



Experiment of Reducing Volatile Organic Compounds Concentration in Air by Using Indoor Vertical Garden

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Technology Manufacturing Engineering (Design) with Honours.

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Technology Manufacturing Engineering (Design) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Masalah global adalah disebabkan aktiviti antropogenik dan biogenik. Isu ini bukan sahaja menyebabkan pemanasan global, tetapi juga pencemaran udara terutamanya persekitaran dalaman. Pelepasan gas berbahaya yang dikenali sebagai Compound Organic Volatile (VOCs) adalah bahaya kepada kesihatan manusia, oleh itu tindakan diambil untuk membersihkan udara. Tujuan kajian ini adalah untuk membersihkan keadaan dalaman rumah dengan menggunakan pengesan VOC yang dibuat sendiri. Sensor HCHO digunakan dalam pengesan VOC untuk mengesan nilai tumpuan VOC dengan bantuan Arduino 1.8.3. Satu jenis tumbuhan yang ibu mertua akan dimasukkan dalam kajian ini. Tumbuhan dalaman digunakan untuk membentuk taman rumah menegak di unit sisa. Pra ujian dijalankan untuk menyiasat sensitiviti pengesan VOC yang dibuat sendiri untuk keadaan dalaman, luaran dan bukan peredaran. Percubaan pertama dilakukan untuk mengesahkan produk komersial mengandungi zarah beracun dan menunjukkan bahawa tumbuhan dalaman dapat membersihkan bahan pencemar. Kemudian, eksperimen kedua dijalankan untuk menyiasat keupayaan tumbuhan dalaman terpilih untuk membersihkan udara selama beberapa hari (satu minggu). Data yang dikumpulkan daripada eksperimen ini direkodkan dan diplot sebagai graf nilai tumpuan VOC (ppm) terhadap masa (minit). Dengan merancang graf, trend data nilai kepekatan VOC sama ada mempunyai trend condong atau menurun.

ABSTRACT

The global problem is due to the anthropogenic and biogenic activities. This issue not only causes the global warming, but also the air pollution especially indoor environment. The emission of harmful gases which known as Volatile Organic Compounds (VOCs) are danger to human health, hence action is taken to purify the air. The purposes of doing this project study are to purify the indoor condition of a house by using own-made VOCs detector. HCHO sensor is applied in the VOCs detector in order to detect the VOCs concentration value with the aid of Arduino 1.8.3. One type of plants which is Mother-in-law's tongue will be included in the study. The indoor plants are used to form a vertical house garden in a residual unit. The pre-test is conducted to investigate the sensitivity of the own-made VOCs detector for indoor, outdoor and non-circulation condition. First experiment is done to verify commercial products are containing poisonous particle and to show that the indoor plants are able to purify the contaminants. Then, second experiment is conducted to investigate the ability of selected indoor plants to purify the air for several days of time (one week). The collected data from these experiments are recorded and plotted as a graph of VOCs concentration values (ppm) against time (minutes). By plotting the graph, the data trends of VOCs concentration values either have an inclined or declined trend can be observed.

DEDICATION

To my beloved parents

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LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

Al_2O_3	-	Aluminium oxide
AREF	-	Analog Reference
API	-	Air Pollution Index
AQHI	-	Air Quality Health Index
AQI	-	Air Quality Index
COMEAP	-	Committee on Medical Effects of Air Pollutants
DAP	-	diammonium phosphate
DEHP	-	di-(2-ethylhexyl)phthalate
DIY	-	Do It Yourself
EPA	-	Environment Protection Agency
FID	-	Flame-ionization detector
GC	-	Gas Chromatography
GC/MS	-	Gas Chromatography/Mass Spectrometry
GND	-	Ground
HCHO	-	Formaldehyde
LPG	-	Liquefied petroleum gas
MAP	-	monammonium phosphate
MEP	-	Ministry of Environment Protection
MRLs	-	Minimal Risk Levels
NO_2	-	nitrogen dioxide
PAS	-	Photo-acoustic sensor
PID	-	Photo-ionization detector
$PM_{2.5}$	-	suspended particulates smaller than 2.5 μ m in aerodynamic diameter
PM_{10}	-	suspended particulates smaller than 10 μ m in aerodynamic diameter
PPB	-	Part per Billion
PPM	-	Part per Million

POMs	-	Particulate Organic Matter
PWM	-	Pulse-Width Modulation
RX	-	Receive
SBS	-	Sick Building Syndrome
SO ₂	-	sulphur dioxide
SVOCs	-	Semi Volatile Organic Compounds
TCE	-	Trichloroethylene
TVOC	-	Total Volatile Organic Compounds
TX	-	Transmit
UV	-	Ultraviolet
VOCs	-	Volatile Organic Compounds
VVOCs	-	Very Volatile (gaseous) Organic Compounds

CHAPTER 1

INTRODUCTION

1.0 Introduction

In chapter 1, the criteria that will be discussed are the background, problem statement, objective and scope of my project. The VOCs will be roughly explained in background so that reader can have a basic understanding about this project. Problem statement is important to decide the title. After title is decided, objectives and scope are set for a project's guideline. The scope will tell reader about the actually what the project focus on.

1.1 Background

VOCs consist of variety of organic, carbon-containing chemical compounds which release molecules into air in gaseous form at room temperature. The most common types of VOCs consist of the benzene, trichloroethylene, and formaldehyde.

VOCs are naturally occurrence and significant to interactions of environment since all organisms have to live in the same environment on the earth. A large number of VOCs are released from manmade processes. The VOCs are emitted from burning fossil fuel, exhaust emission from industries, and some commercial products. If inhaled the VOCs at certain concentrations, they are hazardous to human health. According to Canadian Environmental Protection Act 1999 (2011), there are 5 kilotons of VOCs are emitted from coatings and surface cleaners for each of year when these sources are used in automotive refinishing operations. Hence, Canadian Environmental Protection Act 1999 decided to establish the Volatile Organic

Compounds (VOC) Concentration Limits for Automotive Refinishing Products Regulations in order to reduce the annual VOC emissions. This is because the concentration of VOCs indoors is much higher than outdoors, because people are purchasing commercial products for house decoration. According to U.S. Environmental Protection Agency (1989), some of the people are suffered from health diseases since they are spending more time indoors.

Many of the VOCs contents will affect to human health condition. VOCs cause some effects on human health and comfort. There are divided into two categories, which are short-term and long-term adverse diseases. VOCs are always surveyed and evaluated when there are complaints from occupants about poor indoor air quality. People are concerned about the “sick building syndrome” and “building related” illness that causes symptoms to human due to poor indoor air quality (Liu, 2015). Since VOCs are associated with the sense of odours, thus occupants will feel uncomfortable with bad indoor air quality condition. The adverse health reactions after living indoor with VOCs content are irritation of mucous membranes, mostly of the eyes, nose and throat, and various kinds of long-term toxic reactions. The same concentration level of VOCs may vary by the sequences of magnitude as VOCs contents consists of different chemical classes (Berglund et al., 1997).

Based on the research from Fadilah R. and Juliana J. (2012) in University Putra Malaysia, 47.5% and 33.8% of reported cases had been received for new commercial building and old commercial building respectively, means that both building have high risk on SBS. Therefore, the most appropriate corrective methods are significantly recommended to cope with the “Sick Building Syndrome (SBS)”.

IAQ complaints and SBS will be made by people while they are surrounded by poor indoor air quality. IAQ complaints and SBS influenced by personal, psychological and occupational variables. Factors causing SBS are building factors, specific environmental factors and pollutants, and personal factors. Therefore, it is necessary to identify the cause of complaints whether it is actually related to indoor air quality. Based on the report from World Health Organization, there are occupants from more than 30% of new or remodelled commercial building, complaint about the health and comfort which related to indoor air quality. More than 20 to 35% of

workers made reports for SBS symptoms. (Gomzi M. and Bobic J., 2009; Brits P. J., 2011)

1.2 Problem Statement

As the global problem of air pollution is rising sustainability after the human activities such as burning fossil fuels (such as gasoline, wood, coal, or natural gas) and the exhaust from factories and industries (such as oil gas fields and diesel exhaust), hence the outdoor air condition become worse from day to day. Nevertheless, the indoor air condition is usually more polluted than outdoor and can sometimes reach up to 2 times more polluted than the outside (Orwell et al., 2004; S. Vardoulakis et al., 2015). The indoor gases which affect the human health are known as Volatile Organic Compounds (VOCs). Volatile organic compounds (VOCs) are chemicals consisted elements of carbon and hydrogen and they can be easily evaporated into the air to form gases from solids or liquids state. VOCs include the gases of benzene (C_6H_6), formaldehyde (CH_2O), trichloroethylene or TCE (C_2HCL_3), ammonia (NH_3), xylene (C_8H_{10}) and toluene ($C_6H_5 - CH_3$) and etc. These gases are emitted from manmade process; the gasoline, wood, coal, or natural gas is emitted after burning fossil fuels. Besides, the exhaust from factories and industries included also VOCs contents such as oil gas fields and diesel exhaust. Other than the emission from manmade process, commercial product such as paints, inks and household cleaning products, they give off toxic into the air. Since people are spending more time to stay indoors, which is 90 percent compared to outdoor, hence people will breathe in these chemicals frequently and affects their body health (U.S. Environmental Protection Agency, 1989). VOCs contents can be detected at housing areas, schools, offices, and commercial buildings at anywhere anytime. People can suffer from health effects when long term living with VOCs; there are the cancer, damage to liver, kidneys, or central nervous system. Other than that, some short term diseases are momentary irritation of the eye or throat, nausea, headache and etc. To improve the indoor air condition quality, many type of electrical air purifiers existed in the market nowadays in order to solve people's problem. But, the simple house garden can be the perfect solution to purify the VOCs contents in air instead of using

the existing product of electrical air purifiers. The simple house garden helps to bring a bit of nature to your indoor occupied space. It is able to give some relaxation of eye for people whenever they are facing to the mobile device for a long time. Besides, house garden is more to green concept by comparing to purchasing an electrical air purifier. This is because the materials used for the air purifier are non-biodegradable and will increase garbage to environment when the users would like to change for another air purifier product. Furthermore, extra processes are needed to decompose the non-biodegradable materials at factories and industries, but this may be expensive. The processes that needed to decompose the materials will emit toxic to environment hence cause air pollution.

1.3 Objective

The emissions of Volatile Organic Compounds (VOCs) are harm to human health after purchasing the new furniture and painting the wall indoor. As people are spending more time indoor, so they are always breathing in the chemical compounds. Thus, the objectives of this project are:

- To purify VOCs in indoor air condition by using indoor plants.
- To build a VOCs detector.

1.4 Scope

The scopes of the research are shown as below.

- i. Type of plants used: Mother-in-law's tongue or Snake plant

Mother-in-law's plant with a low growing leaf is chosen for growing. This is because this kind of plants is very carefree for indoor environments. The Mother-in-law's tongue is chosen to used for this project, because it is easy to find and easy to grow.

- ii. Number plants needed: 9 plants for 14 meters square
- iii. Appropriate condition for plants: warmth condition is preferred, minimal light is enough for it to perform photosynthesis.

The plant will suffer if exposed to temperature below 10 °C. The ideal temperature for the plant to grow is 15.5 to 24 °C, but it can tolerate other temperature except the freezing condition. Besides, the plants can grow in shady conditions. Watering is needed whenever the soil is dry by the sense of touch since the plants like dry soil and air.

- iv. Planting method: The plants are growing vertically.

The concept of vertical garden or green wall is applied to grow the Mother-in-law's tongue. This concept can help to save indoor occupied space. But, the simulation to verify the strength of method and materials chosen are not included.

- v. Type of suitable soil used: black clay with the combination of the fibre from coconut shell

Loose and well-drained potting mix is appropriate for the Mother-in-law's plant to grow since this type of soil is sandier than the others. The soil which consists of the coconut shell's fibre can keep the soil wet for longer time and provide the function of well-drained.

