Building and Environment 60 (2013) 280–290

Contents lists available at SciVerse ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

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

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ARTICLE INFO

Article history:
Received 14 May 2012
Received in revised form
12 October 2012
Accepted 1 November 2012

Keywords:
Vapor decontamination
Tea tree oil
Indoor air quality
Healthcare building
Mould

ABSTRACT

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.

1. Introduction

Air borne infectious diseases have become a growing concern after the spread of the influenza H1N1 and the severe acture 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 methicilin-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

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http://dx.doi.org/10.1016/j.buildenv.2012.11.001

surfaces. There are several steps of decontamination, which include a combination of cleaning, disinfecting and sterilizing. However, only a limited number of chemical disinfectants is available for air decontamination. A research study was carried out regarding air decontamination in healthcare buildings aiming to solve these issues, using hydrogen peroxide as the common solvent [16–20]. The European EN1276 and EN12054 standard suspension tests [21], and a trial for the clearance of MRSA colonization [22] showed that the tea tree oil had an antibacterial activity capability. The just mentioned studies have shown its significant potential to serve as an alternative agent for decontamination purposes. However, literature review reveals that the research work on using the tea tree oil vapour as the solutions of decontamination of indoor air microbial in the space is very rare.

For this purpose, the present study is conducted to investigate the potential of tea tree oil vapour as decontamination of indoor air microbial control in a newly-commissioned healthcare building.

2. Methodology and materials

The decontamination study was carried out in a newly-commissioned healthcare building, with the methodology being shown in Fig. 1. The healthcare building was launched for construction in 1998 and completed in three years. This is a fully air-conditioned eight-storey building with a level roof and can be categorized into critical and non-critical areas. The overall floor area of the healthcare facility is 41,450 m^2, with the critical area measuring about 4553 m^2.

The building does not contain a basement level. The first storey of the building contains the Information Technology (IT) Department, Medical Record Department, the Cancer Centre, mortuary, laboratory, material management and waste management, laundry and linen service, auditorium, and staff facilities. The second storey is where the cafeteria. Physiotherapy Department, Wellness and Heart Centre, Kidney and Stone Centre, Imaging Department, Accident and Emergency Department, Special Outpatient Clinic (SOC) and general administration are located. The third storey contains the Central Sterile Supply Department, the Invasive Cardiac Laboratory, Cardiac Catheterization Department and critical areas, which include the operating theatre, Coronary Care Unit and Intensive Care Unit. The fourth to the eighth storeys of the building are wards.

The air-conditioning system for the building is a centralized chilled water system, with the chiller plant located outside the main building. The chilled water is distributed to all air-handling units located throughout the building. Note that the measurements are conducted in an unoccupied condition and without operation (i.e. in the absent of major sensible and latent heat loads). Hence, the air conditions can be considered as an isothermal state in the room.

Each department is served by at least one Air Handling Unit (AHU). The building has a total of 72 AHUs, with 14 AHUs serving the critical areas located at level 3 of the eight-storey building. All AHUs are installed with primary and secondary filters. The operating theatres contain high efficiency particulate air (HEPA) filters, which the air has to pass through before being supplied into the work space.

2.1. Walkthrough inspection

A walkthrough inspection was carried out before samples were taken. The objective of the walkthrough was to identify the potential indoor sampling points according to the AHUs' serving area and also the outdoor sampling points according to the location of the AHUs [23]. Once the sampling points at the area of interest were identified, floor plans and drawings of the air-conditioning and the mechanical ventilation (ACMV) systems were collected.

2.2. Measurements

For the measurement of IAQ parameters, a total of 360 sampling points were taken. There were 336 indoor air measurements and 24 outdoor air measurements. All measurements were taken before and after the air decontamination process. There were also 84 locations sampled inside of the building, which could be subdivided into 58 locations within the general zone and 26

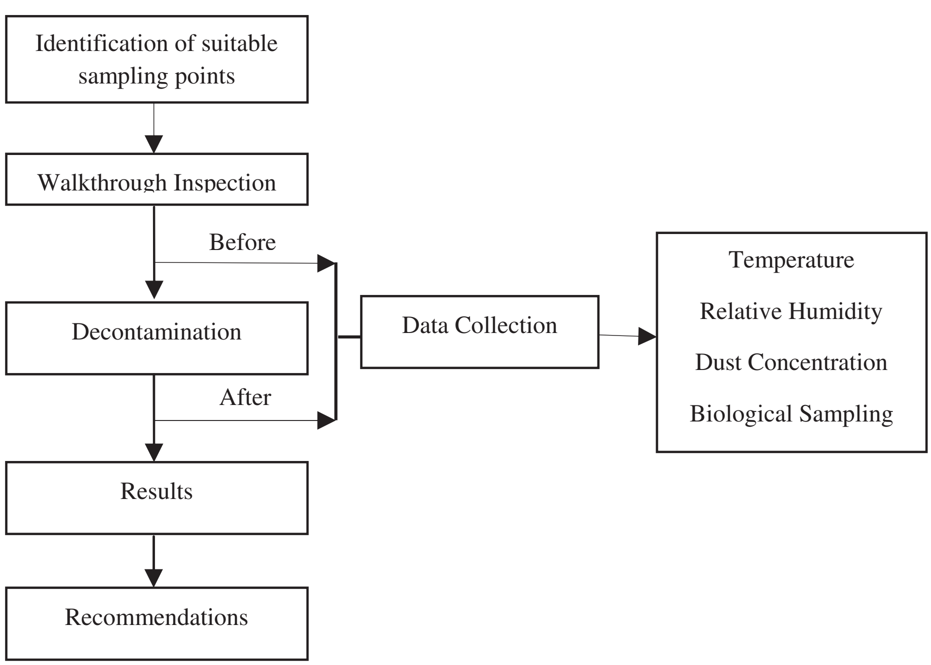

Fig. 1. Methodology for the decontamination study.