UNIVERSITI PUTRA MALAYSIA

EFFECTIVENESS OF VOC ABSORPTION BETWEEN Rhapis excelsa (Thunb.) A. Henry, Nephrolepis exaltata (L.) AND Dracaena fragrans (L.) IN SMALL ROOMS

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Recently, airtight envelope building system has become popular in order to help reduce heating and cooling loads. The change in building design was to improve energy efficiency resulting modern structures to be more airtight. Volatile organic compounds (VOC) are one of the most mentioned indoor pollutant and exposures to it can cause a series of effect towards human health. There are numerous methods that can help rid off indoor pollutants. However, combination of several methods may seem more efficient in ensuring good indoor air quality. This study is aimed to examine which among three selected tropical indoor plants to be the best in absorbing VOC in a small office space. The reading of VOC was recorded using Aeroqual Model S500 VOC Gas Detector. Data was collected for four hours and the VOC source was oil-paint painted on a panel measuring 0.05 x 0.05 m. The plants used in this study were *Rhapis excelsa (Thunb.) A. Henry*, *Nephrolepis exaltata (L.)* and *Dracaena fragrans (L.)*. The result showed there was significance difference within the plant species. There was also significant difference within the number of

pots used in the room. From the experiment, among three plants used in this study, *R. excelsa* has been identified as the best indoor plant to absorb VOC with the highest decrement when using six pots. The result of this finding strengthens previous research about the plants' capability and effectiveness in filtering the polluted indoor air.

Keywords: Indoor air quality, tropical indoor plants, volatile organic compounds

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

KEBERKESANAN MENYERAP VOC ANTARA *Rhapis excelsa (Thunb.) A. Henry, Nephrolepis exaltata (L.)* DAN *Dracaena fragrans (L.)* DALAM RUANG KECIL

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Kebelakangan ini, sistem pembinaan bangunan yang kedap udara telah menjadi semakin popular dalam usaha untuk membantu mengurangkan beban tenaga. Sistem ini mengakibatkan perubahan dalam rekabentuk bangunan moden supaya lebih cekap dalam penjimatan sumber tenaga. Sebatian organik yang mudah meruap atau 'volatile organic compounds' (VOC) adalah salah satu gas beracun yang paling banyak didapati di dalam bangunan dan pendedahan terhadap VOC boleh menyebabkan kesan tidak baik kepada kesihatan manusia. Terdapat pelbagai kaedah yang boleh membantu menyingkirkan bahan beracun ini. Walaubagaimanapun, gabungan beberapa kaedah adalah lebih berkesan dalam memastikan kualiti udara dalaman yang baik. Terdapat tiga jenis tanaman tropika digunakan dalam kajian ini dan tanaman ini sering digunakan di dalam ruangan pejabat. Kajian ini bertujuan untuk mengenalpasti tanaman manakah yang mempunyai potensi terbaik dalam menyerap VOC. Bacaan VOC telah direkodkan menggunakan alat 'Aeroqual Model S500 VOC Gas Detector'. Data telah dikumpulkan selama empat jam dan sumber

VOC adalah cat minyak yang disapu pada panel berukuran 0.05 x 0.05 m. Tanaman-tanaman yang digunakan dalam kajian ini adalah *Rhapis excelsa (Thunb.) A. Henry*, *Nephrolepis exaltata (L.)* dan *Dracaena fragrans (L.)*. Hasil kajian menunjukkan terdapat perbezaan signifikan antara spesies tanaman yang digunakan. Terdapat juga perbezaan yang signifikan antara bilangan pasu yang diletakkan di dalam ruang. Daripada eksperimen, antara ketiga-tiga tanaman yang digunakan dalam kajian ini, *R. excelsa* telah dikenalpasti sebagai tanaman terbaik untuk menyerap VOC dengan susutan yang tertinggi apabila menggunakan enam pasu. Hasil penemuan ini mengukuhkan penyelidikan sebelumnya mengenai keupayaan dan keberkesanan tanaman dalam menapis udara dalam bangunan yang tercemar.

Kata kunci: Kualiti udara dalaman, tanaman tropika, sebatian organik mudah meruap

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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AINI JASMIN GHAZALLI

Date:

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		Page
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CO_2	Carbon dioxide	6
DOSH	Department of Occupational Safety and Health	32
D. fragrans	*Dracaena fragrans*	6
EPA	Environmental Protection Agency	11
HVAC	Heating, ventilating and air-conditioning	3
H_2O	Water	23
IAQ	Indoor air quality	1
NASA	National Aeronautics and Space Administration	6
N. exaltata	*Nephrolepis exaltata*	6
N_2	Nitrogen	14
O_2	Oxygen	14
ppm	Parts per million	8
R. excelsa	*Rhapis excelsa*	6
SBS	Sick Building Syndrome	2
VOC	Volatile organic compounds	3

CHAPTER 1

INTRODUCTION

1.1 General background

The indoor spaces have always been seen as the safe zone, where its occupants are protected against adverse weather and any other possible danger. Residents especially those living in industrial areas spend most of their time indoors. The indoors is seen as a place of great comfort, safety and health. However, sometimes humans fail to see that the air we breathe can sometimes bring greater risk than the outside world.

Indoor air quality (IAQ) refers to the air quality within and around buildings and structures. Other than physical causes such as "Characteristics of the building" (Etzel, 2007, p.612), IAQ can also be affected by microorganisms, contaminants, gasses and other particulates. Etzel (2007, p.611) stated that "The major event in modern times that awakened the world that air pollution could be dangerous to health was the London Smog of 1952". Since then, there has been increasing concern within the scientific community over the effects of poor IAQ on health due to the increasing health problems affected by indoor air pollution.

People are aware that outdoor air pollution is detrimental to their health, but indoor air pollution can also have significant, harmful effects. Poor IAQ has been associated with a few cases of allergy, asthma and even cancer. Indoor source of pollution is the closest cause as we spend most of our time indoors – be it at home or office. Sometimes, upon entering a newly furnished building, we may experience uncomfortable odours. This disturbing scent can be an indicator that the indoor air is not within the acceptable 'clean' level.

One of the health effects associated with IAQ is the Sick Building Syndrome (SBS). Gupta, Khare & Goyal (2007, p.2797) stated, "SBS is defined as a set of sub-clinical symptoms with no specifically identified cause". It is a collection of symptoms experienced when a person is exposed to high concentration of certain gasses especially those living or working inside a building. Examples of these symptoms include allergies, asthma, headache and eye, nose, skin and throat irritations (Wolverton, 1997). These symptoms seem to appear when the occupants are inside the building and when the occupants are away, the symptoms are absent. As soon as the occupants re-enter the room, the symptoms may re-appear. This unhealthy condition usually can be diminished almost immediately by increasing the ventilation to circulate more fresh air. A research founded that the effects associated with SBS depended on a number of factors including sex, nature of the job, building and also room characteristics (Gupta et al., 2007).

In Malaysia, the SBS symptom has been reported to occur even in one of the newest buildings. It is a general understanding; new buildings should have the latest support system in order to ensure occupants' satisfaction. However, the IAQ still fail to reach

an acceptable level mainly due to the construction of buildings that was meant to be energy efficient but have "Poor maintenance and services" of the heating, ventilation and air conditioning (HVAC) system, resulting in increase of indoor air pollution levels (Syazwan Aizat, Juliana, Norhafizalina, Azman & Kamaruzaman, 2009, p.127).

Various researches have proven that building materials and interior products/finishing used indoors can emit various types of chemicals and is the main contributor for indoor air pollution (Destaillats, Maddalena, Singer, Hodgson, & McKone, 2008; Song, Kim, & Sohn, 2007; Sollinger, Levsen, & Wünsch, 1994; Wallace, Pellizzari, Leaderer, Zelon, & Sheldon, 1987). It was also found that interior finishes and furnishings such as carpeting, paints, electrical equipments and even clothing emit pollutants such as volatile organic compounds (VOC), texanol isomers, formaldehyde, particulate matter and ozone (Weschler, 2009; Destaillats et al., 2008).

Among all indoor pollutants, VOCs are the major group of indoor pollutant (Zhang, Steinmaus, Eastmond, Xin, & Smith, 2008; Weschler, 2009; Chan, Lee, Chen, Mak, Wong & Chan, 2009; Destaillats et al., 2008; Wang, Ang, & Tade, 2007). VOCs are volatile gasses that have high evaporative rate and at high concentrations can negatively affect human health. There are many sources of VOCs in the indoor air and it is difficult to specifically identify its origin. Zhang et al. (2008) commented that one of the most toxic air pollutants is formaldehyde and has been classified by the International Agency Research on Cancer as a human carcinogen.

There are three (3) basic methods that have been frequently used to maintain good IAQ; source control, air cleaning and ventilation. Occupants in office premises mainly rely on ventilation systems that allow buildings to be free of IAQ problems, thus allowing people in them to be safer and more productive. Another way to promote good IAQ is by aeration and dilution of indoor air by outdoor air interference; provided the outdoor air is of better condition compared to the indoors. According to Gupta et al. (2007, p.2797), "Poor operation of the ventilation system in office buildings causes ineffective removal of polluted indoor air".

Recently, the use of plants has become popular as plants not only add beauty to a space; it also helps improve air quality and gives calming effect on people. The use of plants as an alternative method in improving IAQ is an "accepted scientific fact" (Wolverton, 1997, p.22) and can aid in improving IAQ due to the unsuccessfulness of one specific method.

1.2 Justification of study

Previously, designers tend to design office buildings to have a more "airtight envelope system" (Gupta et al., 2007, p.2797) in order to reduce energy consumption. A more airtight office means less power is used to maintain acceptable temperature inside the office. This airtight system must come with a very good ventilation system in order to maintain good level of IAQ because characteristics of the building are one of the factors that can influence IAQ. Malaysia is no exception

as SBS symptoms have become a "common issue" (Syazwan Aizat et al., 2009, p.127).

Evolution in construction changes the way buildings are constructed and air conditioning has been widely applied in order to improve the quality of living in many parts of the world. Most office buildings in the world including Malaysia apply centralized air conditioning system, where the cool inside air is circulated and distributed using one single system. Having improper handling and maintenance of this system lead to many health problems (Yu, Hu, Liu, Yang, Kong, & Liu, 2009; Guieysse, Hort, Platel, Munoz, Ondarts, & Revah, 2008; Leslie, 2000; Lee & Chang, 2000).

Ventilation system and air conditioning have always been seen as an important method to maintain good IAQ (Yu et al., 2009; Dascalaki, Lagoudi, Balaras, & Gaglia, 2008; Namiesnik, Górecki, Kozdron-Zabiega la, & Lukasiak, 1992). A ventilation system helps dilute the polluted indoor air by bringing in fresh air from outside. It is also used to keep the indoor air circulating in order to avoid air stagnation thus removing any unpleasant smells. However, Namiesnik et al., (1992, p.353) stated that increasing ventilation rate is "economically unfeasible option". When the ventilation system constantly brings in outside air, there is the need to increase air conditioning power in order to achieve acceptable level of temperature for the occupants.

Another method to maintain good IAQ is source control but according to Destaillats et al. (2008, p.1374), "Characterizing emissions from office equipment can be

difficult due to the diversity of available equipment". Although many other methods have been suggested, problems still persist (Wolverton, 1997). These preventive and curative methods may work better if the use of plants were to be included.

In 1984, scientist from The National Aeronautics and Space Administration (NASA) published studies that demonstrated the plants' ability to filter the air. NASA studied a number of tropical houseplants suitable and has been used in Malaysia's office buildings such as *D. fragrans, N. exaltata, R. excelsa, Aglaonema* spp., *Anthurium* spp., and *Sansevieria trifasciata*. The study was done to find solutions of elevated carbon dioxide (CO_2) inside spacecrafts. Since then, there have been other studies on the effectiveness of plants in absorbing several types of harmful gasses. However, most of these studies use specially built chambers that ignore a real room condition because the test was specifically to test the plants only. This study was done in a small room with standard office furniture and air-conditioning system. This study is to confirm the effectiveness of plants to help absorb harmful gasses in the office. Malaysians are starting to spend more time indoors and therefore the indoor air is as important as the outdoor air – both must be acceptably healthy and clean.

1.3 Goal and objectives of study

The goal of this study is to monitor the effectiveness of Malaysian indoor plants in absorbing air pollutant in a small room.

The specific objective is:

i. To determine which species of indoor plant (*D. fragrans*, *N. exaltata* and *R. excelsa*) is the most effective in absorbing VOC.

1.4 Importance of the study

This study focuses on typical small room and uses indoor plants that are most favourable. From observation and comparing the best tropical indoor plants listed by NASA (Wolverton, 1997), three (3) most used indoor plants are chosen: Boston Fern (*N. exaltata*), Dracaena (*D. fragrans*), and Lady Palm (*R. excelsa*). In the end of this study, the indoor plant that has the best capability in absorbing VOC is determined. The findings can aid in increasing people's confidence in using a more natural approach to create a healthier living environment.

1.5 Limitations of the study

The limitations of this study are:

i. Previous experiments were conducted in a sealed chamber, ensuring that there is no outside interference during the research. The emission of VOC is highly related to temperature. Temperature is one of the environmental parameters that influence VOC emissions from building materials. The climate of Malaysia is hot and humid all year round and therefore the dependency to air-conditioning is high. This research was conducted in a small room, which means interference of outside air cannot be evaded.

ii. The device Aeroqual has its limits. The reading of VOC must not exceed 25 parts per million (ppm) or the sensor head will be contaminated. The safe level for a person according to the guideline provided by Department of Occupational Safety and Health Ministry of Human Resources Malaysia (2005) is 3ppm. Therefore, at the beginning of each experiment the reading of the device is to be ensured that it does not exceed 25ppm.

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