

**INDOOR AIR QUALITY (IAQ): AN ASSESSMENT
OF COARSE AND FINE PARTICLES AT
SELECTED TASKA IN KOTA BHARU,
KELANTAN**

by

NUR FARZUANA BINTI ABDUL RAHIM

**Dissertation submitted in partial fulfilment of
the requirements for the degree of Bachelor of
Health Sciences (Honours) (Environmental and
Occupational Health)**

JUNE 2015

ACKNOWLEDGEMENT

In the name of ALLAH, the Most Gracious and the Most Merciful.

Alhamdulillah all praised for the strength and His blessing all the way completing this thesis. First of all, I wishes to express thanks and gratitude to my supervisor, Dr. Nurulilyana Binti Sansuddin, for her supervision and support. Her comment, ideas and help has contributed to completing this thesis.

Besides, I would like to thank to all the owner of Taska Mrs. Marina Izura Binti Ismail, Mrs. Zubaidah Binti Abd Razak, Mrs. Wan Zaimah Binti Wan Ab Rahman, Mrs. Nik Rahimah Binti Nik Mustapha, Mrs. Juriah Binti Rehman Khan and Mrs. Fauziah Binti Zakaria for allowing me to conduct this study. In addition, I would like to thanks all the teacher involved in this study for their cooperation throughout the data collection. Without their participation, I would never be able to complete this study.

Special thanks to all my friends especially to Nur Farhana Binti Abdul Halim, Nurhida Sazlina Binti Saaban for their willingness to help during the phase of data analysis. My most thanks also goes to Nur Fisya Binti Hamzah and Nur Shazlina Binti Muhammad and others for their kindness and moral support either directly or indirectly in helping me to complete this study.

Last but not least, my deepest gratitude goes to my beloved parents; Mr. Abdul Rahim Bin Saat and Mrs. Fatimah Binti Che Ya and siblings for their endless love, prayers, financial support and encouragement. Thank you very much.

Nur Farzuana Binti Abdul Rahim, June 2015.

TABLE OF CONTENTS

	Page
APPROVAL PAGE	ii
DECLARATION PAGE	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS AND ABBREVIATIONS	xi
ABSTRAK	xii
ABSTRACT	xiii
CHAPTER 1 – INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	2
1.3 Objective of Study	4
1.3.1 General Objective	4
1.3.2 Specific Objectives	5
1.4 Null Hypothesis (H_0)	5
1.5 Significance of Study	6
CHAPTER 2 – LITERATURE REVIEW	
2.1 Air Pollution	7
2.2 Indoor Air Quality (IAQ)	8

2.3 Indoor Air Pollution at Daycare Center	10
2.4 Particulate Matter (PM)	11
2.5 Effect of Air Pollution	12
2.6 Temperature and Relative Humidity	13
2.7 Available IAQ Standard and Guidelines	14
2.8 Statistical Analysis	15
CHAPTER 3 –METHODOLOGY	
3.1 Flow of Study	16
3.2 Study Location	17
3.3 Sampling Method	18
3.3.1 Study Instrument	18
(a) Handled 3016 IAQ Particle Counter Gen E	19
3.4 Data Collection	19
3.4.1 Step 1: Measuring floor area	20
3.4.2 Step 2: Set up the instrument	22
3.4.3 Step 3: Walkthrough survey	22
3.5 Data Analysis	23
3.5.1 Microsoft Office Excel Version 10	23
3.5.2 Statistical Package for Social Sciences (SPSS)	23
(i) Descriptive statistics	24
(ii) Inferential statistics	25

CHAPTER 4 – RESULTS

4.1 Pilot test	27
4.2 The Walkthrough Survey	28
4.2 The Trend of PM Concentration	29
4.3 The Differences of PM Concentration between All Taska	34
4.4 Differences of PM Concentration between Roadside Area Residential Area	35
4.5 Temperature and Relative Humidity	36
4.6 The Correlation between PM _{2.5} and PM ₁₀ with Temperature and Relative Humidity	36

CHAPTER 5 – DISCUSSION

5.1 The Trend of Particulate Matter Concentrations (PM _{2.5} and PM ₁₀)	38
5.2 The Differences between PM _{2.5} and PM ₁₀ Concentration at All Taska	42
5.3 The Differences between PM _{2.5} and PM ₁₀ Concentration with Roadside Area and Residential Area	43
5.4 Temperature and Relative Humidity	44
5.5 The Correlation between PM _{2.5} and PM ₁₀ with Temperature and Relative Humidity	44

CHAPTER 6 – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion	46
6.2 Recommendations	46

REFERENCES	48
-------------------	----

APPENDICES	54
-------------------	----

Appendix 1	The Listed Register Taska in Kota Bharu, Kelantan	54
Appendix 2A	Consent Letter for Taska Mata Hati	55

Appendix 2B	Consent Letter for Taska Nur Usrah	56
Appendix 2C	Consent Letter for Taska Pintar Progresif	57
Appendix 2D	Consent Letter for Taska Ilham Murni	58
Appendix 2E	Consent Letter for Taska MMChilcare	59
Appendix 2F	Consent Letter for Taska Adiikku Bijak	60
Appendix 3	Checklist for Walkthrough Survey in Each Taska	61

LIST OF TABLES

Table		Page
1.1	The distribution of population by states in 1980, 1991, 2000 and 2010	3
2.1	The classification of air pollutants	7
2.2	The potential indoor air pollutant	9
2.3	Acceptable range of temperature and relative humidity	14
2.4	Standards for air pollutant	14
3.1	Statistic of residents in Kelantan from 2012-2014	17
3.2	The description of study location	18
3.3	Minimum number of sampling points for IAQ parameters	21
4.1	The characteristic of all Taska	28
4.2	PM _{2.5} concentration between all Taska	34
4.3	PM ₁₀ concentration between all Taska	35
4.4	The differences of PM concentration between roadside area and residential area	35
4.5	The mean readings of temperature (°C) and relative humidity (%)	36
4.6	The correlation between PM _{2.5} and PM ₁₀ concentration with temperature and relative humidity	37

LIST OF FIGURES

Figures		Page
3.1	Flow chart of study	16
3.2	Handled 3016 IAQ Particle Counter Gen	19
3.3	The steps of data collection	20
3.4	The measurement of floor area	21
3.5	The position of Handled 3016 IAQ Particle Counter	22
4.1	Concentration of PM _{2.5} and PM ₁₀	27
4.2	The concentration of PM _{2.5} at Taska located near to roadside area	30
4.3	The concentration of PM _{2.5} at Taska located in the residential area	31
4.4	The concentration of PM ₁₀ at Taska located near to roadside area	32
4.5	The concentration of PM ₁₀ at Taska located in the residential area	33
5.1	The location of Taska B	39
5.2	The outdoor activity by children	40
5.3	The used of comforter	41
5.4	The children playing at carpet area	41

LIST OF SYMBOLS AND ABBREVIATION

ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
API	Air Pollution Index
CFM	Cubic Feet per Minute
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
DOSH	Department of Safety and Health
DSW	Department of Social Welfare
EPA	Environmental Protection Agency
et al.	Et alia (and others)
e.g	Exempli gratia
HVAC	Heating, Ventilation, Air-conditioning
IAP	Indoor Air Pollutant
IAQ	Indoor Air Quality
ICOP	Industrial Code of Practice
NAAQS	National Ambient Air Quality Standard
NEP	New Economic Policy
NDP	National Development Policy
NHRMC	National Health and Research Medical Center
NVP	National Vision Policy
O ₃	Ozone
PEL	Permissible Exposure Limit
PM	Particulate Matter
PM ₁₀	Particulate Matter with aerodynamic size of 10 micrometer
PM _{2.5}	Particulate Matter with aerodynamic size of 10 micrometer
SBS	Sick Building Syndrome
SO ₂	Sulphur Dioxide
SPSS	Statistical Package for Social Sciences
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation
µg/m ³	microgram per meter cubic

KUALITI UDARA DALAMAN (IAQ): PENILAIAN ZARAH KASAR DAN HALUS DI TASKA TERPILIH DI KOTA BHARU, KELANTAN

ABSTRAK

Kajian ini dijalankan untuk menilai kualiti udara dalaman (IAQ) di Taska yang terpilih di Kota Bharu, Kelantan. Golongan kanak-kanak sensitif terhadap pencemaran udara dalaman. Tambahan lagi, hampir 90% masa mereka dihabiskan di dalam bangunan. Kajian ini bertujuan untuk mengenal pasti pola kepekatan zarah terampai (PM) serta membandingkannya dengan garis panduan sedia ada, untuk mencari perbezaan kepekatan $PM_{2.5}$ dan PM_{10} antara Taska yang dipilih, untuk membandingkan kepekatan $PM_{2.5}$ dan PM_{10} antara Taska yang terletak di kawasan tepi jalan dan kawasan perumahan dan untuk mencari hubungan antara kepekatan $PM_{2.5}$ dan PM_{10} dengan suhu dan kelembapan dalam Taska. Kepekatan PM telah diukur di 6 Taska terpilih di Kota Bharu menggunakan Handled 3016 Particle Counter. Data dicerap di setiap Taska semasa hari bekerja sebanyak 5 sesi (Ahad hingga Khamis) dan berterusan selama 8 jam bagi setiap sesi. Senarai semak IAQ juga digunakan untuk pemerhatian ketika kajian dilakukan dan mengukuhkan keputusan yang diperolehi daripada kajian ini. Kepekatan $PM_{2.5}$ ($89.71 \mu\text{g}/\text{m}^3$) tertinggi dicatatkan di Taska B pada hari Khamis, manakala kepekatan untuk PM_{10} tertinggi ($537.81 \mu\text{g}/\text{m}^3$) dicatatkan di Taska A pada hari Rabu. Secara keseluruhan, bacaan kepekatan $PM_{2.5}$ dan PM_{10} adalah melebihi had yang dicadangkan oleh Piawaian Kualiti Udara Persekitaran Kebangsaan. Pola bacaan kepekatan PM didapati sama bagi kedua-dua saiz PM untuk enam Taska terpilih di Kota Bharu. Selain itu, terdapat perbezaan antara kepekatan PM untuk kedua-dua saiz dan semua Taska dengan nilai $p=0.000$ menggunakan ujian Kruskal Wallis. Suhu dan kelembapan relatif mencatatkan bacaan yang melebihi julat optimum yang dicadangkan oleh Jabatan Keselamatan dan Kesihatan Pekerjaan. Dengan menjalankan ujian Kolerasi Spearman, terdapat perbezaan yang signifikan antara suhu dengan $PM_{2.5}$ ($p=0.000$) dan antara suhu dan kelembapan relatif dengan PM_{10} ($p=0.000$; $p=0.001$). Tahap PM yang tinggi direkodkan dipengaruhi oleh aktiviti, pergerakan dan bilangan penghuni, serta keadaan sekitar semasa pengumpulan data. Kesimpulannya, penambahbaikan daripada pihak yang bertanggungjawab harus diambil untuk mengekalkan dan megawal keadaan IAQ.

INDOOR AIR QUALITY (IAQ): AN ASSESSMENT OF COARSE AND FINE PARTICLES AT SELECTED TASKA IN KOTA BHARU, KELANTAN

ABSTRACT

This study was conducted to assess indoor air quality (IAQ) at selected Taska in Kota Bharu, Kelantan. Children are sensitive to indoor environmental pollution. Moreover, up to 90% of their time spend indoors. The study aimed to identify the trend of concentration of suspended particles (PM) and to compare it with the guidelines, to find the differences of PM_{2.5} and PM₁₀ concentration between selected Taska, to compare PM_{2.5} and PM₁₀ concentration between Taska located at roadside area and residential area and to find the relationship of PM_{2.5} and PM₁₀ concentration with the temperature and relative humidity within Taska. The concentrations of PM were measured at 6 selected Taska in Kota Bharu by using Handled 3016 Particle Counter. The data were collected during weekdays in 5 sessions (Sunday to Thursday) at each Taska for 8 hours continuously. An IAQ checklist was used to strengthen the results obtained from this study. The highest concentration of PM_{2.5} (89.71 ug/m³) was recorded at Taska B on Thursday, while the highest concentration for PM₁₀ (537.81 ug/m³) recorded in Taska A on Wednesday. Overall, the reading of PM_{2.5} and PM₁₀ concentrations were exceeded the limits recommended by the National Ambient Air Quality Standard. The trend of PM concentration was found similar for both sizes of PM at six selected Taska in Kota Bharu. Besides, there were differences between PM concentrations for both sizes and all Taska with $p=0.000$ through Kruskal Wallis analysis. The temperature and relative humidity recorded higher reading compared to the optimum range suggested by Department of Occupational, Safety and Health (DOSH). By using Spearman Correlation test, there were significant difference between temperature and PM_{2.5} ($p=0.000$), between PM₁₀ with both temperature and relative humidity ($p= 0.000$; $p=0.001$). The high levels of PM recorded were influenced by activity, movement and number of occupants, and surrounding conditions during data collection. As a conclusion, the improvement by responsible parties must be taken in order to maintain and control the IAQ conditions.

CHAPTER 1

INTRODUCTION

1.1 Background

Indoor air quality (IAQ) in building is important to be concerned in order to provide healthy and comfortable environment. From the epidemiological and toxicological studies that were done by previous researcher, the problem of fine particle increased yearly (Lee *et al.*, 2006). According to Clement-Croome *et al.* (2006) and Siskosis *et al.* (2001) they were proved that there are relation between effect on human health, performance and productivity with indoor air quality.

Recently, the average peoples spend their major time indoors. Likewise, children spend their time more in school or daycare centre instead of home. The indoor air pollutants in indoor air are at higher concentrations compared to outdoor air. They also stated that in good IAQ, occupants can gained healthy life, good productivity and performance (Kamaruzzaman and Sabrani, 2011).

The buildings systems, environments, locations, attitudes of human and the equipment in the buildings are considered as a sources that can contributes to poor IAQ. For example, the sources of the particulate matter (PM) that attribute by indoor human activities are include smoking, cooking, cleaning activities and outdoor contribution such as from motor vehicle and street dust. The present of the sources of indoor pollutant can cause the level of indoor PM concentration to be higher (Barraza *et al.*, 2014).

Previous study at nursery schools by Muhamad Darus *et al.*, (2011), stated that the source of IAQ was dust that get into the indoor environment through a variety of means. These include infiltration from outside and indoor sources such as smoke, building materials and furniture, consumer product and activity of occupant. Child spend up to 90% of their time in school or in educational institutions (nursery, pre-school) rather than indoor environment as well as at home. They were vulnerable group to environmental interference because their immature body system as at early stage of development, making them more susceptible to functional damage or disorders (Cartieaux *et al.*, 2011).

1.2 Problem Statement

Air pollution is harmful to the habitat, including humans. Pollution means any natural or artificial substance, whether in solid, liquid or gas that change directly or indirectly related to the physical, thermal, and biological properties or any part of the environment that cause harm to wildlife (Environmental Quality Act (EQA), 1974). Environmental problem is one of the issue that under government concerns. In order to achieve Vision 2020, the principles in the policy often kept updated in response to the global environment, and development aspirations. This is to ensure that strategies are achieved. Policies of this government are to create an equitable society, to maintain high economic growth, improving competitiveness, economic development, strengthening human capital and protect the environment (Government Transformation Plan, 2014).

There are varieties of sources, chemical composition and size that can caused the air pollution. The sources of indoor pollutant were from cooking, building materials such as furniture, the heating, ventilation and air conditioning (HVAC) system and occupant's habit. IAQ has been concern more due to fact that everyone were spent most of their time indoors (Alexis *et al.*, 2004).

In this study, six Taska were chosen in Kota Bharu as sampling location. Kota Bharu is one of developing district in Kelantan. There are many infrastructures' projects and constructions have been developed in Kota Bharu. The distribution of population in Kelantan also were increase from 1980 to 2010 which are from 13,136,109 to 27, 565, 821 as in Table 1.1.

Table 1.1: The distribution of population by states in 1980, 1991, 2000 and 2010

States	Year			
	1980	1991	2000	2010
Johor	1580423	2069740	2584997	3233434
Kedah	1077815	1302241	1571077	1890098
Kelantan	859270	1181315	1287367	1459994
Melaka	446769	506321	605239	788706
Negeri Sembilan	551442	692897	829774	997071
Pahang	768801	1045003	1229104	1443365
Perak	1743655	1877471	1973368	2258428
Perlis	144782	183824	198288	227025
Pulau Pinang	900772	1064166	1231209	1520143
Sabah	929299	1734685	2468246	3120040
Sarawak	1235553	1642771	2009893	2420009
Selangor	1426250	2291429	3941316	5411324
Terengganu	525255	766244	880234	1015776
Wilayah Persekutua Kuala Lumpur	919610	1145342	1305792	1627172
Wilayah Persekutuan Labuan	26413	54241	70871	85272
Wilayah Persekutuan Putrajaya	*(b)	5730	11501	67964

*(b) Data for the Federal Territory of Putrajaya was included as part of Selangor.
(Source: Population and Housing Census of Malaysia, 2010)

As known, children spent their time more than seven hours in the school building (Elbayoumi *et al.*, 2014). The increasing of asthmatic problem among the children is worldwide. The poor environment condition are the main factor to this problem. Its include air pollution, house dust mite, exposure to passive cigarette and immunisation.

Asthma always attack all age groups but, popular among children. It is a disease that involves difficulty in breathing and the symptoms is different for every person. This condition is caused by inflammation of the airways in the lungs and affects the sensitivity of nerve endings in the airways, so they become easily tired. During an asthma attack, the lining of the air passages swell causing narrowing and reducing the flow of air into and out of the lungs (World Health Organisation (WHO), 2015a). Study conducted by Pekkanen *et al.* (1997) stated that children who suffer from asthma are very overwhelmed with particulate pollution and easily get affected (Noorhassim *et al.*, 1995). Previous study found that there was a relationship between individual livings in roadways area with increasing asthma hospitalisation and increasing affected of respiratory system (Alexis *et al.*, 2004). This study were conducted in two area which roadside area and residential area.

1.3 Objective of Study

1.3.1 General Objective:

To study the pattern of PM_{2.5} and PM₁₀ concentrations at selected Taska in Kota Bharu.

1.3.2 Specific Objectives:

1. To determine $PM_{2.5}$ and PM_{10} concentration trends within the selected Taska and compare with guidelines.
2. To find the differences of $PM_{2.5}$ and PM_{10} concentrations between selected Taska.
3. To compare $PM_{2.5}$ and PM_{10} concentrations between Taska located at roadside and residential area.
4. To find the relationship between $PM_{2.5}$ and PM_{10} concentrations with temperature and relative humidity.

1.4. Null Hypothesis (H_0):

- i. There is no significant difference of concentrations of particulate matters ($PM_{2.5}$ and PM_{10}) between selected Taska.
- ii. There is no significant difference of $PM_{2.5}$ and PM_{10} concentrations between Taska located at roadside area and residential area.
- iii. There is no significant relationship between $PM_{2.5}$ and PM_{10} concentrations with temperature and relative humidity.

1.5 Significance of Study

In this study, the findings will reveal the PM concentrations in six selected Taska. Since the Taska selected in this study were divided into locations, the difference of PM level between the Taska located at roadside area and residential area can be determined as the sources of pollutants are different. So that, the potential factors or sources of PM for each group of Taska can be identified. Besides, physical factors that might influence the PM concentrations including temperature and relative humidity can be investigated. Hence, the prevention action can be implemented to reduce the concentration of PM. For an instance, the owner of Taska can install ventilation and air-conditioning system and plan for its maintenance schedule.

CHAPTER 2

LITERATURE REVIEW

2.1 Air Pollution

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that disturb the natural characteristics of the atmosphere. There are many sources of the air pollution which are combustion, motor vehicles, industrial facilities and forest fires (WHO, 2015b). According to Alexis *et al.* (2004), there are variety of sources that will cause air pollution, where the burning of fossil fuels is one of the primary sources. Air pollutants can be classified accordingly to the source, chemical composition, size and mode that can be released into indoor and outdoor environment. Table 2.1 show the classification of air pollutants.

Table 2.1: The classification of air pollutants

Primary and Secondary Pollutant	Indoor and Outdoor Pollutant	Particulate Pollutant
<p>Primary Pollutant: Pollutant that directly emitted into the atmosphere (e.g. Sulphur dioxide (SO₂), Carbon monoxide (CO) and PM</p> <p>Secondary Pollutant: Pollutant that formed in the air as a results of chemical reaction with other gases (e.g. Ozone, (O₃))</p>	<p>Indoor Pollutant:</p> <p>Sources: Cooking, combustion, buildings material, HVAC, smoking</p> <p>Products: CO, CO₂, microbial</p> <p>Secondary Pollutant:</p> <p>Sources: Industrial, commercial, mobile, agriculture, natural.</p> <p>Products: O₃, CO, PM, SO₂</p>	<p>Particulate Matter (PM) Coarse PM (2.5≤10µm), Fine PM (0.1≤2.5µm)</p>

(Source: Alexis *et al.*, 2004)

2.2 Indoor Air Quality (IAQ)

Indoor air is an air inside the building, including air within the rooms and air removed from room by mechanical ventilation (DOSH, 2010). IAQ is very complex and occupants potentially exposed to various contaminants. Moreover, the contaminants in the form of gas and particles such as from office machines, cleaning products, construction activity, carpets and furniture, perfumes, microbes (fungi and bacteria), and outside pollutants. Instead of that, temperature, relative humidity, and ventilation levels are the other factors of IAQ that affect the way individuals respond to an indoor air (Centers for Disease Control and Prevention (CDC), 2013).

Many possible causes related to health problems arise in indoor environment. There are many sources of air pollution such as materials and furnishings in buildings, asbestos-containing insulation, wet or damp carpet, and cabinetry or furniture made of certain pressed wood products, products for household cleaning and maintenance, personal care and human activity (United State of Environmental Protection Agency (USEPA), 2013). In addition, modern buildings structures focused on occupant's comfort. Installation of mechanical ventilation system such as HVAC system led to generate the sources of indoor air contamination (Chang and Gershwin, 2004).

Indoor air pollutants may exist in gaseous formed and particulate matter. Carbon dioxide (CO₂), sulphur dioxide (SO₂), nitric dioxide (NO₂), formaldehyde, and ozone are example of the gaseous formed created air pollution. The various type of potential indoor air pollutants were showed in Table 2.2. Thus, in this study, the potential indoor air pollutants were from infectious agent, allergic agents such pollen, mold, dust mite, toxins and particulates such asbestos and there was no

environmental tobacco smoke for all Taska. Previous studies by Munir *et al.*, (1995) the study was conducted in seven day-care centres in order to determine the levels of major mite (*Der p 1 / Der f 1*), cat (*Fel d 1*) and dog (*Can f 1*) allergen levels. The median of dust weight collected from table/chair surfaces was 54 mg and curtains, 71 mg. They were low compared to dust collected from floors, 282 mg; mattresses/cushion like toys, 572 mg; and sofas/cushion-like toys, 802 mg. Besides, the allergens are probably carried to the day-care centres in the clothes of children and staff.

Table 2.2: The potential indoor air pollutants

Allergic agents	Infectious agent	Toxins	Particulates
Pollen, Mold Nonmold indoor allergens: Dust mite, Dog, Cat, Rodents, Cockroach	Viral, Bacterial, Fungal	Gases: SO ₂ , NO ₂ , Formaldehyde, Radon, VOC	Asbestos, Environmental tobacco smoke

(Source: Chang and Gershwin, 2004)

The particle size affects the level of penetration into the respiratory tract. There are five ways that indoor air pollutants can affect the health of the individual. These include toxic effects, irritant effects, infectious diseases, allergic diseases, and psychological effect (Chang and Gershwin, 2004). In addition, the sources of indoor air pollution also were released from cleaning solutions, new carpets, electronics hardware, paints and glues, building materials, printed materials and heating equipment.

In Malaysia, the previous study in same field conducted by Zamani *et al.* (2013), stated that the Sick Building Syndrome (SBS) and IAQ were related. Their study was conducted in order to determine IAQ and its association with SBS among the office workers in two different buildings in Selangor. They found that SBS was influenced by the ventilation system, with the prevalence of SBS being higher in buildings with mechanical ventilation systems compared to normal ventilation system. There were also found the related risk factors to this problems such as the number of occupant, type of job performed, workplace area and conditions, building design and age.

2.3 Indoor Air Pollution at daycare center

Taman Asuhan Kanak-Kanak (Taska) also known as childcare center, daycare center and kindergarden. Under Section 2, Act 308 TASKA means any premises which receives four or more children under the age of four year old to be treated (Department of Social Welfare (DSW), 2015). These children were cared for in organised childcare centers and in residences. On average, they spent up to 37 hours per week in childcare (Arbes *et al.*, 2005). According to Salo *et al.* (2009), in daycare center there were many of potential allergen such as covered furniture, pillows, and toys. The indoor allergens (e.g dust mite allergens) were significantly higher in carpeted area. The level of airborne dust mite allergen is significantly higher during the day because daily activities in day care center. The highest level recorded in the daycare center with the high level of mite allergens in carpets (21.8 mg/g). Carpeting and furnishings are the sources of exposure in schools and daycare centers, particularly in humid regions.

Besides, the carpet, curtains, and soft toys can become the sources of PM_{2.5} levels, (Zuraimi and Tham, 2008). They also found that there was generally higher PM concentration using of naturally ventilated compared to air-conditioning system. In addition, there also has inadequate ventilation problem at daycare center. The researcher found that the owner was aware about the problem, but many have not to discourse the issues as it not their responsibility (Feng *et al.*, 2002).

2.4 Particulate Matter (PM)

PM is one of the major atmospheric pollutions (Tian *et al.*, 2014). PM are known as particulate pollution is a mixture of solid and liquid droplets suspended in air (DOSH, 2010). Some particles were emitted directly to atmosphere and some formed in the atmosphere after react with other pollutants.

PM concentrations in indoor environment are higher than outdoor environment may due to indoor contaminants includes from the products used such as furnishing, cleaning product and may due to indoor habits such as smoking. The maintenance of the HVAC systems also the important aspect that should be highlighted. Based on the previous study, there is evident that low ventilation rates can cause respiratory problem due to the viruses (Daisey *et al.*, 2002). A study in Korea was conducted at ten childcare centres that were located at residential areas, commercial areas which is near to the roadways, and the centers that near to the construction site. They found that the concentration of particulate in the roadside areas is higher than residential area (Oh *et al.*, 2014).

PM can come in anthropogenic and natural sources. It contains biological material, hydrocarbon, acid aerosol and others. Traffic intensity is a major determinant of anthropogenic PM concentrations. From previous studies, they had estimated the contributions of PM_{2.5} and PM₁₀ are 13% and 32% respectively and other study estimated that up to 50% of PM_{2.5} mass concentrations are originating from traffic emissions and re-suspension of road dust (De Kok *et al.*, 2006).

PM₁₀ is one of inhalable particles. The sources of PM₁₀ include natural dust, industrial emissions and traffic gasses (Tian *et al.*, 2014). According to Oh *et al.* (2014), they found that, PM₁₀ was composed by particles from road dust, while PM_{2.5} are from the combustion processes. Natural ventilation also influenced the PM concentration because particles coming from the outdoor environment.

2.5 Effect of Air Pollution

There are possible short term and long term health effects when humans are exposed to air pollution. PM can accumulate in the long term exposed. It might affect human health such as respiratory distress and other effects especially for children (Halek *et al.*, 2009). Particulate pollution has a relationship with respiratory mortality and morbidity. Besides, a study by Alexis *et al.* (2004) showed that asthma hospitalisations increased, with the decreasing association of lung function in residents near busy roadways.

Halek *et al.* (2009) found that PM pollution has been linked to respiratory disorders that even can caused mortality. $PM_{2.5}$ and PM_{10} are particles which are penetrate to the thoracic regions of the respiratory system. The problem of fine particles are well concern because there was significance association between the mortality and fine particle (Lee *et al.*, 2006).

2.6 Temperature and Relative Humidity

Almost all buildings in Malaysia were used air – conditioning in order to maintain the temperature. Ventilation is a system that supplying air outside to the inside in order to control air contaminant level, temperature and humidity within the space (DOSH, 2010). An adequate ventilation system is important in order to reduce the health effect and increase the performance of occupant in indoors environment. It is because inadequate ventilation system are lead to health problem and indirectly affected the performance (Daisey *et al.*, 2002). Bayer *et al.*, (2002), found that higher temperature and relative humidity was resulted in poor IAQ. Berglund and Cain (1989) concluded that for a subjective evaluation of IAQ, the concentration of pollutants in the air may in some instances prove to the influences of temperature and humidity. The increasing level of humidity might result in microbial growth and discomfort. Therefore, the temperature and relative humidity should be kept as in range suggested or low as possible in order to give less effect to IAQ.

The personal comfortability was depends on many factors includes the personal activity. The increase of temperature and relative humidity level are one the factors in growth of bacterial, mold and dust mite. The temperature and relative humidity should be maintained as suggested by DOSH to maintain the IAQ as well. Table 2.3 shows the acceptable range of temperature and relative humidity.

Table 2.3 Acceptable range of temperature and relative humidity

Parameter	Acceptable Range
Temperature	23 – 26 ⁰ C
Relative Humidity	40 – 70%

(Source: DOSH, 2010)

2.7 Available IAQ Standard and Guidelines

There are few information is available regarding to the standard for known indoor air pollutants. Therefore some experts recommended indoor air pollutant is at 50% or less than National Ambient Air Quality Standard (NAAQS) for outdoors pollutants establishes by USEPA (refer Table 2.4). Thus based on the standard given, the outdoor limit for PM_{2.5} should be 35 µg/m³ for 24 hour, while the standard for indoor air it should be 50% of the value outdoor limit which is 17.5 µg/m³. Same goes to PM₁₀, the outdoor air limit is 150 µg/m³ for 24 hour and the standard is 75 µg/m³, which is also 50% of the outdoor air limit.

Table 2.4 Standards for air pollutant

Pollutants	Period		
	24 hour (outdoor)	8 hour (indoor)	Annual
PM _{2.5} (µg/m ³)	35	17.5	15
PM ₁₀ (µg/m ³)	150	75	50

(Sources: USEPA, 2013)

2.8 Statistical Analysis

After the data was collected, the hypotheses must be tested to determine the significance of the study. Inferential statistic was used to determine the probability of characteristic and help to access the strength of the relationship between the variables (Albrechth, 2015). This was done by using a simple software which is Statistical Package for Social Science (SPSS).

Statistical tests are used to analyse the data. The results of the test to be generalisable to the population from which that sample was drawn. For instance, the test that will be used such as Mann Whitney U test, regression and Kruskal Wallis test (Bruin, 2006).

Jalaludin *et al.*, (2014), it was done to investigate the association between high level of indoor air pollutants in the buildings that influenced the prevalence of respiratory health symptoms. The Mann Whitney test was performed to compare the level of IAQ and indoor air pollutant concentration level at building A (new building) and building B (old buildings) in two difference office. They found that the level of ultrafine particles (UFP) was significantly higher in old building compared to new buildings which may contribute to health effects to human.

In this study, Kruskal Wallis and Mann Whitney test were used to analyse data of PM_{2.5} and PM₁₀. This test was used for non-parametric test with more than two independent samples. The non-parametric test were used when statistical methods that require very limited assumptions to be made about the data (Whitley and Ball, 2002).

CHAPTER 3

METHODOLOGY

3.1 Flow of Study

Figure 3.1 shows the flow of methodology in this study. Firstly, the title for this study were identified, followed by the determination of study location and study methods. After that, all the data were collected and analysed by using statistical method. Data analysis were done in Microsoft Excel and Statistical Package for Social Sciences (SPSS).

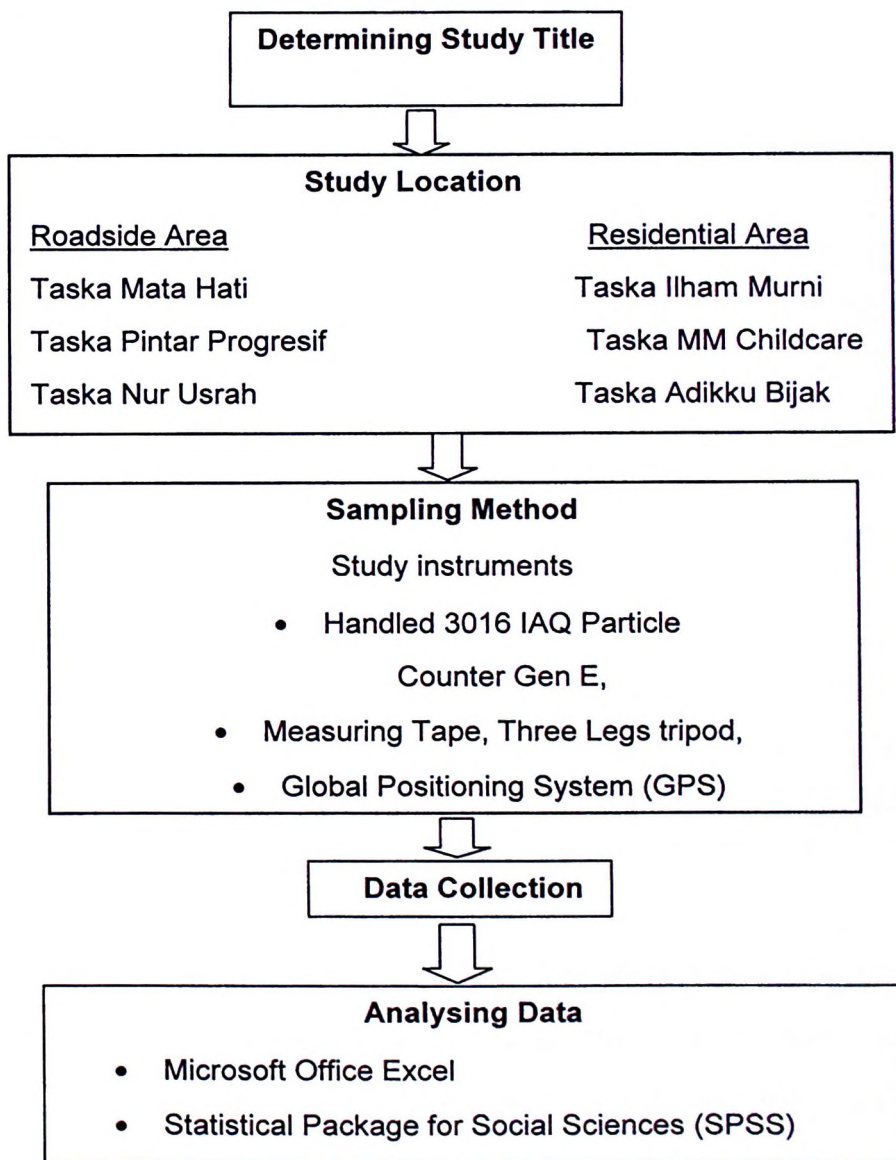


Figure 3.1 Flow chart of study

3.2 Study Location

This study was conducted at six selected Taska in Kota Bharu, Kelantan which are located in the northeast of Peninsular Malaysia (Department of Statistic, 2014). Kelantan are divided into ten districts which are Bachok, Kota Bharu (Head of State), Machang, Pasir Mas, Pasir Puteh, Tanah Merah, Tumpat, Gua Musang Kuala Krai and Jeli. This study was conducted in Kota Bharu. Based on statistic as shown in Table 3.1, 1.6 million populations were recorded in Kelantan. As a capital, Kota Bharu gives is the highest number with 551.2 million in 2014, increasing from 528.0 million in 2012 and 539.6 million in 2013.

Table 3.1: Statistic of residents in Kelantan from 2012-2014

Districts	Year / Number of residents (per 1,000,000)		
	2012	2013	2014
Bachok	142.1	144.5	146.9
Kota Bharu	528.0	539.6	551.2
Machang	97.5	98.3	99.1
Pasir Mas	199.4	201.3	203.3
Pasir Puteh	122.1	122.7	123.3
Tanah Merah	130.1	132.3	134.5
Tumpat	162.6	164.7	166.8
Gua Musang	98.3	100.3	102.3
Kuala Krai	116.7	118.1	119.5
Jeli	43.6	44.2	44.4
TOTAL	1640.4	1665.9	1691.9

(Source: Department of Statistic, Kelantan, 2014)

As mention before, this study was conducted at selected Taska in district of Kota Bharu that registered under DSW, Kota Bharu. The listed register Taska were obtained in DSW, Kota Bharu (refer Appendix 1). All the sampling location were given permission by the owner of Taska with consent letter (refer Appendix 2A until

2F). This premise were established especially in taking cares of children generally from two months to four years old. Basically, it opens from morning to afternoon (7.30am-3.30pm). Table Table 3.2 shows the description of study location. From six selected Taska that were involved in this study, they were divided by roadside and residential area.

Table 3.2: The description of study location

Taska	Symbol	Coordinate	Location
Mata Hati	A	N06°05.037' E102°14.043	Roadside area
Pintar Progresif	B	N06°07.070' E102°15.553	
Nur Usrah	C	N06°05.301' E102°13.691	
Ilham Murni	D	N06°07.120' E102°15.052	Residential area
MM Childcare	E	N06°07.085' E102°15.352	
Adikku Bijak	F	N06°06.764' E102°16.094	

3.3 Sampling Method

3.3.1 Study Instruments

There are various instruments that were used throughout this study which are Handled 3016 IAQ Particle Counter Gen E (Figure 3.2), measurement tape, three legs tripod, extension and global positioning system (GPS).

(a) Handled 3016 IAQ Particle Counter Gen E

As the main instrument in this study, Handled 3016 IAQ Particle Counter Gen E as shown in Figure 3.2 was used to measure the concentrations of PM_{2.5} and PM₁₀. The physical parameters such as temperature and relative humidity were also measured in all selected Taska. The temperature and relative humidity can be also measured by this instrument. This instrument was used to record the concentration of both size of PM for 8 hours continuously in this study (Lighthouse Worldwide Solutions, 2014).



Figure 3.2: Handled 3016 IAQ Particle Counter Gen
(Source: Lighthouse Worldwide Solution, 2014)

3.4 Data Collection

The sampling period was carried out from end of December 2014 until middle of February 2015. The data were collected in 5 times from Sunday to Thursday for each Taska. The data were collected daily continuously for eight hours starting from 7.30am to 3.30pm. Data were collected while conducting the field work at the selected Taska.

Figure 3.3 shows the steps of the data collection in this study. It includes three main steps which were measuring the floor area, setup the instrument and lastly walkthrough survey.

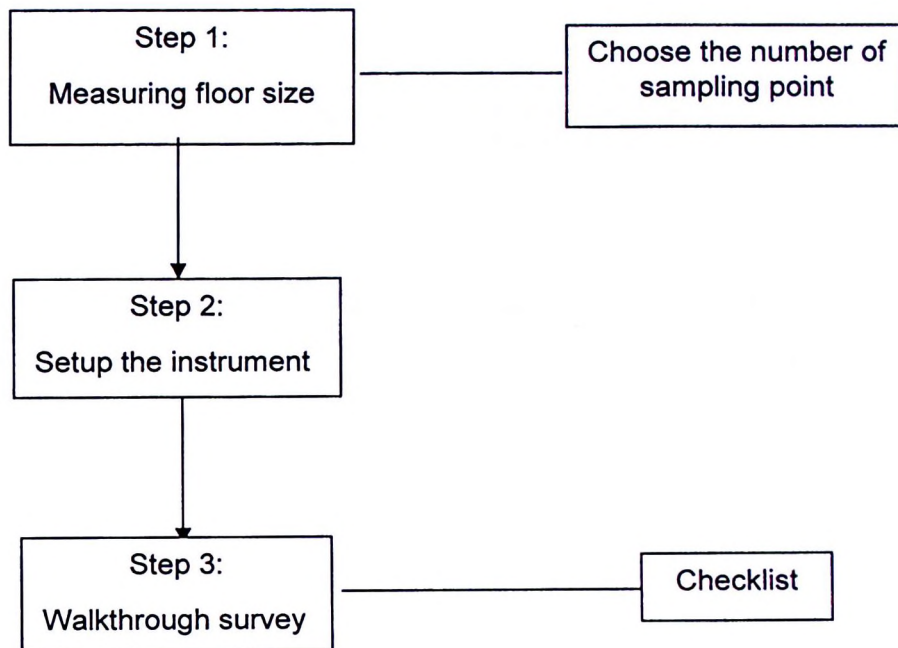


Figure 3.3: The steps of data collection

3.4.1. Step 1: Measuring floor area

The floor areas were measured by using measurement tape. The height and width of the floor was measured in metres (h x w) in order to obtain the floor area (refer Table 3.2). The minimum number of sampling point were determined (refer Table 3.3). Overall, the total of the floor area for each Taska is less than 3000m² which means the minimum number of sampling point is only one sampling point.

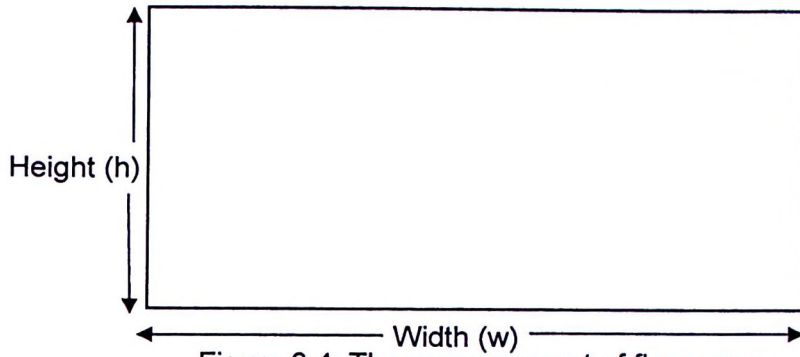


Figure 3.4: The measurement of floor area.

Table 3.3: Minimum number of sampling points for IAQ parameters

Total floor area to be certified (served by MVAC system) (m ²)	Minimum number of sampling points
< 3000	1 per 500 m²
3000 - < 5000	8
5000 - < 10000	12
10000 - < 15000	15
15000 - < 20000	18
20000 - < 30000	21
≥ 30000	1 per 1200 m ²

(Source: DOSH, 2010)

3.4.2. Step 2: Set up the instrument

As far as possible, the Handled 3016 IAQ Particle Counter was placed in the middle of the room. According to the requirement from Industrial Code of Practice (ICOP) IAQ 2010 (DOSH, 2010), the sampling instrument was positioned at distance around 1 meter (m) from the bottom floor and at least 0.5 m from the ceiling surface and located not within 2 meters of doors (refer figure 3.5). The position of the instrument will be changed if the condition is not suitable (Elbayoumi *et al.*, 2014).

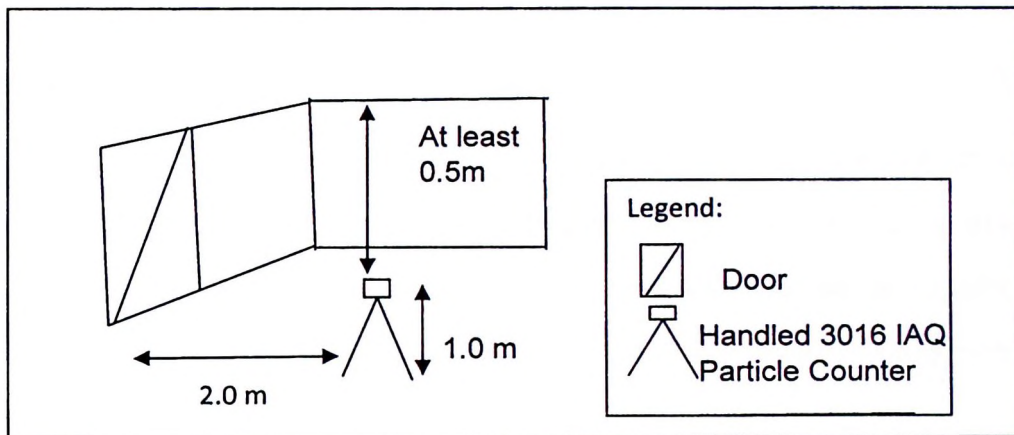


Figure 3.5: The position of Handled 3016 IAQ Particle Counter

3.4.3. Step 3: Walkthrough Survey

The surrounding observation also was done by using the checklist that adopted from ICOP IAQ (refer Appendix 3). The purposed of walkthrough survey was to identify the characteristic and the environment of the Taska that may influenced the PM concentration. Besides, it was done to identify the potential factor that affect the PM concentration. Overall, the six Taska had same characteristic which are using the natural ventilation (windows and door) and also with helped from the mechanical ventilation which is fan. Moreover, the other characteristic that could influence the PM concentration was the kitchen.

3.5 Data Analysis

Quantitative data is used to quantify the problem by way of generating numerical data measurable data to formulate facts. Therefore, in this study the quantitative data were used by using checklist walkthrough survey and it is also include observations and monitoring (Whyse, 2011). The data processing and statistical analyses were performed using Microsoft Office Excel and Statistical Package for Social Sciences (SPSS).

3.5.1 Microsoft Office Excel Version 10

The Microsoft Office Excel Version 2010 was used in this study. Excel is convenient for data entry, and for quickly manipulating rows and columns prior to statistical analysis (Eva, 2007). Microsoft Office Excel was used to describe the pattern of the PM concentration. The pattern of PM_{2.5} and PM₁₀ concentration were plotted by using line graph.

3.5.2 Statistical Package for Social Sciences (SPSS)

The Statistical Package for Social Sciences (SPSS) software was used in order to analyse the data in this study. It used to analyse the result, to generate tabulated report, charts and plot of trends, and descriptive statistic (Bachok, 2011). The descriptive and inferential statistical methods were used to summarise all the data of PM concentration that have been recorded.

(i) Descriptive statistics

Descriptive statistic was used to describe the characteristic of variable. Mean, median, mode, standard deviation, normal distribution and Z score were used to describe the characteristic (Chua, 2013). Descriptive statistics are used in this study to determine the central tendency and the dispersion of the variable

The central tendency usually refer middle value or typical value and measured using mean, median and mode. Mean is simply the sum of the values divided by the total number of data. However, median is determined by sorting the data from lowest to highest values and taking the data in the middle. Unlike mean, the median is not influenced by the extremes of the value (Ibid). The mean can be used to describe the characteristics of a variable by calculating the average PM concentration value, its use is inappropriate when a small number of extreme values exist in the data. The extreme values can exist either very low or very high. To overcome this problem, the median is used as it is not influenced by these extreme values (Ibid).

Besides, the dispersion of the variable were also measured to determine the values in a data group are near or far away from each other. The dispersion of data can be identified by calculating the values of range, standard deviation and variance. The standard deviation was measured using SPSS program in this research (Ibid).

Standard deviation is the main measurement indicator in research to explain the dispersion of values in a distribution. Furthermore, it is used for interval and ratio scale data. The standard deviation shows the average total of an individual's value which deviates from the mean value in a distribution (Ibid).