is necessary to assess the overall sustainability of the entire system, including the construction, operation, and disposal phase. Though there are several studies that focused on the sustainability performance of LW systems (Feng and Hewage, 2014; Oquendo-Di Cosola et al., 2020), however, this is still rare for ALW systems.

It is very important to mention that direct comparison between systems for indoor air pollutant removal efficiency is difficult and not straightforward due to the specific conditions under which the tests were conducted as well as the nature of the pollutants themselves (Pettit et al., 2019c).

AUTHOR CONTRIBUTIONS

Conceptualization, MM and SA-G; data curation, MM; formal analysis, MM; and SA-G; project administration, SA-G; supervision, SA-G; writing–original draft, MM; writing–review and editing, SA-G All authors have read and agreed to the final version of the manuscript.

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