



THE TREND OF AIRBORNE PARTICULATES
DISTRIBUTION AT RESIDENTIAL AREAS IN RELATION
TO COAL POWER PLANT IN MANJUNG, PERAK

BY

MUHAMMAD IHSAN SHAHARIL

A thesis submitted in fulfilment of the requirement for the
degree of Master of Science (Built Environment)

Kulliyyah of Architecture & Environmental Design
International Islamic University Malaysia

JUNE 2015

ABSTRACT

Due to the deterioration of air quality in recent years in line with the rapid development, this study is an initiative to provide an overview of the results of the case study and report on the trends of airborne particles distribution at residential areas in relation to distance from coal power plant in Manjung, Perak. Particulate matter from Manjung coal power plant may possibly one of the decreasing health condition factors of the residents' related to respiratory besides motor vehicles, industrial activities and other sources. An 8-hour airborne sampling by using 7-hole Sampler (for total inhalable dust) and Cyclone Sampler (for respirable dust) was conducted to measure and quantify physical characteristics of airborne particulates in the site study area both indoor and outdoor. Four sampling points (housing at Teluk Rubiah, Lumut, Sitiawan and Ayer Tawar) were determined by the radius distance 5km, 10km, 15km, 20km away respectively from the coal power plant and the direction, considering the meteorological factors. For indoor mass concentration of total inhalable dust, the trend shows that 5km and 10km sampling point recorded 0.3788 mg/m^3 and 0.2575 mg/m^3 , which exceed the standards for good indoor air quality by EPD (0.180 mg/m^3) compared to 15km (0.0663 mg/m^3) and 20km (0.1515 mg/m^3). As for outdoor mass concentration, the percentage of respirable dust towards total inhalable dust at 10km radius sampling point is the highest among the four sites with 97% (others ranging from 38% to 79%), due the other sources nearby like sea-port, ferry terminal to Pangkor, heavy traffic at tourism point and industrial activities. From the findings, it can be concluded that the level of airborne particulates distribution has association with the coal power plant. Although indoor air quality of the resident's house was influenced by the nearby coal power plant, however the house design and smoking habits also play the role, studies have shown. The outdoor particulate measurement at residential house in Manjung not only determined by the location or distance from the coal power plant, but the results also considering the meteorological factors and other sources around the sampling point.

خلاصة البحث

نظرا لتدهور نوعية الهواء في السنوات الأخيرة والذي كان بالموازاة مع التطور السريع، فإن هذه الدراسة تعتبر مبادرة لتقديم لمحة عامة عن نتائج دراسة حالة، وتقريراً لاتجاهات توزيع الجسيمات المحمولة بالهواء في المناطق السكنية، وهذا بالعلاقة بالمسافة من محطة طاقة الفحم في ماجونج التابعة لولاية بيراك. يمكن اعتبار الجسيمات الناتجة من محطة طاقة الفحم بـ ماجونج إحدى العوامل المؤدية إلى تدهور صحة السكان المتعلقة بالجهاز التنفسي، وهذا بالإضافة إلى السيارات، والنشاطات الصناعية، إلى غير ذلك من المصادر الأخرى. لقد تم أخذ عينة من المواد المتحركة بالهواء في مدة استغرقت 8 ساعات، وذلك باستعمال أداة التعيين ذات السبع حفر (للغبار القابل للاستنشاق كلياً)، وأداة التعيين الإحصاري (للغبار القابل للتنفس كلياً)، وهذا لقياس وتكميم الخواص الفيزيائية للجسيمات المحمولة بالهواء بكلا الوسطين الداخلي والخارجي لموقع الدراسة. لقد تم تحديد أربع نقاط لأخذ العينات (المناطق السكنية لكل من تيوك روبيا، ولموت، وسيتياوان، وآبير توار) من خلال مسافات أنصاف الأقطار التالية: 5 كلم، و10 كلم، و15 كلم، و20 كلم بعداً من محطة طاقة الفحم والاتجاه على التوالي، وهذا بأخذ العوامل الجوية بعين الاعتبار. بالنسبة لتركيز الكتلة الداخلية للغبار القابل للاستنشاق الكلي؛ فإن التوجه يظهر أن عيني 5 كلم و 10 كلم قدمتا التسجيلات التالية: 0.3788 ملغ/م³ و 0.2575 ملغ/م³ التي تجاوزت المعايير الجيدة لنوعية الهواء الداخلي حسب معيار EPD (0.180 ملغ/م³) وهذا مقارنة بـ 15 كلم (0.0663 ملغ/م³)، و20 كلم (0.1515 ملغ/م³). أما بالنسبة لتركيز الكلة الخارجية، فإن نسبة الغبار القابل للتنفس (97%) عند عينة مسافة نصف قطر 10 كلم تعتبر الأعلى من بين المواقع الأربع (بينما تراوحت نسب العينات الأخرى ما بين 38% إلى 79%)، وذلك بسبب وجود مصادر أخرى مجاورة مثل الميناء البحري، ومحطة السفن المؤدية الى جزيرة بانكور، وحركة المرور الكثيفة عند موقع السياحة، وأخيراً الأنشطة الصناعية. يمكن أن نستنتج من خلال هذه النتائج أن مستوى توزيع الجسيمات المتحركة بالهواء علاقة بمحطة طاقة الفحم. وعلى الرغم من أن جودة الهواء في الأماكن الداخلية لتلك السكنات كان متأثراً بمحطة الفحم المجاورة، ومع ذلك فإن تصميم المنازل، وعادة التدخين تلعب دوراً في ذلك على حسب ما دلت عليه الدراسات. إن قياس الجسيمات في الوسط الخارجي للمناطق السكنية بـ ماجونج لم يتم تعيينه بالموقع أو المسافة من محطة طاقة الفحم فقط، بل وكذلك باعتبار العوامل الجوية، والمصادر الأخرى المجاورة للموقع الذي تم أخذ العينات منه.

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).

.....
Shamzani Affendy Mohd Din
Supervisor

I certify that I have 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).

.....
Niza Samsuddin
Internal Examiner

I certify that I have 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).

.....
Ahmad Makmom Abdullah
External Examiner

This thesis was submitted to the Department of Applied Art & Design and is accepted as a fulfilment of requirement for the degree of Master of Science (Built Environment)

.....
Zumahiran Kamaruddin
Head, Department of
Applied Art & Design

This thesis was submitted to the Kulliyyah of Architecture & Environmental Design and is accepted as a fulfilment of the requirement for the degree of Master of Science (Built Environment)

.....
Alias Abdullah
Dean, Kulliyyah of
Architecture &
Environmental Design

DECLARATION

I hereby declare that this thesis the result of my own investigation, 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.

Muhammad Ihsan Shaharil

Signature.....

Date

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

**DECLARATION OF COPYRIGHT AND AFFIRMATION
OF FAIR USE OF UNPUBLISHED RESEARCH**

Copyright ©2015 by Muhammad Ihsan Shaharil. All rights reserved.

**THE TREND OF AIRBORNE PARTICULATES DISTRIBUTION
AT RESIDENTIAL AREAS IN RELATION TO COAL POWER
PLANT IN MANJUNG, PERAK**

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below.

1. Any material contained in or derived from this unpublished research may be used by others in their writing with due acknowledgement.
2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purposes.
3. The IIUM library will have the right to make, store in a retrieval system and supply copies of this unpublished research if requested by other universities and research libraries.

Affirmed by Muhammad Ihsan Shaharil

.....
Signature

.....
Date

Thanks to Allah the Almighty for His bounties and blessings throughout my whole life, and this journey of studies. Special dedication to my parents, wife, family, supervisors, lecturers, friends and others who are always be supportive and understanding.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor Asst. Prof. Dr. Shamzani Affendy Mohd Din for the useful comments, remarks, advices, assistance and engagement through the learning process of this master thesis. Furthermore I would like to thank him for introducing me to the topic as well for the support on the way. Also, to my post-supervisor, Assoc. Prof. Dr. Niza Samsuddin for the guidance since my viva voce until the establishment of my thesis and Assoc. Prof. Dr. Makmon Abdullah as my panel of viva voce. In addition, my sincere thanks also goes to my fellow teammates; Sis Nik Nurul Hidayah Nik Yahya, Sis Nurul Iffa Nayan, Sis Norsyamimi Hanapi, Sis Nor Fadhillah Bahroldin and Bro Nik Azmin for their supports, helps and cooperation in understanding and enjoying the gist of the research for the entire years.

Also, I like to thank the participants in my survey, the officers of Majlis Perbandaran Manjung, Department of Environment Putrajaya, Department of Environment Ipoh, Statistical Department Putrajaya, Meteorological Department Kuala Lumpur, and also the residents of Manjung, who have willingly shared their precious time during the process of interviewing and assisting in collecting data. I would like to thank my loved ones, who have supported me throughout entire process, both by keeping me harmonious and helping me putting pieces together. I will be grateful forever for your love.

TABLE OF CONTENTS

Abstract	ii
Abstract in Arabic	iii
Approval Page.....	iiiv
Declaration	v
Copyright Page.....	vi
Dedication	vi
Acknowledgements.....	vii
List of Tables	xiii
List of Figures	xv
List of Abbreviations	xix
List of Symbols.....	xix
CHAPTER ONE: INTRODUCTION	1
1.1 Problem Statement.....	2
1.2 Research Questions.....	3
1.3 Aim and Objectives of Research	4
1.4 Research Hypothesis.....	4
1.5 Research Methodology	5
1.5.1 Data Collection	5
1.5.2 Further Scientific Data Collection	6
1.5.3 Data Analysis and Laboratory Experiment.....	7
1.6 Significance of Research	7
1.7 Scope of Research.....	9
1.8 Summary.....	9
CHAPTER TWO: ATMOSPHERIC POLLUTION EFFECTS TOWARDS HEALTH	10
2.1 Introduction.....	10
2.2 Atmospheric Layers.....	10
2.3 Global Warming	11
2.3.1 Greenhouse Effects	12
2.3.2 Carbon Emission	14
2.3.3 Industrial Activities.....	16
2.3.4 Effects of Global Warming	16
2.3.4.1 Temperature Changes	17
2.3.4.2 Rise of Sea Level.....	17
2.3.4.3 Population.....	19
2.4 Atmospheric Cycle	20
2.5 Air Pollution and Its Pollutants	22
2.5.1 Forms of Air Pollutants.....	25
2.5.1.1 Solid.....	25
2.5.1.2 Liquid Droplet	26
2.5.1.3 Gaseous.....	27
2.5.2 Natural Sources of Air Pollution.....	27

2.5.2.1 Volcanic.....	28
2.5.2.2 Dust.....	28
2.5.2.3 Methane (CH ₄).....	29
2.5.3 Anthropogenic Sources of Air Pollution.....	30
2.5.3.1 Power Plant.....	31
2.5.3.2 Mobile Vehicles.....	31
2.5.3.3 Chemical Controlled Burn.....	32
2.5.3.4 Aerosol	33
2.5.4 Primary Air Pollutants	34
2.5.4.1 Chlorofluorocarbon (CFC)	34
2.5.4.2 Particulate Matter (PM).....	35
2.5.4.3 Sulphur Dioxides (SO ₂).....	35
2.5.4.4 Nitrogen Oxides (NO _x).....	36
2.5.4.5 Carbon Monoxides (CO).....	37
2.5.4.6 Carbon Dioxides (CO ₂)	38
2.5.4.7 Asbestos.....	38
2.5.4.8 Lead (Pb)	39
2.5.5 Secondary Air Pollutants	40
2.5.5.1 Smog and Fog.....	40
2.5.5.2 Ultra-Violet.....	41
2.5.5.3 Ground Level Ozone	42
2.6 Airborne Particulate Matter	43
2.6.1 Sources Of Airborne Particulate	44
2.6.2 Physical Categorization Of Airborne Particulates	44
2.6.2.1 Mass Concentration.....	44
2.6.2.2 Size Distribution.....	45
2.6.2.3 Particulate Numbers	47
2.6.2.4 Morphology	47
2.6.3 Toxicology And Dangers Of Particulate Matter	49
2.6.4 Effects Of Exposure Of Particulate Matters.....	50
2.6.4.1 Human Health.....	51
2.6.4.2 Flora.....	52
2.6.4.3 Fauna	53
2.6.4.4 Building And Materials	53
2.6.4.5 Environment	54
2.7 Occupational Health	54
2.7.1 Types Of Occupational Health Disease	54
2.7.2 Occupational Health Effects	55
2.8 Public Health	56
2.8.1 Sources Of Public Health Disease	56
2.8.2 Public Health Effects	57
2.9 Susceptible Groups	58
2.10 Indoor Air Quality (IAQ).....	59
2.10.1 Sick Building Syndrome (SBS)	61
2.10.2 Green Building Index (GBI)	61
2.11 Standards and Guidelines	62
2.11.1 Environmental Impact Assessment (EIA).....	64
2.11.2 National Ambient Air Quality Standards (NAAQS)	64
2.11.3 Department Of Occupational Safety And Health (DOSH)	65

2.11.4 Department Of Environment (DOE).....	66
2.11.5 Malaysia Meteorological Department (MMD).....	71
2.12 Summary.....	73
CHAPTER THREE: COAL-FUELED ENERGY & RESIDENTIAL AREA	74
3.1 Introduction.....	74
3.2 Energy for Electrical Supply	75
3.2.1 Renewable Sources	75
3.2.2 Non renewable sources	76
3.2.3 Decision on Energy Choosing.....	76
3.3 Coal and Electricity	78
3.4 Coal Combustion Cycle.....	79
3.5 Hazardous Emissions from Coal Combustion.....	80
3.6 Coal Power Plant	82
3.6.1 Manjung Coal Power Plant	82
3.6.2 Coal Combustion Process	87
3.7 Meteorological Factors & Coal Pollution in Manjung	88
3.7.1 Meteorological in Sitiawan	89
3.7.2 Emission of Pollutants	89
3.7.3 Sources and Effects of Coal Pollution	91
3.8 Summary.....	93
CHAPTER FOUR: RESEARCH METHODOLOGY.....	94
4.1 Introduction.....	94
4.2 Secondary Data Collection	94
4.2.1 Sources of Literature Review.....	94
4.2.2 Input from Literature Review.....	95
4.3 Primary Data Collection	96
4.4 Equipment Used in Airborne Particulate Sampling.....	96
4.4.1 7-hole Sampler	96
4.4.2 Cyclone Sampler	97
4.4.3 Filter paper	98
4.4.4 Mass Balance	98
4.4.5 Pump	99
4.4.6 Flow Calibrator	99
4.4.7 Dessicator	100
4.4.8 Analytical Equipment.....	101
4.5 Sampling Process.....	101
4.5.1 Weighing the Filter Paper before the Sampling Process Using Mass Balance	103
4.5.2 Calibrating Flow Rate For The Pump	104
4.5.3 Preparation of 7- hole Sampler	105
4.5.4 Preparation of Cyclone Sampler	106
4.5.5 Weighing the Filter Paper after the Sampling Process.....	108
4.6 Analysis Software and Microsoft Excel Software.....	109
4.7 Indoor and Outdoor Reading	109
4.7.1 Equipment Used For Relative Humidity & Temperature Reading	110
4.7.2 Sampling at Manjung District, Perak.....	111
4.8 Summary.....	115

CHAPTER FIVE: RESEARCH ANALYSIS AND FINDINGS	116
5.1 Introduction.....	116
5.2 Results of the Airborne Particulates Mass Concentration Analysis	116
5.2.1 5km Radius Sampling Point (Teluk Rubiah)	117
5.2.2 10km radius Sampling Point (Lumut).....	117
5.2.3 15km radius Sampling Point (Sitiawan)	118
5.2.4 20km radius Sampling Point (Ayer Tawar)	118
5.3 Analysis On Relationship Between Mass Concentrations At Four Sampling Points	119
5.3.1 Mass Concentration of Airborne Particulates at Four Sampling Points (mg/m ³).....	119
5.3.2 Ratio of Indoor and Outdoor Respirable Dust towards Total Inhalable Dust (%).....	120
5.3.3 Ratio of Mass Concentration towards Wind Velocity (ms ⁻¹), Relative Humidity (%) and Temperature (°C) at Four Sampling Points.....	124
5.3.4 Comparison of Mass Concentration at Four Sampling Points with Standards Emission PMs Guideline by EPD, DOE and DOSH....	126
5.4 Characterization Analysis Of Airborne Particulate (Pm ₁₀ & Pm _{2.5}) at 10km Radius Sampling Point.....	128
5.4.1 Lumut Sampling Point (10km radius) Physical Characterization Indoor and Outdoor Sampling under FESEM.....	128
5.4.2 Lumut Sampling Point (10km radius) Particle Number and Size Distribution.....	130
5.4.3 Calculating The Aerodynamic Diameter for Airborne Particulate Size Distribution at Lumut Sampling Point.....	131
5.4.5 Observation at Sampling Points	135
5.5 Discussion.....	136
5.6 Summary.....	143
 CHAPTER SIX: CONCLUSION AND RECOMMENDATION.....	 144
5.1 Introduction.....	144
5.2 General Conclusion	144
5.3 Research Limitation.....	147
5.4 Recommendation	148
5.5 Future Research Area	149
5.6 Summary.....	149
 REFERENCES.....	 150
 APPENDIX A:LIST OF PUBLICATIONS	 157
 APPENDIX B:SUPPLEMENTARY DATA.....	 158

LIST OF TABLES

<u>Table No.</u>		<u>Page No.</u>
1.1	Research Questions, Objectives, Methodologies and Output	9
2.1	Main air pollutants, sources and how they affect human health	24
2.2	Summary of different particle types and associated relations of particle density, material density, and shape factor	49
2.3	Health effects of air pollutants and populations at greatest risk	60
2.4	WHO, US Environmental Protection Agency (EPA), and European Union (EU) air quality guidelines and standards for ozone, nitrogen dioxide, and particulate matter	64
2.5	Guideline on 8-hour based weighted of average airborne concentration for indoor air contaminant	66
2.6	API scale used by DOE and air quality	67
2.7	Parameters measured in 4 categories of CAQM stations	68
2.8	List of CAQMS in Malaysia	71
2.9	PM ₁₀ Concentration measured by MMD stations in 2012	73
3.1	Toxicological and Environmental Properties of Hazardous Air Pollution (HAPs) Emitted from Electric Generating Station Fueled by Coal	82
3.2	Meteorological Factors in Sitiawan, 2004-2009	91
3.3	Sources and effects of air pollution on human and plants	94
4.1	Total number and age stratified in Manjung according to radius (km) from the coal power plant	115
5.1	Relationship between indoor and outdoor mass concentration of airborne particulate by sampling points	121
5.2	Airborne Particulate Mass Concentration according to distance radius from coal power point	122
5.3	Meteorological measurement at four sampling points	125
5.4	Size distribution using Bin 0.50 range for 7-hole and Cyclone Sampler	131

6.1	Reverse Research Questions, Objectives, Methodologies and Findings	146
-----	--	-----

LIST OF FIGURES

<u>Figure No.</u>		<u>Page No.</u>
1.1	Flow of Research	7
2.1	Atmospheric Layers	12
2.2	Greenhouse effects	14
2.3	Global temperature in 100-year run of a climate model.	15
2.4	Annual Greenhouse Gas Emissions by Sectors	16
2.5	Annual Average Global Surface Temperature Anomalies 1880-2008	18
2.6	Predicted globally averaged sea level rise 1900-2200	20
2.7	Carbon cycle	22
2.8	Examples of solid air pollutants	26
2.9	Effect of acid rain	27
2.10	A great "roller" moves across the plains during the 1930's.	30
2.11	Source and chemical links between ozone and PM formation.	33
2.12	Sulphur oxides emissions in the United States (1966) by the activities.	36
2.13	Smog and fog caused haze in Beijing	42
2.14	Particulate matter air pollution size distribution.	47
2.15	SEM photomicrographs of airborne particles	50
2.16	Acute SO ₂ damage	53
2.17	Respiratory system	58
2.18	Continuous Air Quality Monitoring Station	69
2.19	High Volume Sampler (HVS)	69
2.20	Location of Air Monitoring Stations in Peninsular Malaysia	70
2.21	Location of MMD Air Pollution Monitoring Station	72
3.1	Hubbert's graph	78

3.2	Total World Electricity Generation	79
3.3	Coal Combustion Cycle	80
3.4	Key Plan (Peninsular Malaysia)	84
3.5	Location Plan (Manjung District) and Site Plan (Manjung Coal Power Plant)	84
3.6	Manjung Coal Power Plant	85
3.7	Existing and Future Operation	85
3.8	Existing Generator Floor Plan	87
3.9	Carbon Cycle from mining, burning and wasting to Electricity Generation	88
3.10	Wind rose diagram for Peninsular Malaysia	89
3.11	Average annual concentration of PM ₁₀ by sub-urban area Malaysia, 2008	91
3.12	Emissions of Pollutants to Atmosphere from 3 Major Sources, Malaysia, 2008	92
4.1	7-hole Casella Sampler used in Inhalable dust sampling	97
4.2	Cyclone Casella Sampler used in Respirable dust Sampling	98
4.3	Filter paper in plastic cup	99
4.4	Mass balance	99
4.5	Casella Measurement Apex Sampling Pump	100
4.6	Casella Dry Flow Calibrator	101
4.7	Dessicator	101
4.8	The Olympus Metallurgical Microscope	102
4.9	Flow of 8-hour Sampling Process in Schematic Diagram	103
4.10	Flowchart of Sampling Process	
4.11	Mass balance at zero	104
4.12	A set of equipment for calibrating flow rate for the pump	105
4.13	Placing the filter paper inside the sampler using a tweezers	106
4.14	Ready equipped 7-hole sampler with connected to Casella pump	107

4.15	Placing the filter paper inside the sampler using a twizzer	107
4.16	Ready equipped cyclone sampler with connected to Casella pump	108
4.17	A set of equipment of 7-hole and cyclone sampler on a standing tripod to represent human respiration	108
4.18	The filter papers from both samplers placed in dessicator for one day	109
4.19	Sampling Point for Indoor & Outdoor Air Sampling	111
4.20	Testo 416 for meteorological analysis	112
4.21	Location of residential areas and wind direction in Manjung	113
5.1	Relationship between mass concentration of respirable dust towards inhalable dust (mg/m^3) for indoor in 8 hours	123
5.2	Relationship between mass concentration of respirable dust towards inhalable dust (mg/m^3) for outdoor in 8 hours	124
5.3	Ratio of mass concentration (mg/m^3) of particulates sampled with the relatives humidity and temperature at four sampling points in Manjung	126
5.4	Indoor airborne particulate on mass concentration in according to distance from coal power plant	127
5.5	Outdoor airborne particulate on mass concentration in according to distance from coal power plant	128
5.6	7-hole Sampler (indoor) at 10km sampling point	129
5.7	Cyclone Sampler (indoor) at 10km sampling point	130
5.8	Airborne particulate size distribution in aerodynamic diameter (AED) for 7-hole sampler	134
5.9	Airborne particulate size distribution in aerodynamic diameter (AED) for cyclone sampler	134
5.10	Comparison of airborne particulate size distribution in AED for 7-hole sampler with BMRC graph convention	135
5.11	Comparison of airborne particulate size distribution in AED for cyclone sampler with BMRC graph convention	136
5.12	Effect of airborne particulate on leaves at 5km radius sampling point	139
5.13	Effect of airborne particulate on building material at 10km radius sampling point	140

5.14	Air Pollutant Index (Top ten affected areas) on 25 th June 2013	141
5.15	Airborne Particulate Sampling Flow Model	142

LIST OF ABBREVIATIONS

AED	Aerodynamic Diameter
AELA	Australian Earth Laws Alliance
API	Air Pollution Index
CAQMS	Continuous Air Quality Monitoring Station
CEMs	Climate Envelope Models
COPD	Chronic Obstructive Pulmonary Disease
CWP	Coal Workers' Pneumoconiosis
DOE	Department of Environment
DOSH	Department of Occupational Safety and Health
DOSM	Department of Statistics Malaysia
E&EPRE	Energy and Endurance Pre-Workout
ECD	Equivalent Circular Diameter
EE	Energy Efficiency
EH&E	Environmental Health and Engineering
EPA	Environmental Protection Agency
EPD	Environmental Protection Department
EQ	Indoor Environmental Quality
EDX	Energy-Dispersive X-ray
FESEM	Field Emission Scanning Electron Microscopy
GBI	Green Building Index
HVAC	Heating, Ventilation and Air Conditioning
HVS	High Volume Sampler
IAQ	Indoor Air Quality
IEA	International Energy Agency

IIUM	International Islamic University Malaysia
IN	Innovation
MMD	Malaysia Meteorological Department
MOSTI	Ministry of Science, Technology and Innovation
MR	Material and Resources
NAAQS	National Ambient Air Quality Standards
NAP	National Academies Press
NCAR	National Center for Atmospheric Research
PCC	Pulverised Coal Combustion
PMF	Progressive Massive Fibrosis
PSI	Pollutant Standard Index
SBS	Sick Building Syndrome
SEM	Scanning Electron Microscope
SM	Sustainable Site Planning & Management
TEM	Transmission Electron Microscope
USDA	United States Department of Agriculture
USDHEW	United States Department of Health, Education and Welfare
WE	Water Efficiency
WHO	World Health Organisation
YPTE	Young People's Trust for the Environment

LIST OF SYMBOLS

Al	Aluminium
Ba	Barium
C	Carbon
CFC	Chlorofluorocarbon
CH ₄	Methane
CO	Carbon Monoxide
Cr	Chromium
Cu	Cuprum
Fe	Iron
FP	Fine Particulate
GHGs	Greenhouse Gases
µ	Micro
HC	Hydro Carbon
m ³	Cubic Meter
mg	Milligram
Mg	Magnesium
Mn	Mangan
MW	Megawatt
NO ₂	Nitrogen Dioxide
O	Oxide
Ø	Diameter
O ₃	Ozone
Pb	Lead
PM _{2.5}	Particulate Matter

POA	Primary Organic Aerosol
S	Sulphur
Sb	Antimony
Si	Silicon
SO ₂	Sulphur Dioxide
TSP	Total Suspended Particulate
UFP	Ultra Fine Particulate
VOCs	Volatile Organic Compounds
Zn	Zinc

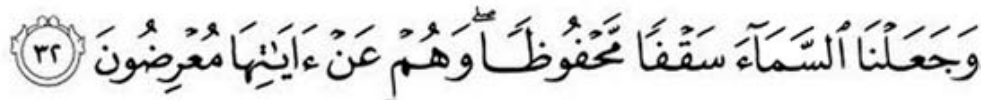
Chapter One

INTRODUCTION

Airborne particulates usually act as toxicants, and are more complex than pollutant gases and vapours because of the additional variables of particle size and mixed chemical composition. The size and chemical composition of these particles affect the impacts on human health. The effects will become worse when it comes to human health in public buildings. Nowadays, public building is not healthy anymore. In certain places, coal power plant is still used to generate energy, thus resulting in air pollution which lead to environmental concern. International Energy Agency (IEA) is concerned about the environmental impact of burning fossil fuels, and coal in particular that contributes to acid rain, air pollution, haze and leads to global warming. The case studies conducted on several site locations which are the residential area at 5,10,15 and 20 km radius from the Manjung coal-fired power plants. The results of this research will include the comparison of mass concentration, both indoors and outdoors of the building, the relationship of air quality indoor and outdoor, the effects of airborne particulates towards public health and the physical characterization of airborne particulates that may come from different sources in which the sample of inhalable dust and respirable dust will be collected so that it may cover also the effects towards human health focusing on residents of Manjung, Perak. The relationship of airborne particulates with temperature and relative humidity will also be highlighted as the combination of those agents of decay will be as harming and damaging towards public health.

1.1 PROBLEM STATEMENT

In general, air pollution is the result of chemicals, particulate matter, and biological materials located in the air that provide harm and discomfort to human being and living things including animals and plantation. The atmosphere supports life, as it is made from gaseous system. Air pollution which leads to global warming phenomenon slowly damages the atmospheric layer, and this is called ozone depletion which will affect life and activities on the planet.



"And We made the sky a protected ceiling (canopy). but they are turning away from its signs." (Qur'an, 21:32)

Islamic scholars addressed the ceiling mentioned above is most probably the ozone layer where it protects living things, including human beings underneath. As a matter of fact, ozone depletion caused many side effects such as increased Ultra-violet light from the Sun, which may cause skin cancer; and other biological effects where it attacks human and non-human health. The chlorofluorocarbon (CFC) is an organic compound that contains carbon, chlorine, and fluorine, produced as a volatile derivative of methane and ethane, which is often used as refrigerants, propellants (in aerosol applications), and solvents which also contributes to ozone depletion.

The main sources of air pollution in Malaysia are motor vehicles, power stations, industrial fuel burning and processes, domestic fuel burning, burning of municipal and industrial waste. The main pollutants include Carbon Monoxide (CO), Nitrogen Dioxide (NO₂), Ozone (O₃), Particulates (minutes particulates suspended in the air), and Sulphur Dioxide (SO₂). In fact, coal-fired power plant occupies about