Potential of vapour decontamination for improving IAQ — Making use of tea tree oil: The case of a healthcare facility

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A B S T R A C T

This paper describes a practical investigation into the indoor air quality of a fully air-conditioned eight-storey healthcare facility in the East Malaysia region before and after vapour decontamination. East Malaysia is located in a hot and humid climate, which favours the growth of bacteria, yeasts and moulds. The main purpose of the investigation is to identify the potential of tea tree oil vapour decontamination to improve the indoor air quality by reducing the active bacteria, yeast and mould concentrations in indoor air. A total of 336 samples have been taken inside the building for indoor air at 84 different locations and 24 samples have been taken for outdoor air at 12 locations, which are near the fresh air intakes of the air handling units. The vapour decontamination method is used in the present study.

Results show that the humidity levels remain high during the entire study period, exceeding 60% relative humidity, favouring the growth of bacteria, yeasts and moulds. By applying vapour decontamination from the air handling units to the ventilated air serving areas, the average bacteria, yeast and mould count is successfully reduced to below the recommended threshold of 500 CFU m$^{-3}$ for normal zones, and 35 CFU m$^{-3}$ for critical zones. The decontamination study result strongly suggests that the very real potential for applying tea tree oil vapour as air treatment in tropical countries like Malaysia for indoor air quality management in healthcare facilities.

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1. Introduction

Air borne infectious diseases have become a growing concern after the spread of the influenza H1N1 and the severe acute respiratory syndrome (SARS) viruses. Research has shown that transmission through air was a significant factor contributing to the outbreaks [1,2]. In the early 19th century, humans had already identified air as a transport medium for infectious diseases [3], with important factors being the relative humidity and temperature [4]. Infectious diseases can spread directly or indirectly from one person to another. Bacteria, fungi and moulds are among the pathogenic microorganisms which cause infectious diseases [5]. Moulds, yeasts and bacteria are likely to build up in air conditioning systems, especially in the presence of high/sufficient humidity levels [6]. This suggests that hot and humid environments the in tropics, such as Malaysia, favour the growth of moulds, yeasts and bacteria in air conditioning systems.

The cleanliness of the space and air conditioning system of a healthcare facility is crucial. The performance of the ventilation, the dust loading conditions as well as biological contaminants all contribute to the air quality. Most biological contaminants, such as bacteria, moulds and yeasts, are categorized as potentially allergenic [7,8]. Continuous exposure to these biological contaminants can lead to irritation, allergies and infections [9].

Research on the relationship between temperature and relative humidity in the air has shown that high humidity favours the growth of bacteria, yeasts and moulds, and that a lower temperature will require a more humid environment to encourage such microbial growth [10,11]. Malaysia is located in a hot and humid climate region. Growth of fungi inside buildings in tropical climates is an issue of concern [12].

A hospital is a facility that requires exceptional caution in the control of infectious diseases, especially with regards to the design of the ventilation system to control possible contamination by air. However, humidity is not the only factor that influences the growth and spread of bacteria, because bacteria like Staphylococcus aureus and methicillin-resistant S. aureus (MRSA) can survive in dry environments for prolonged periods of time [13–15]. Decontamination is therefore required to decrease the survival chances of infectious agents.

The purpose of decontamination is to eliminate or minimize the level of biological contaminants on medical devices and room
The average concentration of all locations before and after the decontamination process was similar, with values of 4.9 mg/m³ and 1.6 mg/m³, respectively. This has proven that particulate matter is not the main factor contributing to the reduction of the microbial count.

For the critical area, the average concentration of suspended particulate matter was reduced during the sampling after the decontamination, due to the cleaning process. The reduced microbial count may have been affected by the reduction of particulate matter.

### 3.2.3. Evaluation of microbial pollutants

For conventional operating rooms, the minimum standard for the microbial air count was 35 CFU m⁻³ when the theatre was empty [26,27]. Fig. 8 shows the measurements of bacteria count and fungus as well as the mould count for critical areas. The average bacteria count was reduced by 70%, from 70.1 CFU m⁻³ to 8.2 CFU m⁻³ (Table 1). While the average yeasts and moulds count was reduced by 30.5%, from 30.8 CFU m⁻³ to 9 CFU m⁻³ (Table 1). The bacteria count was successfully reduced to the recommended levels after decontamination, using vaporized tea tree oil. Again, the yeast and mould counts of post-sampling for some points are even higher than pre-sampling data. This is due to the same reason mentioned in sub-section 3.1.3.

### 4. Conclusions

The investigation into the indoor air quality of a fully air-conditioned eight-storey healthcare facility in the East Malaysia region before and after vapour decontamination has been successfully conducted. The findings can be used as an important guide for building services engineers involving in healthcare building services work. The overall results obtained from this research study on the microbial counts of bacteria, yeasts and moulds show that tea tree oil can be used as an alternative agent for vapour decontamination. This gaseous method is particularly useful for decontaminating complex furniture and equipment that is difficult to clean manually. Tea tree oil decontamination is easier and requires less equipment and procedures compared to vapour decontamination using hydrogen peroxide.

Future investigations comparing the antibacterial properties of tea tree oil with other chemical disinfectants for indoor air are required. Results from this investigation should be taken into consideration when considering methods for air decontamination in hot and humid tropical climates.

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