



**CHARACTERISTIC OF AIRBORNE PARTICULATES
MONITORED IN A MUSEUM: A CASE STUDY AT
NATIONAL TEXTILE MUSEUM, KUALA LUMPUR**

BY

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ABSTRACT

The explosion of global warming and climate change occurs parallel to the rise of earth development. This is due to the deterioration of atmospheric environment that roots from man-made sources. Ranges of air pollutants had been discovered. However, this research focuses on Particulates Matter (PM) in particular, source from transportation. The Particulate Matter is a complex mixture of extremely small solids and liquid particles suspended in air. This complex mixture contains a number of components, including acidic and organic chemicals, and soot, smoke, pollen, and dust particles. It comes in many particle sizes of ranges, coarse particles, which known as Inhalable Particulates (PM_{10}) and fine particles as Respirable Particulates ($PM_{2.5}$). Studies have been carried out on specimens of airborne particulates in National Textile Museum, Kuala Lumpur. The objective is to investigate the main sources of suspended airborne particulates in the air of the outdoor museum, indoor and showcase atmospheric in determining the risk level of artefact deterioration. The analysis was done to compare the mass concentration, size distribution, physical characterisation of airborne particulates indoor and outdoor of the museum. The evidence is believed that the fine particles provide higher degrees of illness than coarse particles. The fine particles from outdoor atmospheric can deposit into deeper part of museum showcases and apart from the size of the particles, other specific physical, chemical, and biological characteristics that include the presence of metals, other organic components, or certain toxins provide adverse negative effect towards the artefacts in the museum and also brings influence harmful health effects to worker and visitor.

ملخص الدراسة

إن بروز ظاهرة الإحتباس الحراري وتغير المناخ كان بالموازاة مع التقدم المتزايد في الأرض. وتعزى أسباب هذه الظاهرة إلى تدهور بيئة الغلاف الجوي والذي يرجع أساسا إلى مصادر إنسانية. لقد تم اكتشاف أنواع ملوثات الهواء التي أسهمت في بروز هذه الظاهرة، ومع ذلك فإن هذا البحث سيركز على جسيمات المواد (PM) على وجه الخصوص، والذي تعتبر كمصدر من وسائل النقل. تعتبر جسيمات المواد خليطا معقدا من المواد الصلبة والجسيمات السائلة الصغيرة للغاية والعالقة في الهواء. يحتوي هذا الخليط المعقد على عدد من المكونات بما في ذلك المواد الكيميائية الحمضية والعضوية، والسخام، والدخان، وحبوب اللقاح، وذرات الغبار. ويأتي هذا الخليط على أنواع وأحجام متعددة: الجسيمات الخشنة وتسمى بالجسيمات القابلة للإستنشاق (PM10)، والجسيمات الدقيقة التي تدعى بالجسيمات القابلة للتنفس (PM2.5). لقد أجريت العديد من الدراسات على عينات من الجسيمات المحمولة بالهواء في المتحف الوطني للنسيج بكوالا لمبور، والهدف هو التحقق من المصادر الرئيسية للجسيمات العالقة والمحمولة بالهواء في الغلاف الجوي لكل من الوسط الخارجي والداخلي للمتحف، وكذا أماكن العرض فيه، وهذا لتحديد مستوى خطر تدهور النتاج الصناعي للإنسان. وقد تمت عملية التحليل لمقارنة التركيز الكلي، وتوزيع الحجم، والخصائص الفيزيائية للجسيمات المحمولة بالهواء داخل وخارج المتحف. ويعتقد أن الدليل هو أن الجسيمات الدقيقة تقدم درجات أعلى من المرض من الجسيمات الخشنة. إن الجسيمات الدقيقة للغلاف الجوي الخارجي يمكن أن تودع في أعماق جزء من معارض المتحف، وبصرف النظر عن حجم الجسيمات، فإن الخواص الفيزيائية، والكيميائية، والبيولوجية الأخرى والتي تحتوي على وجود معادن، ومكونات عضوية أخرى، أو بعض السموم، كلها تنتج تأثيرا سلبيا نحو المنتوجات في المتحف، وأيضا تجلب آثارا صحية ضارة للعامل والزائر.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion; it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Built Environment).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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*This humble work is dedicated to,
my beloved mother and father, Zabedah Hashim, Allahyarham Mohd.Baroldin,
my cherished granny, Allahyarhamah Khadijah,
my respectful brothers and sisters, Noorfaizah, Abdul Rahman,
Nurman, Rosilah,
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and my loving husband, Muhammad Hilmy,
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CHAPTER 1

INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION

Human activities have a result in harmful substances and polluting emissions being released into the air. The burning of fossil fuels such as coal, oil and gas as well as clearing of forests as well as industrial production lead to harmful emission. It can endanger human health and natural ecosystem and also lead to an additional greenhouse effect.

This thesis presents an in-depth study of the particulates monitoring and control of airborne particulates to the museum environment by identifying the particulate matter from airborne particles that dispersed by the traffic and its effect towards museum artefacts, and human health. The study analysis included: identifying the environmental factors (e.g., mass concentration, particles number and size distribution) that can adversely affect museum artefacts and human health.

1.2 RESEARCH BACKGROUND

Case study in this thesis is Kuala Lumpur National Textile Museum, which is located at Jalan Sultan Hishamuddin, Kuala Lumpur, in the middle of Kuala Lumpur city. The museum has officially opened in January 2010 with valuable collections and historical origins of the textile industry in Malaysia.

The results of this research include the comparison of mass concentration, indoor and outdoor of the National Textile Museum, the relationship of air quality indoor and outdoor on weekends and weekdays, the effects of airborne particulates

towards artefacts and public health, the physical characterization of airborne particulates that may come from different sources in which the sample of Inhalable Particulates and Respirable Particulates collected. The relationship of airborne particulates with temperature and relative humidity; will also be highlighted as the combination of those agents of deterioration will as much harming and damaging the heritage building and museum artefacts.

1.3 PROBLEM STATEMENT

Human activities have resulted in harmful substance emission being released into the air. The lifestyle of modern society is highly dependent on transportation that leads to harmful effect and also endangers human health, natural ecosystem and greenhouse effect.

Table 1.1: Contribution of Traffic Pollution in Malaysia, 2003

Pollutant	Total Emission Load (Tonnes)	Traffic	Industry	Power Plants	Others
CO (carbon monoxide)	1,455.840	93%	2%	1%	4%
SO (sulphur dioxide)	280.278	6%	25%	32%	37%
PM (Particulate Matter)	20.453	36%	19%	45%	-

Source. Department of Safety & Health (DOSH), Malaysia (2002)

The Table 1.1 shows the contribution of traffic, power plants, industry and households to the overall air pollution in Malaysia, 2003. Most of the pollutants shown here lead to local and regional pollution problems, but some of them, especially carbon dioxide, are highly harmful greenhouse gases that change the climate worldwide.

Malaysia economic growth is mainly based on its manufacturing, chemical and rubber industries. But higher production rates also lead to higher emissions of organic and inorganic gases, chemical and particulates. Kuala Lumpur is one of the 15 Asian cities that have the greatest levels of pollution and brings negative impact on human health, plantation, animal and also building. Particulate matters (PM) also affect museum artefacts by giving more potential damage to the materials such as stone, textile, metal, glass and more, and also bring adversely effects to occupants in the building. This is not just an urban problem of developed countries. In order to combat this problem, further study and observation is needed to study ways of mitigating the problem.

1.4 RESEARCH OBJECTIVES

The goal and aim of the study is to investigate the main sources of suspended airborne particulates in the air of a museum environment towards artefact deterioration and its surrounding. The objectives of the study are:-

- i. To compare the level of particulate matter that contributes on work days and week days by identifying mass concentration, particle number and size distribution of airborne particulates.
- ii. To measure and quantify airborne particulates with indoor and outdoor museum with the existing guidelines and standards of Indoor Air Quality (IAQ) in Malaysia for creating a pollutant-free in the museum environment for healthy artefact condition.
- iii. To classify the physical characterizations of Inhalable Particulates (coarse particles with a size range from 0.01 to 2.5 μm -micrometer) and

Respirable Particulates (fine particulates with a size range from 2.5 to 10 μm) at the indoor and outdoor museum.

- iv. To produce a recommendation that provides a healthy air environment for the museum environment and artefacts.

1.5 RESEARCH QUESTIONS

- i. What are the possible sources of particulate matter at the museum?
- ii. What is the mass concentration of Inhalable and Respirable Particulates at the museum whether the mass concentrations exceeding the standard emission of Particulates Matter Guideline by DOE and DOSH?
- iii. What are the physical characterizations of Inhalable and Respirable Particulates at the museum?
- iv. How to reduce the level of particulate matter at the museum?

1.6 RESEARCH HYPOTHESIS

Particulate matter of Inhalable and Respirable Particulates from the standard emission on Particulate Matter by DOE and DOSH bring bad impacts towards human health and museum artefacts. The particulate matter that derived inside the museum building from sources of traffic vehicles, construction sites, and museum visitor can be reduced by controlling the museum weather and environment. Thus, this study hypothesized the level of particulate matter at the National Textile Museum is depending on surrounding environment.

1.7 RESEARCH METHODOLOGY

The method used to achieve the aim and objectives of the research involves four (4) key activities which are data collections – site survey, structured interview, scientific data collections and data analysis.

Data collections are divided into two types, which could be gained from primary sources and secondary sources. Primary data are the data that we can get by the first hand, the methods and collections of data that are assessed and gained at selected site studies such as mass particulates sampling, temperature or relative humidity readings.

Secondary data are the data that are readily available; it includes a literature review such as existing journals, paperwork, articles, newspaper, books, reports or any other data that are already existing. The main purpose of doing a literature review is to collect information and data from the right sources in order to obtain all the theories related to investigating from various sources and to study the different techniques and methods used by the professionals.

1.8 OVERVIEW OF THE THESIS CHAPTER

The structures of the thesis are as follows:

Chapter 1 is the introductory chapter, which introduces the background of the study upon which the thesis based, namely, the introduction of the subject matter, background of research, research issues, objectives, hypothesis, methodology, scope and significance, limitations and research component.

Chapter 2 review the background case study of the research. The first section reviews the studies and methodology that apply to the study of how to monitor and control the environmental pollutants in the museum. The second section comes with

sampling and collection data of mass concentrations of particulate matter, particles number and size distribution in the museum.

Chapter3 clarify to the design study and methods of analysis that was to be used in this research paper.

Chapter 4 presents the findings and analysis. The chapter divided into five main sections according to the data collection according to the research aims and objectives followed by a data analysis of the findings.

Chapter 5 is the recommendation chapter, which includes some suggestion of monitor and control the environmental pollutants in the National Textile Museum.

1.9 RESEARCH COMPONENTS

The components of the research stated earlier such as research questions, objectives, methodologies and expected results is illustrated in Table 1.2 to show how those components related to each other.

Table 1.2: Research Components

No	Objectives	Research Questions	Methodologies	Expected Results
i.	To identify the possible sources of particulate matter either from inside or outside the museum	What are the possible sources of airborne particulates at the museum?	<ul style="list-style-type: none"> • Literature Review • Site Survey and Observation • Laboratory analysis – Physical and Chemical Characterisation 	<ul style="list-style-type: none"> • Traffic emission • Climate factors • Constructions • Artefact inside • Museum occupant • Museum environment
ii.	To measure and quantify airborne particulates with indoor and outdoor museum with the existing guidelines and standards of Indoor Air Quality (IAQ) in Malaysia for creating a pollutant-free in the museum environment for healthy artefact condition.	What is the mass concentration of Inhalable and Respirable Particulates at the museum whether they're mass concentrations exceeding the standard emission of Particulates Matter Guideline by DOE and DOSH?	<ul style="list-style-type: none"> • Airborne particulates sampling • Laboratory analysis • Calculation 	<ul style="list-style-type: none"> • Comparison of mass concentration of inhalable and Respirable Particulates
iii.	To classify the physical characterizations of Inhalable Particulates (coarse particles with a size range from 0.01 to 2.5 µm-micrometer) and Respirable Particulates (fine particulates with a size range from 2.5 to 10 µm) at the indoor and outdoor museum.	What are the physical characterizations of Inhalable and Respirable Particulates at the museum?	<ul style="list-style-type: none"> • Laboratory analysis and Experiments • Measurement and calculation using microscope 	<ul style="list-style-type: none"> • Particle number • Size distribution of particulate matter •
iv.	To produce a recommendation that provides a healthy air environment for the human health and museum artefacts.	How to reduce the level of particulate matter at the museum?	<ul style="list-style-type: none"> • Site observation • Literature review 	<ul style="list-style-type: none"> • Museum environment control • Good Maintenance • Preservation methods

CHAPTER 2

STUDY BACKGROUND

2.1 INTRODUCTION

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere.

2.2 INDOOR AIR POLLUTION

Indoor Air Pollution (IAP) is defined as chemical gas and small particulates that enter the atmosphere of structure which can make the air unhealthy and cause short and long term of illness (Morawska and Salthammer, 2004). Critical suspended indoor air pollutants may harm human health and affect indoor environment compared to staying outside which actually also dirty. Thus, the research case study has conducted to identify the effect of indoor pollution in the heritage building of the National Textile Museum that will be explained further in Chapter 3.

IAP is a term which refers to the air quality inside building environment. According to Griffin (2007), the various environmental regulatory agencies recommend to public should remain indoors to avoid the air pollutants outside. However, the recommendation is being argued due to high levels of air contaminants indoor air is caused from the outdoor air quality. (Roslina, 2010). Furthermore, USEPA, (2013) asserted that inadequate ventilation can increase indoor air pollutant by not bringing in enough outdoor air to dilute emissions from indoor sources and also by not carrying the indoor air pollutants out of the building. Thus, better air filtration

and ventilation system are the primary methods in improving the indoor air quality (IAQ) in certain buildings. In another matter, high temperature and high humidity levels can also increase particulate concentrations of some pollutants.

2.2 INDOOR AIR POLLUTANT AND ITS SOURCES

Heating, ventilation, and air conditioning (HVAC) systems are the key components combining outdoor air with indoor air, and one of their purposes is to prevent outdoor PMs from entering indoor air, (Norsyamimi, 2011). However, much of the SO_x, NO_x, O₃ and particulate matter detected in the library or museum environment is introduced by way of the HVAC system. Even though in buildings with HVAC systems, lacking of pollutant gas removal capability, the ratio of indoor-to-outdoor concentrations is typically less than one due to the reaction of the gases with building surfaces or with objects in the artefacts.

There are numerous other sources of indoor air pollutants i.e. Combustion sources like coal, gas, oil, tobacco and wood products; building furnishings such as damp or wet carpet, and furniture or cabinetry made of pressed wood products; and products for household maintenance and personal care. In addition, various effects of indoor air pollutions towards artefact materials are due to the different type of pollutants in the air. The deterioration of the artefact materials by the indoor air pollution are described in Table 2.1.

Table 2.1: Indoor Air Pollution Damage to Materials

Materials	Type of Impact	Principal Air Pollutants	Other Environmental Factors	Methods of Measurement
Metals	Corrosion, tarnishing	Sulphur Oxides, Hydrogen Sulphide, and Other Acidic Gases	Moisture, air, salt, particulate matter, ozone	Weight loss after removal of corrosion products, change in surface characteristics
Paintings and Organic Coatings	Discoloration, soiling	Sulphur Oxides, Hydrogen Sulphide, Alkaline Aerosol	Moisture, sunlight, ozone, particulate matter, microorganisms	Surface reflectivity loss, chemical analysis
Paper	Embrittlement, discoloration	Sulphur Oxides	Moisture, physical wear, acidic materials introduced in manufacture	Decreased folding endurance, PH change molecular weight measurement, tensile strength
Photographic Materials	Microblemishes 'sulphiding'	Sulphur Oxides	Particulate matter, moisture	Visual and microscopic examination
Textiles	reduced tensile strength, soiling	Sulphur and Nitrogen Oxides	Particulate matter, moisture. Light, physical wear, washing	Reduce tensile strength, chemical analysis (e.g. molecular weight), surface reflectivity
Textile Dyes	Fading, colour change	Ozone, Nitrogen Oxides	Light, high temperature	Reflectance and colour value measurements
Leather	Weakening, powdered surface	Sulphur Oxides	Physical wear, residual acids introduced in manufacture	Loss in tensile strength, chemical analysis, shrinkage
Rubber	Cracking	Ozone	Sunlight, physical wear	Loss in elasticity and strength, measurement of crack frequency and depth.

Source. Ahmad (2010) and Norsyamimi (2011)

2.3 RELATIONSHIP BETWEEN OUTDOOR AND INDOOR POLLUTANTS

Particulate matter (PM), including dust, mist, fog, microorganism, pollen and so on, is one of the most important pollutants in outdoor air and indoor air. Heating,