RISKS OF RESPIRATORY EFFECTS AMONG RESIDENTS LIVING NEARBY RICE MILL IN TUMPAT, KELANTAN

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RISKS OF RESPIRATORY EFFECTS AMONG RESIDENTS LIVING NEARBY RICE MILL IN TUMPAT, KELANTAN

by

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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 ABBREVIATIONS AND SYMBOLS	xi
ABSTRAK	xiii
ABSTRACT	xiv
CHAPTER 1 - INTRODUCTION	1
1.1 Background of Study	1
1.2 Problem Statement	3
1.3 Research Objectives	4
1.3.1 General Objective	4
1.3.2 Specific Objectives	4
1.4 Alternative Hypothesis	5
1.5 Significant of Study	5
CHAPTER 2- LITERATURE REVIEW	7
2.1 Particulate Matter	7

2.2 Exposure to Dust Particulates 8

2.2.1 Standard Limit For Particulate Matter 10

2.3 Routes of Entry of Dust and Lung Defence Mechanism 11

2.4 Respiratory Health Effects 14

2.4.1 Respiratory Symptoms 16

(a) Breathlessness & Wheezing 16

(b) Cough & Phlegm 17

2.5 Lung Function Test 18

CHAPTER 3- METHODOLOGY **22**

3.1 Study Design 22

3.2 Study Location 22

3.3 Study Participants 23

3.4 Study Period 24

3.5 Sample Size Calculation 24

3.6 Sampling Method 24

3.7 Research Tools 25

3.7.1 Cosmed Pony FX Desktop Spirometer 25

3.7.2 Respiratory Questionnaires 26

3.7.3 Lighthouse Handheld 3016-IAQ 27

3.8 Data Collection 28

3.9 Data Entry & Analysis 29

3.10 Ethical Issues and Clearance 30

CHAPTER 4- RESULTS **31**

4.1 Socio Demographic 31

4.2 Respiratory Symptoms Experienced by Residents 32

4.2.1 Respiratory symptoms and living duration 33

4.2.2 Respiratory symptoms and age 34

4.2.3 Respiratory symptoms and smoking status 35

4.3 Respiratory Symptoms and Lung Condition 36

4.4 Lung Function Performance of Residents 36

4.4.1 Differences in lung function performance between male and female residents. 37

4.4.2 Lung Impairments of Residents 37

4.5 PM_{10} Concentration at Two Different Radiuses in Residential Area 38

4.6 PM_{10} Concentration in Rice Mill Factory 40

CHAPTER 5- DISCUSSION **41**

5.1 Socio Demographic 41

5.2 Resident's Awareness 41

5.3 Respiratory Symptoms Experienced by Residents 43

5.3.1 Respiratory symptoms and living duration 43

5.3.2 Respiratory symptoms and age 44

5.3.3 Respiratory symptoms and smoking status 44

5.3.4 Respiratory symptoms and lung condition 45

5.4 Lung Function Performance among Residents 45

5.4.1 Differences in lung function performance between male and female residents. 46

5.4.2 Lung impairments of residents 46

5.5 PM_{10} Concentration 47

5.5.1 PM_{10} concentration at two different radiuses 48

5.6 Limitations of Study 48

CHAPTER 6- CONCLUSION **50**

6.1 Conclusion 50

6.2 Recommendations for Future Study 51

REFERENCES **53**

APPENDICES **60**

APPENDIX A : Respiratory Questionnaires 60

APPENDIX B : Ethical Approval Letter 65

LIST OF TABLES

Table		Page
2.1	Standard limits for particulate matter	11
3.1	Inclusion and exclusion criteria	23
4.1	Socio demographic data	31
4.2	Resident's awareness on dust problems	32
4.3	The association between respiratory symptoms and living duration at residential areas near rice mill.	34
4.4	The association between respiratory symptoms and age of residents	35
4.5	The association between respiratory symptoms and smoking status	35
4.6	Association between respiratory symptoms and lung condition	36
4.7	The pattern of FVC, FEV1, and FEV1/FVC ratio	37
4.8	Differences of lung function parameters between male and female residents.	37
4.9	PM_{10} concentration at two different radiuses	40
4.10	Average PM_{10} concentration at different area in rice mill	40

LIST OF FIGURES

Figure		Page
2.1	Human respiratory systems	13
2.2	Normal spirometry graph	20
3.1	COSMED Pony FX Desktop Spirometer	26
3.2	Lighthouse Handheld 3016-IAQ	27
4.1	Types of respiratory symptoms experienced by residents	33
4.2	Lung Impairments of Residents	38
4.3	Average PM_{10} concentration	39

LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
<	Less than
>	More than
≤	Less than or equal to
≥	More than or equal to
$\mu g/m^3$	Microgram Per Meter Cubic
AHR	Airway Hyperresponsiveness
ATS	American Thoracic Society
CCOSH	Canadian Center for Occupational Health and Safety
cm	Centimetre
COPD	Chronic Obstructive Pulmonary Diseases
DOE	Department of Environment
FEV_1	Forced Expiratory Volume
FEV_1/FVC	Ratio of Forced Expiratory Volume over Forced Vital Capacity
FVC	Forced Vital Capacity
IAQ	Indoor Air Quality
IRRI	International Rice Research Institute
kg	Kilogram
km	Kilometre
m	Metre
PM_{10}	Particulate Matter 10

$PM_{2.5}$	Particulate Matter 2.5
USEPA	United States of Environmental Protection Agency
WHO	World Health Organisation

RISIKO TERHADAP SISTEM PERNAFASAN DALAM KALANGAN PENDUDUK YANG TINGGAL BERHAMPIRAN KILANG BERAS DI TUMPAT, KELANTAN

ABSTRAK

Terdapat banyak kajian yang dijalankan telah membuktikan bahawa pencemaran udara dari kawasan industri memberikan kesan kesihatan terhadap sistem pernafasan penduduk setempat. Kajian keratan rentas ini telah dijalankan untuk mengkaji kefungsian paru-paru dan simptom pernafasan penduduk yang tinggal berhampiran dengan kilang beras.Kajian ini juga bertujuan untuk menentukan nilai purata dan perbezaan kepekatan PM_{10} di kawasan kediaman yang terletak pada jarak 1 dan 2 km radius daripada kilang. Populasi kajian ini terdiri daripada 47 orang penduduk yang tinggal di kawasan berhampiran kilang tersebut. Mereka telah ditemuramah menggunakan borang soal selidik mengenai pernafasan dan ujian kefungsian paru-paru juga telah dijalankan. Pengukuran PM_{10} telah dijalankan selama 8 jam pada 8 titik persampelan di sekitar kawasan kediaman penduduk. Batuk dan kahak pada waktu pagi merupakan gejala yang paling biasa dialami oleh kebanyakan penduduk kawasan sekitar tersebut. Tempoh mendiami kawasan tersebut mempunyai hubungan yang signifikan dengan gejala sesak nafas (p = 0.004) dan kahak pada waktu pagi (p = 0.026). Umur penduduk menunjukkan hubungan yang siginfikan dengan batuk pagi (p = 0.028) dan kahak pada waktu pagi (p = 0.032). Status merokok juga menunjukkan perkaitan signifikan dengan batuk pagi (p = 0.008), kahak pada waktu pagi (p = 0.002) dan sakit dada (p = 0.022).Keadaan paru-paru pula mempunyai perkaitan yang signifikan dengan batuk pagi (p = 0.020) dan kahak pada waktu pagi (p = 0.048). Secara keseluruhan, keupayaan kefungsian paru-paru penduduk didapati menurun. Keupayaan fungsi paru-paru dalam kalangan penduduk lelaki lebih tinggi berbanding wanita.Terdapat perbezaan yang signifikan pada bacaan FEV_1 antara penduduk lelaki dan wanita. Kebanyakan penduduk di kawasan tersebut mengalami masalah paru-paru restriktif. Terdapat perbezaan yang signifikan dalam kepekatan PM_{10} antara kawasan perumahan yang terletak pada jarak 1 km dan 2 km radius daripada kilang beras (p < 0.001). Kesimpulannya, penduduk yang tinggal berhampiran kilang beras mempunyai risiko tinggi untuk mengalami masalah pernafasan. Masalah ini boleh menjadi semakin teruk disebabkan oleh pelbagai faktor risiko termasuk jantina, umur, tempoh mendiami kawasan tersebut dan status merokok.

RISKS OF RESPIRATORY EFFECTS AMONG RESIDENTS LIVING NEARBY RICE MILL IN TUMPAT, KELANTAN

ABSTRACT

Many studies that have been conducted shows that industrial air pollution can trigger significant respiratory health effects on population that lived in the nearby area. This cross sectional study was carried out to investigate the lung function and respiratory symptoms of residents living near to a rice mill in Tumpat, Kelantan. This study also aimed to determine the average and differences of PM_{10} concentration at residential areas located at 1 and 2 km radius from the factory. The study population consisted of 47 residents who lived near to the factory. They were interviewed using respiratory questionnaires and lung function test also was performed. PM_{10} measurements were carried out for 8 hours at 8 sampling points around the residential area. Morning cough and phlegm were the most common symptoms experienced by the residents. Duration of residence was significantly associated with breathlessness ($p = 0.004$) and morning phlegm ($p = 0.026$). Age of residents was significantly associated with both morning cough ($p = 0.028$) and morning phlegm ($p = 0.032$). Smoking status was found associated with morning cough ($p = 0.008$), morning phlegm ($p = 0.002$) and chest illness ($p = 0.022$). Lung condition were found to have significant association with morning cough ($p = 0.020$) and morning phlegm ($p = 0.048$). Overall, lung function capabilities of the residents were reduced. Lung function capabilities of males were higher than female residents. There was significant difference of FEV_1 between male and female residents. Most of residents have restrictive lung impairments. There was significant difference in PM_{10} concentration between residential areas located at 1 km and 2 km radius ($p < 0.001$). In conclusion, residents living nearby rice mill have high risk of respiratory problems. This can be worsen by various risk factors including gender, age, duration of residence and smoking status.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Air pollution has become a problem and a globally crucial issue nowadays due to the rapid rate of economic growth not only in the European countries but also in Asian countries. Air pollution gives effect not only to the environment but also to the health of the population through reduced in the air quality. In Malaysia, problems towards air pollution rise from the abrupt growth of factories and facilities and due to the improper planning. Some factories are located nearby the residence and also near the academic institution (Nur Shaylinda *et al.*, 2008).

Point sources of air pollution can be defined as stationary location or fixed facility where the pollution are being emitted such as power stations, steel works, wood and pulp processing, paper mills and incinerators. There are many people who lived close to the point sources and there are suggestions that clusters of diseases often developed around this area (Kibble & Harrison, 2005). According to Vanadeep & Krishnaiah (2011), in terms of exposure to pollution, residential areas are considered to be sensitive and vulnerable. This is because, mostly the population that lived there were infants and children, people that suffer from chronic ailments, older people, pregnant and breastfeed mother.

The emissions of pollutants in the air keep on increasing especially in industrial area. In addition, small sized industries are generally located in the populated area where

the emission control is less effective and problematic. Thus this condition creates a problem among residents in the nearby area (Rafia *et al.*, 2003).

Rice serves as the staple food not only in Malaysia but also in most of the world populations. It is known that Asian region produces approximately 90% of the total rice output globally. The demand for rice is expected to remain high for about a few decades more based on the economic and population growth in many countries which includes African and Asian countries (Mohanty, 2008). Therefore, rice industry will remain sustainable for a long time period of time and the production of by-product will also keep on increasing (Wopereis *et al.*, 2009).

Malaysia is known as one of the major rice growing country. Usually rice is cultivated in irrigated fields. After the harvesting and drying process, rice is then subjected to milling operation. Usually, an ideal milling process will yield about 20% of husk, 8-12% bran depending on the milling degree (International Rice Research Institute (IRRI), 2009). Rice husk is the largest by product of rice milling industry which amounts to 22-24% of total paddy (Central Pollution Control Board, 2012).

Milling process is very crucial step in post-production of rice because the main purpose of milling process is to remove the husk and bran layers (IRRI, 2009). It is during the milling activities, a vast amount of dust is generated (Glyseth *et al.*, 1984). In 2008, the world paddy production was 661 million tons. This means that, about 132 millions of rice husk was also produced from the total paddy weight (IRRI, 2009).

Usually airborne materials that caused health and safety hazard consist of particulates, gases, vapours or some combination of these substances. Grain dust

have been classified as nuisance dust and it composed of many materials which includes various types of grains, disintegration products and also pollens, fungi, insects and mites. However their composition and concentration vary from one working station to another (Yeung *et al.*, 1985).

Most of industrial process produced a lot of air-borne contaminants and usually their common route of entry to human body is through inhalation process. Inhalation of industrial dust for a long period of time can lead to changes in lungs such as proliferation and fibrotic changes (Boyd, 1997). People who lived near to the point sources can be exposed to the pollutants in various pathway depend on the point source and the type of release (Kibble & Harisson, 2005).

1.2 Problem Statement

Air pollution is one of the major issues that may affect human health. There are many previous studies that relate the air pollution and its impact on human health especially to respiratory health. In this study, it was found that the residential areas are located very close to the rice mill factory. Even the nearest houses are located just beside the factory. This condition, increase the risk of resident's exposure to dust from rice mill factory. This is because, according to the study conducted by Kiattisak & Thanatchai (2010) in Thailand, a large amount of dust from rice milling process is typically experienced not only by workers in the rice mill itself but also by the villagers nearby.

Besides that, most of the residents have been living in that area for duration of more than 20 years. Thus it means that, they have been exposed to the dust from rice mill

for a long period of time. World Health Organisation (WHO) (1999) have stated that, there were about 30% of respiratory diseases that occur due to the personal exposure to high level of particulate matter concentration in the ambient air.

Furthermore, rice dust can cause harmful effect towards respiratory health since it has silica content that may cause allergic irritation to respiratory health (Standards and Industrial Research Institute of Malaysia, 1983). Furthermore, this biogenic silica could cause a pleural thickening, fibrosis as well as bronchogenic carcinoma a pulmonary resembling asbestosis (Newman, 1986).

1.3 Research Objectives

1.3.1 General objective:

To investigate the respiratory function of residents living near to the rice mill in Tumpat, Kelantan.

1.3.2 Specific objectives:

1. To measure the lung function of residents living near to the rice mill.
2. To compare the lung function of male and female residents living near to the rice mill.
3. To identify the respiratory symptoms of residents living near to the rice mill.
4. To find the association between lung condition and respiratory symptoms among residents living near to the rice mill.
5. To compare the PM_{10} concentration level between residential areas located 1 km and 2 km radius from the rice mill.

1.4 Alternative Hypothesis

H_{A1}: There is a significant decrease of lung function of the residents living near to the rice mill.

H_{A2}: There is a significant difference of lung function between male and female residents.

H_{A3}: There is presence of respiratory symptoms among residents living near to the rice mill.

H_{A4}: There is a significant association between lung condition and respiratory symptoms among residents living near to the rice mill.

H_{A5}: There is a significant difference of PM_{10} concentration between residential areas located at 1 km and 2 km radius from rice mill.

1.5 Significant of Study

The concern in this study is to determine the respiratory conditions among residents who lived near to the rice mill factory based on lung function test. Therefore, the importance of conducting this study is that, it helps giving information to the residents about their respiratory health condition based on the lung function that have been conducted. This study also helps to find out the common respiratory symptoms that have becomes a burden among residents due to exposure to dust.

In other hand, this study also helps to increase the awareness among residents regarding the exposure and the effect of the long term exposure to PM_{10} towards

their health. Therefore, residents become more alert and concern about their health status. This otherwise, help to encourage them to do further medical check-up at the hospital and seek medical advice from the doctors especially among vulnerable groups.

Furthermore, from this study the complaints from residents regarding the dust problems and ambient air measurement result can be used as a main issue to be addressed to the stakeholder, rice mill factory management, researchers and public. They should start to focus on ideas and actions that are needed to be taken in order to minimize the risk of air pollution from rice mill factory to the residents. This study somehow might help in educating not only residents living nearby the rice mill factory, but also public that environmental pollution does have impact on human health.

In addition, measurement of PM_{10} in the ambient area near the rice mill factory helps in determining how much the dust from the rice mill dispersed to the outside area and affecting the respiratory health of the residents.

CHAPTER 2

LITERATURE REVIEW

2.1 Particulate Matter

Particulate matter refers to the solid and liquid that is suspended in the air and it is a mixture of extremely small particles and liquid droplets that can be divided into two, which are fine and course particulate matter (Nur Shaylinda *et al.*, 2008). Particulate matter is usually defined based on their size or diameter as these two factors will determine how long they will stay in the air. It is also important determinant of how far particulate matter will be transported and in aspect of health, how they will be deposited in the respiratory symptoms (Zereini & Wiseman, 2010).

The type of particulate matter includes coarse particles or PM_{10} or also known as inhalable particle which has the size less than 10 μm in diameter. It can be found mainly near the roadways and dusty industries. The other one is fine particles or $PM_{2.5}$ which is generally found in smoke and haze (United States of Environmental Protection Agency (USEPA), 2013). The suspended particles usually originate from various kinds of sources such as from the factory, vehicle exhaust, wood burning, mining, construction activity and agriculture. Their physical and chemical characteristics are different to each other and they can be emitted or be formed in the atmosphere (USEPA, 2012a).

PM_{10} consists mainly of small liquid and solid particles that float freely in the air. It is actually a mixture of materials that includes smoke, soot, dust, salts, acids and

metals. Nowadays, PM_{10} has becomes one of the greatest concern to public health because the particles are small enough to be inhaled deep into the lungs. PM_{10} is harmful because when being inhaled these particles will escape from respiratory systems natural defence. Then it will lodge deep into the lungs and health problems will then begin when the body react will foreign particles (California Environmental Protection Agency, 2009). Short term exposure can cause irritated eyes, nose and throat while long term exposure might reduce the lung function and will increase the rate of disease progression (New South Wales Government Health, 2013).

2.2 Exposure to Dust Particulates

Aerosols are particles that are suspended in a gaseous medium or in the context of occupational hygiene suspended in the air. Aerosol can exist in many forms which are airborne dust, spray, mists, smokes and fumes. Usually the airborne dust become the main concern as they are known to be associated with the occupational lung disease or any other allergic reaction which can occur even at much lower exposure level (World Health Organization (WHO), 1999). Dust is a general name for solid particles with has diameter less than 500 μm. In ordinary air, dust is usually smaller than 10 μm (Kiattisak & Thanatchai, 2011).

Tiny solid particles that are suspended in the air were called dust and depending on their source they can either be classified as organic and inorganic dust. Inorganic dust usually comes from activities such as grinding metals and minerals. The examples of inorganic dust are asbestos and silica. Meanwhile, organic dust mainly comes from plants and animals for example dust that is produced from the handling

of grains activities. Besides that, they main contain fungi and microbes (Canadian Center for Occupational Health & Safety (CCOSH), 2012).

Grain dust can be defined as a complex mixture of the grain particles and its associated materials and it is produced during the mixing, pouring, and transport of the grains such as wheat, corn, barley and rice (US Army Center for Health Promotion and Preventive Medicine, 2003). In the milling process, usually there are large amount of dust which is rice husk generated (Razlan *et al.*, 2000).

According to Reddy *et al.,* (2009), high aflatoxins have been detected in rain damaged rice grains and paddy in India and also in parboiled rice (Toteja *et al.*, 2006). Aflatoxins actually a secondary metabolites that is produced by the *Aspergillus* species named *A.flavus* and *A.parasiticus* that contaminate a variety of agricultural and food commodities (Bhat & Vasanthi, 2003). These kinds of mycotoxins are recognized to be hepatotoxins and carcinogens to humans (WHO, 1999).

Grain dust may cause an allergic reaction in some people. Some of the common symptoms associated with the exposure to the grain dust include irritation to the eyes, nose, throat and cough. People that are exposed to the grain dust even at low level is at risk of developing those symptoms (US Army Center for Health Promotion and Preventive Medicine, 2003).

The outermost layer of paddy grain is known as rice husk which is separated from the brown rice in the first step of milling process when the husk is being removed from grain during husking stage. The handling of rice husk is difficult because it is usually bulky and dusty (IRRI, 2009).

Lim *et al.*, (1984) in his study stated that, rice husk was found to be covered with small needle-like hairs that projects outwards as sharp, elongated spines with length about 200-300 and diameter of 30-40 μm tapering into the sharp end.

Place where the highest amount of dust particles with size smaller than 10μm is the paddy pouring station. The result from the study by Kiattisak & Thanatchai (2010) shows that paddy pouring station is the riskiest place that may cause a problem to human respiratory systems.

2.2.1 Standard Limit

There are standard limit for particulate matter that have been established by different agencies. Table 2.1 shows the standard limit for both $PM_{2.5}$ and PM_{10} in the ambient air by two different agencies which were WHO and USEPA. USEPA has established primary and secondary air quality standards. Basically, the ultimate aim of primary standard is not only protecting the public health but also vulnerable populations such as people with respiratory diseases, children and older people. The secondary standards are used to protect environment and it is established in order to avoid adverse effect to environment that may give health effect to human population. However, currently USEPA only has PM_{10} concentration standard limit for duration of 24 hours, where it should not exceed 150 $\mu g/m^3$ (USEPA, 2012b).

According to WHO Air Quality Guidelines, PM_{10} levels should not exceed 20 $\mu g/m^3$ for annual mean and 50 $\mu g/m^3$ for 24 hour mean. All countries are encourages to take preventive steps to adhere these guidelines since there were acute health and chronic health morbidities that were associated with PM_{10} exposure (WHO, 2014).

In Malaysia, the standard limit for PM_{10} is based on Malaysian Ambient Air Quality Guideline (MAAQG) by Department of Environment. PM_{10} must not exceed 50 $\mu g/m^3$ for annual mean and 150 $\mu g/m^3$ for 24 hours mean (DOE, 2015).

Table 2.1: Standard limits for particulate matter

Particulate Matter	[1]WHO	[2]USEPA	[3]MAAQG
$PM_{2.5}$	10 $\mu g/m^3$ annual mean	12 $\mu g/m^3$ annual mean	-
	25 $\mu g/m^3$ 24-hour mean	35 $\mu g/m^3$ 24-hour mean	-
PM_{10}	20 $\mu g/m^3$ annual mean	-	50 $\mu g/m^3$ annual mean
	50 $\mu g/m^3$ 24-hour mean	150 $\mu g/m^3$	150 $\mu g/m^3$ 24-hour mean

Source: [1]WHO (2014), [2]USEPA (2012b) & [3]DOE (2015)

2.3 Routes of Entry of Dust and Lung Defence Mechanisms

Basically, there are three common routes of entry of hazardous substances into human body which were inhalation, absorption through skin and ingestion. Inhalation is the main routes of entry of contaminants into human body. The hazardous substances are being inhaled into the body through normal intake. Next, the second route is absorption through skin where the substances comes into contact with the skin and enter through pores or wounds. The other route of entry is by ingestion through mouth and then being swallowed into the stomach and digestive system (Hughes & Ferret, 2011).

Particles that are small enough to stay airborne will be inhaled through nose or mouth. The inhaled particles may be deposited or exhaled again. Sedimentation and impaction are the most important mechanism related to the inhaled airborne dust and this kind of process is usually governed by the aerodynamic diameter of the particles (Lippmann, 1977).

Lung is one of the organs that are exposed to the danger due to the inhalation of dust in our surrounding area and workplace. However, lungs do have their own defence mechanisms in different regions of respiratory tracts that will protect them (refer Figure 2.1). When inhalation process occur, particles that are suspended in the air will enter the nose while the larger one will be stopped in it until they are eventually being removed mechanically either through blowing or sneezing (CCOSH, 2012).

Actually, during the breathing process, particles are deposited in nose by the filtration of the nasal hairs. Larger particles will be deposited in tracheobronchial region and later it will be eliminated by the mucociliary clearance. For smaller particles it will penetrate more into the alveolar region and maximum deposition in alveolar region occur for particles of approximately 2 μm aerodynamic diameter (WHO, 1999).

When being inhaled, dust may simply deposited in the lung tissue and may be detectable using the X-rays but without any resulting illness or health effects. Physiological response associated with the inhaled dust is that they are deposited in the lungs and then it will induced one or more response from the body thus stimulating and increase in the production of mucus and sometimes it is accompanied by the enlargement of cell that produce mucus (Nims, 1999).

Because the lung has extensive surface area, high blood flow and a thin alveolar epithelium, it becomes an important site of contact with the substances that are inhaled from the environment (Boyd, 1997). When the dust reached the lower part, they will then be attacked by macrophage since there are no cilia in that region. Particles that barely escape from the elimination in nose and throat will settle down in the air sacs and if there is high concentration of dust, it will cause failure to the macrophage system. Furthermore, the amount of dust and types of particles involved will influence how serious the injury to lungs (CCOSH, 2012).

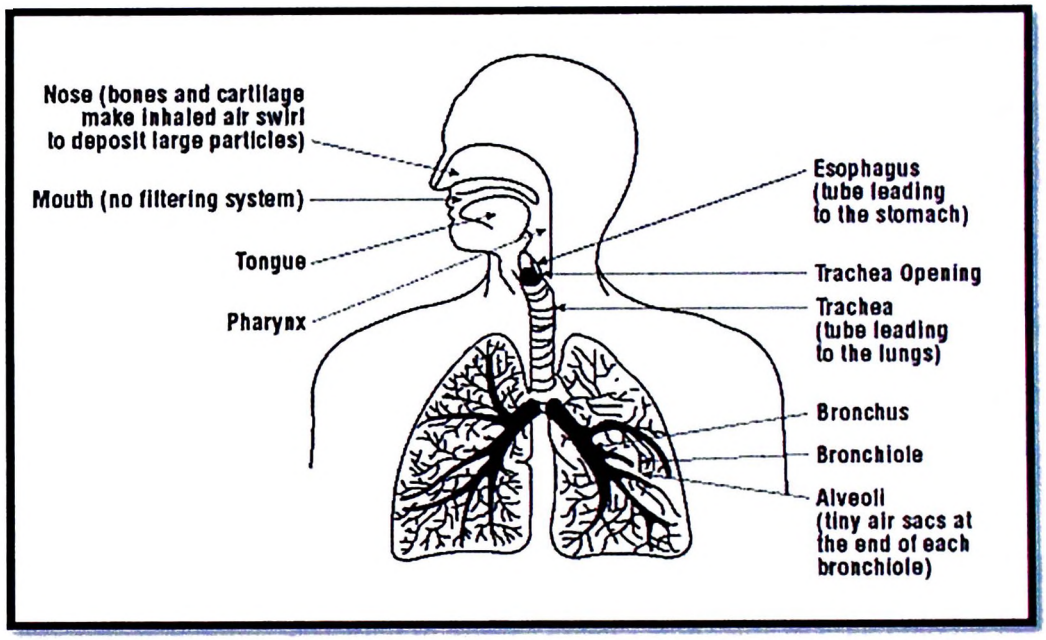

Figure 2.1: Human respiratory systems

(Source: CCOSH, 2012)

2.4 Respiratory Health Effects

According to WHO (1999), the health effect caused by particulate matter can be due to the short and long term exposure to that pollutants. Short term exposure might take hours and days while long term exposure might take months and years. The health effects includes respiratory and cardiovascular morbidity such aggravation of asthma, respiratory symptoms as well as increase in the hospital admissions. Besides that, there was mortality due to lung cancer.

The mortality and morbidity effect due to the air pollution does not linked to ambient level concentration only but they also depends on other kind of factors such as time spent outdoor. People who work hard in outdoor environment are at high risk because they breath in rapidly and deeply. The response to the exposure of pollutants might vary between people since it depends on age, health status and other factor (Joseph *et al.,* 2010). Major concern to human health related to PM_{10} exposure includes effect on breathing, respiratory symptoms, reduced in pulmonary function, lung tissue damage, cancer and also premature death (Sharma *et al.*, 2010).

The exposure to high concentration of PM_{10} can cause various health impacts ranging from coughing, wheezing to asthma attack, bronchitis to high blood pressure, heart attack, stroke and premature death. Usually, population that is most adversely affected due the exposure to high PM_{10} concentration are the children aged 0-4 years old, old person with age more than 65 years old (Donaldson *et al.*, 2006) and people with existing medical condition (WHO, 2011). Study by Holgate *et al.*, (2003) shows that in healthy and asthmatic volunteers the airborne particles might influence and

increase the bronchial responsiveness, resistance to the airways and also to bronchial tissue mast cell.

Due to the structure of rice husk dust that has spikes it suggested that they may responsible for causing irritant cough with or without phlegm, keratoconjuctival irritant and pruritus. Nasal catarrh, respiratory difficulties such as tightness of chest and eosinophilia are probably an allergic response either to a protein constituent of rice husk or might be due to some other microbial contaminants (Lim *et al.*, 1984, Singh *et al.*, 1988).

According to the study conducted by Kiattisak & Thanatchai (2010) in Thailand, they found that the workers in rice mills are more prone to suffer from respiratory disease due to prolonged exposure to rice dust. Younger workers are more vulnerable because their immunity system is immature compared to more adults workers. Young workers aged 15-24 years have a 40% higher rate of non-fatal injuries and acute occupational diseases than older workers in all sectors. This includes skin problems and pulmonary disorders (Bellin *et al.*, 2011).

A study conducted by Razlan *et al.*, (2000) shows that most symptoms that occurred among rice mills workers are chest tightness followed by shortness of breath and lastly morning cough. However, only shortness of breath has significant relationship with the duration of employment while the tightness of chest has no association with it. Through this study also, when being compared to healthy population, the respiratory function for all study populations shows impairment.

Airborne endotoxin can be found in rice husk dust which may cause inflammatory reaction in broncho-pulmonary system. Rice dust may also cause damage to

bronchial passages and also damage the elastic components of alveolar walls (Olenchock *et al.*, 1984).

2.4.1 Respiratory Symptoms

The respiratory symptom often reported due to PM_{10} often involved upper and lower respiratory symptoms. Upper respiratory symptoms includes runny and stuffy nose, sore throat, wet cough while for lower respiratory symptoms are wheezing, dry cough, phlegm, shortness of breath, chest discomfort or pain. With increase in PM_{10} concentration there are also increase in asthma symptoms, hospital visits and mortality (Zielinski & Kelly, 1998).

(a) Breathlessness and Wheezing

According to American Thoracic Society (ATS), breathlessness is a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that varies in intensity. The experience derives from interaction among physiologic, psychological, social, and environmental factors and may induce behavioural response (ATS, 2012).

Breathlessness is also known as shortness of breath or its medical term is dyspnoea which is difficult or laboured breathing. The word dyspnoea is actually derived from Greek word *dys* that means bad or difficult and *pnoia* means breathing. It is a sensation of not being able to get enough air into the lung and is experienced differently among people. It also often described as intense tightening in chest or

feeling suffocated. It is one of the key that represent the symptoms of chronic obstructive pulmonary diseases (COPD) and also chronic heart failure (Yorke & White, 2013).

Wheezing is a condition where there is a high pitched whistling sound produced during breathing. This condition occurs when the air moves through narrow breathing tubes in the lungs. The sound often more obvious during exhalation process and also can be heard during inhalation. It might be due to the blockage in the larger airways. The cause of wheezing can come from asthma, bronchitis, smoking and pneumonia (Kaneshiro, 2014).

(b) Cough and Phlegm

An explosive current of air that is driven forcibly from the chest is known as cough. It is actually a form of protective reflex that helps to clear the air passages from any obstruction. Coughing actually is an essential protective mechanism designed which get rid harmful substance in the lungs and air passages. Dry cough without any phlegm that is experienced by adults may be a symptom of pneumonia or heart disease. If the cough is accompanied by phlegm and the colour of the phlegm changed it shows the sign of infection (Jacoby & Youngson, 2005).

Phlegm is name for a mucus-like substances that are produced in the lower airways which are from lungs and respiratory systems leading to the lungs. Phlegm is usually being noticed when a person cough it up as symptoms of bronchitis or pneumonia. The colour of the phlegm either yellow or green will indicate infection (Madeline, 2010).

2.5 Lung Function Test

Lung function test or also known as pulmonary function test is a breathing test that was conducted to know how well a person could take in the air in and out of the lungs. Usually, this test is conducted to measure the effect of chronic disease such as asthma and COPD on lung function. Besides that, an early change to the lung function could be detected. This lung function test is carried out by using a device known as spirometer. The spirometer will measure how much air a person could breathe in and how quick a person could blow out the air out of the lungs (ATS, 2014).

Spirometry is a simple breathing test that can be used to test the lungs for COPD and asthma. Besides, it can be used to diagnose the different types of lung diseases. Spirometry will measure the Forced Vital Capacity (FVC) and Forced Expiratory Volume (FEV_1). FVC is the largest amount of air blows after taking biggest breath in and while FEV_1 is the amount of air that can be blow out from lung in the one second (Canadian Lung Association, 2012).

Spirometry is a simple and quick procedure where during this test, subject will be asked to take a maximum breath and then forcefully expel the air as long and as quick as possible. In spirometry, measurement made includes FVC, FEV_1 and the ratio of the two volumes (FEV_1/FVC). FEV_1 give a measurement of the volume of air exhale in a given time and suppose a healthy person can exhale about more than 80% of the air in the first second. Besides, lung disease also can be classified using FEV_1 reading when it is being compared to predicted value of age, height, sex and ethnic groups (Cooper & Mitchell, 2003).

Based on the calculation of FEV_1/FVC it will help to identify the obstructive or restrictive ventilator effects. The most common example of obstructive defects includes chronic obstructive pulmonary disease like COPD and asthma (Ranu *et al.*, 2011). Usually, a healthy person will be able to exhale approximately 50% of their FVC in the first 0.5 seconds, 80% in one second and about 98% in three seconds. However, people that suffer from obstructive disease will show reduced ratio of FEV_1/FVC and actual percentage reduction often varies according to the severity of reduction (Lee, 2009).

Reading from the spirometry will usually show one of the four main patterns either a normal, obstructive, restrictive and combined obstructive and restrictive patterns. The normal reading of the spirometry usually vary and it depends on age, size and sex. Normal spirometric pattern usually characterize by high FEV_1 and FVC reading (Cooper & Mitchell, 2003). For obstructive pattern, it will show a reduced in FEV_1 and absolute FEV_1/FVC ratio (Barreiro & Perillo, 2004). It occurs because the airways are narrowed and this condition caused the amount of air that can be blow out is low and the total capacity of lungs is often normal or reduced. The FVC is often normal or near normal. However, a reduced in FVC value together with a presence of normal value of FEV_1/FVC can also be used as an indicator to the presence of restrictive lung function (Vandervoorde *et al.*, 2006).

Figure 2.1 show the normal spirometry graph. Graph A showing the flow-volume curve while Graph B showing the volume-time curve. Basically, the flow-volume - curve show a deep inspiratory effort and has a sharp expiratory flow. As for the volume- time curve, it show plateau and exhalation time that exceeds 6 seconds.

Both of this curve meeting ATS acceptability criteria for normal spirometry (Lee, 2009).

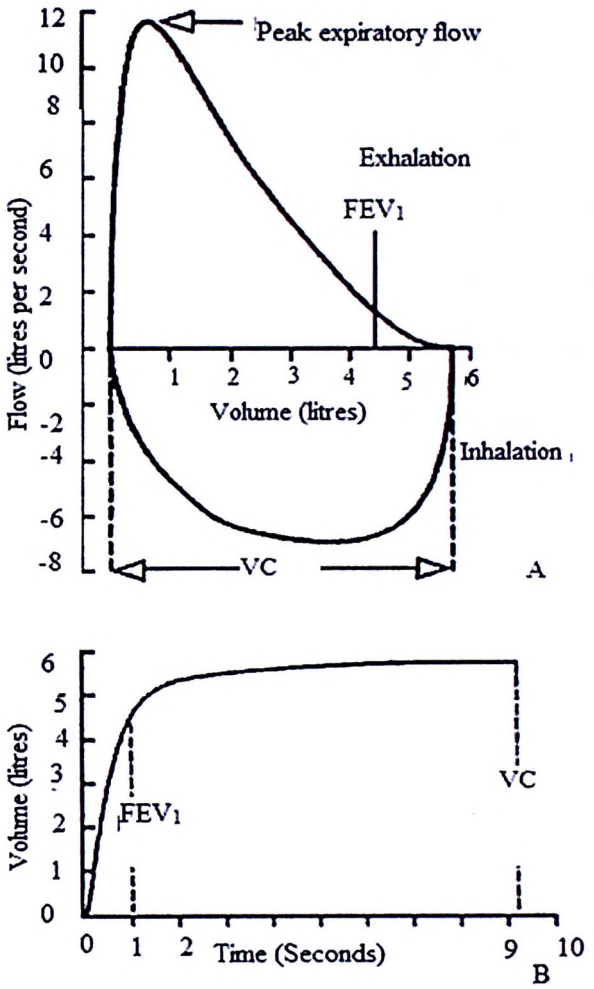

Figure2.2: Normal spirometry graph

(Source: Lee, 2009)

For the general consideration of lung function test, Miller *et al.*, (2005) stated that the testing may be carried out either in sitting or standing position and the position should be recorded. There are also some activities that should be avoided by the

subject before undergo the lung function test such as smoking within 1 hour of test, consuming alcohol 4 hour before test and perform vigorous exercise within 30 minutes of the test. Subject will also be asked to loosen the tight fitting clothing.

Study by Pope & Dockery (1992) stated that, as the particulate pollution level increase, there was a decreased in the lung function test and also increase in the respiratory symptoms. Furthermore, decreased in FVC readings were considered as a result of increasing in PM_{10} level in the air. Besides, a cohort study among older adults by Eckel *et al.*, (2012) found that there is strong evidence that cumulative ozone or PM_{10} exposure were associated with decrease in lung function. A reduced in FVC value are strongly associated with cumulative exposure especially in person with history of frailty and chronic pollution exposure.

CHAPTER 3

METHODOLOGY

3.1 Study Design

Study design that was used in this research is a cross sectional study. Cross sectional study also known as prevalence study (Oxford University Press, 2014). According to Olsen & St.George (2004), cross sectional study is a well-known and most common among all other study design because either entire population or subset thereof will be selected. Cross sectional studies often carried out to investigate the association between risk factor and outcome of interest (Levin, 2006).

3.2 Study Location

This study was conducted in residential area that was located within 1 to 2 km radius from the rice mill factory in Tumpat. Study was also conducted at the selected point inside the rice mill factory. This residential area was selected because based on the observation, the rice mill factory was located about 50 m from the residential area. This distance was considered very close and in fact the nearest house was located just beside the factory. Since rice mill was considered as medium type industries according to the Guidelines for Siting and Zoning of Industry and Residential Area by Department of Environment (DOE), supposed the indicative primary buffer distance from residential area must be minimum 150 m or more (DOE, 2012).

In addition, this area was also chosen because the rice mill factory has started their operation for about more than 30 years. This duration was considered long enough for the pollutants from the rice mill factory to have an effect on resident's respiratory health especially for those who have lived in that area the same duration as the factory started its operation. From the observation during sampling day, the number of vehicles that moving on the road was quite low since it was rural area. This condition somehow, showed that, the PM_{10} concentration reading that was collected not affected much by the sources from the vehicles.

3.3 Study Participants

In this study, the participants involved were the residents who lived within 1 to 2 km radius from the rice mill factory. The study participants were selected within the age range from 20 to 70 years old in consideration with the duration of their residence at that place (refer Table 3.1).

Table 3.1 Inclusion and exclusion criteria

Inclusion	Exclusion
1. Participants live 1 to 2km from the rice mills factory	1. Participants that having pulmonary disease.
2. Participants understand Malay or English language.	

3.4 Study Period

Sampling duration for ambientPM_{10} monitoring was carried out for 8 hours continuously starting from 9.00 a.m. until 6.00 p.m., every Sunday and Thursday. The two days was chosen with consideration on rice mills operation. Overall, the sampling activities, questionnaires interviewing and lung function test took about one month to be completed .Therefore this study took about two months for data collection starting from March until April 2015.

3.5 Sample Size Calculation

The population size at the residential area near the rice mills, the population size is 70 people. Therefore to calculate the minimum sample size required for this study Raosoft Sample Size Calculator was used. From this Raosoft Sample Size Calculator, the confidence level was set at 95% with 5% margin error, thus the minimum recommended sample size required for this study is 60 people (Raosoft, 2004). However, even though 60 peoples are required in this study, only 47 peoples give the consent and volunteered to participate.

3.6 Sampling Method

For this study, non-probability sampling was used because it can demonstrate particular traits exist in a population. Usually in non-probability sampling, the elements were selected by non-random methods. The type of non-probability sampling that was used to select the study participants was consecutive sampling.