



**UNIVERSITI PUTRA MALAYSIA**

***EXPOSURE TO PARTICULATE MATTER (PM<sub>10</sub>) AND  
RESPIRATORY HEALTH AMONG QUARRY WORKERS IN IPOH,  
PERAK.***

**BY  
SYAZWANI BINTI AB. KHALID**

**Ip  
FPSK4 2012 50**

## ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah, all praises to Allah for the strengths and His blessing in enabling me to complete this thesis. Special appreciation goes to my supervisor, Dr. Saliza Mohd Elias, for her supervision and constant support. Her willing and support by giving constructive comments and suggestions throughout the thesis works have contributed to the success of this research. Not forgotten, my appreciation to my co-supervisor, Dr. Juliana Jalaludin for her advices, encouraging and personal guidance have provided a good basis for the preparation of this thesis.

I would like to express my deeply grateful and highest appreciation to the Imerys Minerals Sdn Bhd as well as quarry workers in Imerys Minerals Sdn Bhd for their support and cooperation during my data collection there. Sincere thanks to all my siblings whom accompanied me during my research collection there and also my friends for their kindness and moral support during my study. Last but not least, my deepest gratitude goes to my beloved parents; Ab. Khalid and Zaiton bt Md Isa as well as to my sisters for their endless love, prayers and encouragement. To those who indirectly contributed in this research, your kindness means a lot to me. Thank you very much.

## ABSTRACT

EXPOSURE TO PARTICULATE MATTER (PM<sub>10</sub>) AND RESPIRATORY  
HEALTH AMONG QUARRY WORKERS IN IPOH, PERAK

SYAZWANI BINTI AB. KHALID

**Introduction:** This cross sectional study was conducted among 33 quarry workers and 43 office workers. **Objective:** The aim of this research was to determine the association between the exposure to particulate matter, PM<sub>10</sub> and respiratory health among quarry workers. **Methodology:** A purposive sampling method was used to choose the respondents based on the inclusive criteria such as male, age between 20 to 55 years old, at least 1 year experience as quarry workers and did not have any chronic lung disease. A set of pre-tested questionnaire which was modified from the American Thoracic Society (ATD), 1978 was used to collect information on socio-demographic and respiratory symptoms. SKC Personal Air Sampler and Chestgraph HI-101 Spirometer were applied to measure the concentration of PM<sub>10</sub> and to check the lung condition of the workers. **Result:** The mean PM<sub>10</sub> concentration for exposed group was four times higher ( $459.39 \pm 303.29 \mu\text{g}/\text{m}^3$ ) compared to the mean PM<sub>10</sub> concentration for comparative group ( $116.14 \pm 9.81 \mu\text{g}/\text{m}^3$ ). There was a significant difference ( $z = -4.280$ ,  $p < 0.001$ ) in the exposure level of PM<sub>10</sub> between exposed and comparative group. There was a significant difference in FVC ( $p = 0.009$ ), FEV<sub>1</sub> ( $p = 0.002$ ), FVC % predicted ( $p = 0.004$ ) and FEV<sub>1</sub> predicted ( $p = 0.025$ ) between both groups. The prevalence of respiratory symptoms for chronic cough (OR=5.79, 95% CI=1.44-23.23), chronic phlegm (OR=4.23, 95% CI=1.19-15.07) and chest tightness (OR=9.33, 95% CI=1.06-81.86) were significantly higher among quarry workers compared to office workers. There was no association between exposure to PM<sub>10</sub> and lung function parameters in exposed groups. The result also showed that there was no significant association between working duration (years) and lung function parameters among exposed group ( $p > 0.05$ ). **Conclusion:** As a conclusion, there was no significant association between exposure to PM<sub>10</sub> concentration and lung function among quarry workers.

**Keywords:** Respirable Particles (PM<sub>10</sub>), Lung Function Test, Respiratory Symptoms

## ABSTRAK

### PENDEDAHAN KEPADA PARTIKEL TERNAFAS (PM<sub>10</sub>) DAN KESIHATAN RESPIRATORI DI KALANGAN PEKERJA KUARI DI IPOH, PERAK

SYAZWANI BINTI AB. KHALID

**Pengenalan:** Kajian rentas ini telah dijalankan ke atas 33 orang pekerja kuari dan 43 orang pekerja pentadbiran. **Objektif:** Tujuan kajian ini adalah untuk menentukan perkaitan antara pendedahan kepada partikel ternafas (PM<sub>10</sub>) dan kesihatan respiratori di kalangan pekerja kuari. **Metodologi:** Kaedah persampelan bertujuan telah digunakan untuk memilih responden berdasarkan kriteria inklusif seperti lelaki, umur di antara 20-55 tahun, mempunyai sekurang-kurangnya setahun pengalaman bekerja sebagai pekerja kuari dan tidak mempunyai sebarang penyakit paru-paru kronik. Satu set borang kaji selidik yang telah di pra-uji, yang telah diubahsuai daripada American Thoracic Society (ATS), 1978 telah digunakan untuk mengumpul maklumat sosio-demografik dan simptom respiratori di kalangan responden. Pam Persampelan Personal SKC dan Spirometer Chestgraph HI-101 telah diaplikasikan untuk mengukur kepekatan PM<sub>10</sub> dan untuk menguji keadaan paru-paru pekerja. **Keputusan:** Min kepekatan PM<sub>10</sub> untuk kumpulan terdedah adalah empat kali lebih tinggi ( $459.39 \pm 303.29 \mu\text{g}/\text{m}^3$ ) berbanding min kepekatan PM<sub>10</sub> untuk kumpulan perbandingan ( $116.14 \pm 9.81 \mu\text{g}/\text{m}^3$ ). Terdapat perbezaan yang signifikan ( $z = -4.280$ ,  $p < 0.001$ ) di dalam tahap pendedahan PM<sub>10</sub> antara kumpulan terdedah dan kumpulan perbandingan. Terdapat perbezaan yang signifikan dalam FVC ( $p = 0.009$ ), FEV<sub>1</sub> ( $p = 0.002$ ), FVC % predicted ( $p = 0.004$ ) dan FEV<sub>1</sub> predicted ( $p = 0.025$ ) antara kedua-dua kumpulan. Prevalens batuk kronik (OR=5.79, 95% CI=1.44-23.23), kahak kronik (OR=4.23, 95% CI=1.19-15.07) dan kesesakan dada (OR=9.33, 95% CI=1.06-81.86) adalah lebih tinggi secara signifikan di kalangan pekerja kuari berbanding pekerja pentadbiran. Tiada hubungan yang signifikan antara pendedahan kepada PM<sub>10</sub> dan fungsi paru-paru di kalangan kumpulan terdedah. Keputusan juga mendapati tiada hubungan yang signifikan antara tempoh bekerja (tahun) dan parameter fungsi paru-paru di kalangan kumpulan terdedah ( $p > 0.05$ ). **Kesimpulan:** Kesimpulannya, didapati tiada hubungan yang signifikan antara pendedahan kepada kepekatan PM<sub>10</sub> dan fungsi paru-paru di kalangan pekerja kuari.

**Kata kunci:** Partikel Ternafas (PM<sub>10</sub>), Ujian Fungsi Paru-paru, Simptom Respiratori

## TABLE OF CONTENT

TITLE	Page
DECLARATION	ii
SIGNATURE OF SUPERVISOR, CO-SUPERVISOR AND INTERNAL EXAMINER	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
CONTENTS	vii
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF APPENDICES	xiv
LIST OF ACRONYMS AND ABBREVIATIONS	xv
<b>CHAPTER 1: INTRODUCTION</b>	
1.1 Introduction	1
1.2 Problem Statement	5
1.3 Study Justification	8
1.4 Conceptual Framework	10
1.5 Definition of Variables	
1.5.1 Conceptual Definition	12
1.5.2 Operational Definition	15
1.6 Research Objectives	
1.6.1 General Objective	19

1.6.2 Specific Objectives	19
1.6.3 Study Hypotheses	20
<b>CHAPTER 2: LITERATURE REVIEW</b>	
2.1 Particulate matter (PM <sub>10</sub> )	21
2.2 Particulate Matter (PM <sub>10</sub> ) and its Deposition in Respiratory System	22
2.3 PM <sub>10</sub> and Health Effects	24
2.4 Lung Function Test	26
2.5 Studies Related to the Effect of PM <sub>10</sub> Exposure on Lung Function of the Workers	28
<b>CHAPTER 3: METHODOLOGY</b>	
3.1 Study Location	30
3.2 Study Design	31
3.3 Study Population	31
3.4 Sampling frame	32
3.5 Sampling Method	32
3.6 Sample Size	33
3.7 Instrumentation and Data collection	
3.7.1 Questionnaire	34
3.7.2 SECA Bodymeter	35
3.7.3 SECA Weighing Scale	36
3.7.4 AirCheck ® 52 Personal Sampling Pump	36
3.7.5 Spirometer and lung function test	42
3.8 Ethical Consideration	48

## **CHAPTER 4: RESULT**

4.1 Background and selection of respondents	49
4.2 Response Rate	50
4.3 Socio-Demographic Data among Study Groups	
4.3.1 Ethnicity and Education Level among Study Groups	51
4.3.2 Anthropometric Data among Study Groups	53
4.3.3 Smoking History among Study Groups	54
4.3.4 Previous job employment and working history	55
4.4 Personal respirable particulates (PM <sub>10</sub> ) exposure	57
4.5 Comparison of Lung Function among Study Groups	61
4.6 Comparison of Lung Function Abnormalities between Study Groups	62
4.7 Comparison of Respiratory symptoms	64
4.8 Relationship between Exposure Level to Particulate Matter (PM <sub>10</sub> ) and Lung Function	66
4.9 Relationship between Working Duration and Lung Function among Exposed Group	67
4.10 Study Limitation	68

## **CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATIONS**

5.1 Discussion	
5.1.1 Background and selection of respondents	70
5.1.2 Socio-demographic data	
5.1.2.1 Ethnicity, Education Level and Marital Status of Study Groups	72
5.1.2.2 Anthropometric Data between Study Groups	73

5.1.2.3 Smoking History	74
5.1.2.4 Previous Job and Working History	74
5.1.3 Comparison of exposure level of PM <sub>10</sub> among Study Groups	75
5.1.4 Comparison of Lung Function among Study Groups	76
5.1.5 Comparison of Respiratory Symptoms among Study Groups	79
5.1.6 Relationship between Exposure Level to Particulate Matter (PM <sub>10</sub> ) and Lung Function among Study Groups	80
5.1.7 Relationship between Working Duration and Lung Function among Study Groups	81
5.2 Conclusion	82
5.3 Recommendation	
5.3.1 Engineering Control	84
5.3.2 Administrative Control and House Keeping	84
5.3.3 Employee Exposure Monitoring	85
5.3.4 Personal Protective Equipment (PPE)	85
REFERENCES	86
APPENDICES	

## LIST OF TABLES

<b>Table</b>	<b>Caption</b>	<b>Page</b>
Table 2.1:	Abnormality of Lung Function	27
Table 3.1:	Lung Function Test Interpretation	46
Table 3.2:	Predicted Equation of FVC and FEV <sub>1</sub> Values for Malaysian Male Population with Age Range between 20 – 69 Years Old	47
Table 4.1:	The Distribution of Ethnicity, Education Level and Marital Status among Study Groups	52
Table 4.2:	Distribution of Anthropometric Data among Study Groups	54
Table 4.3:	The Distribution of Smoking History among Study Groups	55
Table 4.4:	The Distribution of Previous Job Employment among Study Groups	56
Table 4.5:	Comparison of Working History between Study Groups	57
Table 4.6:	Comparison of PM <sub>10</sub> Concentration between Study Groups	58
Table 4.7:	Comparison of Exposure Level to PM <sub>10</sub> between Study Groups	59
Table 4.8:	Comparison of Lung Function (FVC%, FEV <sub>1</sub> % and FEV <sub>1</sub> / FVC% predicted) between Study Groups	62
Table 4.9:	Comparison of Lung Function Abnormalities between Study Groups	63
Table 4.10:	Comparison of Respiratory Symptom among Study Groups	65

Table 4.11:	Association between Exposure to PM <sub>10</sub> and Lung Function	67
Table 4.12:	Association between Duration of Exposure and Lung Function	68



## LIST OF FIGURES

<b>Figure</b>	<b>Caption</b>	<b>Page</b>
Figure 1.1	Conceptual framework of PM <sub>10</sub> exposure and respiratory health among quarry workers	11
Figure 2.1	Particle Matter Size Comparison	23
Figure 3.1	SECA Bodymeter	35
Figure 3.2	SECA Weighing Scale	36
Figure 3.3	SKC AirChek 52 Air Sampling Pump	37
Figure 3.4	Chestgraph HI-101 Spirometer	43
Figure 4.1	The distribution of PM <sub>10</sub> concentration level among exposed group	60
Figure 4.2	The distribution of PM <sub>10</sub> concentration level among comparative group	60
Figure 4.3	Distribution of Respiratory Symptoms among Exposed and Comparative Group	66

## LIST OF APPENDICES

Appendix 1	Gantt Chart
Appendix 2	Flow Chart for Data Collection
Appendix 3	Ethic Approval Letter
Appendix 4	Approval Letter from Imerys Mineral Malaysia
Appendix 5	Information sheets for respondents
Appendix 6	Respondents' consent form
Appendix 7	Questionnaire form
Appendix 8	NIOSH Method 0600

## LIST OF ACRONYMS AND ABBREVIATIONS

ATS	American Thoracic Society
PM <sub>10</sub>	respirable particles less than 10µm
FEV <sub>1</sub>	forced expiratory volume in one second
FVC	forced vital capacity
WHO	World Health Organization
NIOSH	National Institute for Occupational Safety and Health

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Air pollution with particulate matter (PM) has been found to be a major threat to human health. Concentrations of PM in ambient air to PM standards, the size of the particles and spatial planning are some of the factors which have caused the health impact related to particulate matter (Priemus *et al.*, 2009).

Stone quarrying and crushing industries are an important class of “essential industry” that supplies the raw material for many large scale construction and transport related projects (Krishnendu *et al.*, 2011). The quarry industry is integral to the construction industry. Its growth is in tandem with the growth of the Malaysian

economy and the construction sector. The raw materials from a quarry are needed, among others, to make concrete, to build roads and as fill material in civil engineering and building works. Currently, one of the main issues that are affecting the industry is the impact of quarry activities on the environment as well as the surrounding residential areas. However, these are not the only problems related to quarry industry, as the health of the quarry workers also affected as they directly exposed to quarry dust while working.

The quarrying activities such as drilling, blasting and crushing may produce small dry dust particles ranging in size from 1 to 100  $\mu\text{m}$  in diameter. They may be airborne depending on their origin, physical characteristics and ambient conditions. Suspended particulate matter is quite outstanding among all pollutants emanating from quarrying operations (USEPA, 2008).

Solid materials generated during quarrying operations which can be found in the form of smoke, dust and also vapour are usually suspended over a long period in the air. Moreover, particulate matter in the air are capable of being transported from the point of generation to areas far removed (UNEP, 1991). Once particles of varying chemical compositions are inhaled, they lodge in human lungs; thereby causing lung damages and respiratory problems (Last, 1998).

Other studies by Ugbogu *et al.* (2009) also stated that these airborne particles have the potential to cause harm either locally or subsequently elsewhere in the body whenever the dust particles are deposited either on the head or in the lungs. Exposure to respirable particulates, PM<sub>10</sub> is associated with a number of human respiratory symptoms such as chronic cough, chronic phlegm, chest tightness and wheezing.

According to Deborah (1996) and National Industrial Sand Association (1997), dusts generated from granite quarrying contain 71 percent silica. Inhaling such dust results in silicosis which is capable of disabling an exposed person and subsequently, leads to death. Apart from silicosis, sandblasters, miners and quarry workers are to suffer from pneumoconiosis ([www.gulflink.osd.ml/particulate](http://www.gulflink.osd.ml/particulate)).

Suspended particulate matter may be affecting more people globally than any other pollutant on a continuous basis (Richard, et al., 2002). PM<sub>10</sub> plays an important role in the causation of asthma, lung cancer, cardiovascular issues, and premature death. Even at relatively low concentration (not exceeding standard guideline of 150ug/m<sup>3</sup> for 24 hours), inhalable particulate matter (PM<sub>10</sub>) have adverse effects on human health. Indeed, an increase of 50mg/m<sup>3</sup> in particulates levels is shown to induce increase death rate from 2 to 8 percent in several countries (Bart, 1993; HEI, 1995).

Reduction in pulmonary performance may be result even the exposure involved a healthy person. Chronic pulmonary problems afflict one in every five persons exposed to the pollutants. Such problems include reductions in spirometry values, increased incidence of chest tightness, and also wheezing (Noor *et al.*, 2000). Serious concern has been given regarding the safety of the employees working in a highly dusty environment. The workers in cement plants and quarries industries are some of the populations who are severely exposed to this occupational hazard.

Despite the high concentration of dust in quarry plant, there are only a few studies that evaluate the relationship between employee's personal exposure to  $PM_{10}$  and the respiratory health of the exposed workers. Therefore, this research will be conducted with the aims to determine the association between personal exposure to  $PM_{10}$  and respiratory health among quarry workers in Ipoh, Perak.

## 1.2 Problem Statement

The complex mixture of gases that make up the earth atmosphere has been altered much more significantly in the recent time. Human activities that range from domestic energy utilization to large scale industrial operations are largely responsible for this undesirable status of atmospheric constituents due to addition of pollutants. Air pollution is a major environmental problem affecting both the developing and the developed countries of the world. The effects of air pollution on human health are very complex as there are different sources; thereby producing varying effects ([www.edugreen.teri.res.in](http://www.edugreen.teri.res.in)).

Although industries such as power plants, cement, refineries, petrol-chemicals and mines have been identified as major sources of air pollutants, the emission of particulates is quite outstanding from quarries. Generally, the effects of dust emission from quarries have both micro and regional dimension. Air pollution and ground vibration arising from blasting, crushing and emission of noxious gases have negative impacts on human health and well-being (Oguntoke *et.al*, 2009).

The number of mining and quarrying companies is increasing from year to year due to the rapid growth of construction sector. Based on Department of Statistics Malaysia, in the year of 2010, there are about 39,225 registered mining and quarrying companies in Malaysia where 89 of them are in Perak.

The work processes in the quarry such as drilling, blasting and stone crushing activities release high concentration of dust to the air. According on Erkki (1997), the work process at the quarry involved the release of high concentration of particulate matter, thus the exposure level is higher among the exposed workers. These particulate matter ( $PM_{10}$ ) and dust will enter the body through inhalation and directly penetrate the respiratory system of the workers.

Inhalation of respirable particles ( $PM_{10}$ ) may affect the lung function normality of the workers. The inhalation of high concentration of dust may lead to either obstructive or restrictive type of pulmonary abnormalities. As the lung function of the quarry workers are affected, it can influence the job performance of the workers and finally can contribute to the low production of the quarry products. This study will be focused on  $PM_{10}$  pollutants which generated from the quarry activities and its implications on the health of the workers.

In this study, the workers will be asked to perform lung function test in order to determine and check their lung function as well as their respiratory system condition. The personal concentration level of PM<sub>10</sub> and respiratory symptoms will be determined to determine their relationship with the level of lung function of the workers. The respiratory symptoms experienced by the workers will be determined through questionnaire which adapted from American Thoracic Society (ATS) questionnaire.

The most common respiratory symptoms include chronic cough, chronic phlegm, chest tightness and wheezing. A study by Pless *et al.* (2000) reported that there was an association between PM<sub>10</sub> concentration level with respiratory symptoms, reduction of lung function and the number of patients admitted to the hospital (related to the respiratory problems) and other health problems.

### 1.3 Study Justification

A growing concern over the impact caused from quarry activities in the Malaysian quarry industry on public health and safety prompted this study which was carried out in Ipoh, Perak. On 31<sup>st</sup> March 2012, The Star newspaper has reported that the residents in Bandar Baru Putra in Bercham, Ipoh, have called on the authorities to act against a quarry factory operating round-the-clock, resulting in dust and noise pollution. The dusts released from the quarry have resulted the people living nearby are getting skin rashes and flu. If the public who do not working at the quarry area experienced these kind of health effects, then the quarry workers experienced more as they directly get exposed to the quarry dust for 8 hours continuously.

Until now, there are only a few local studies on particulate matter (PM<sub>10</sub>) with their effects on respiratory health, particularly among quarry workers in Malaysia. As the number of quarry companies has increased years by years, it is important for health scientists in developing countries like Malaysia to monitor the health impacts of increasing dust concentration which released from the quarry activities among quarry workers.

Through this study, emphasize will be given to respiratory effect of particulate matter (PM<sub>10</sub>) released at the quarry area, exposure through direct inhalation and its effects on quarry worker's lung function and respiratory symptoms. Thus, information and results including the prevalence of respiratory symptoms among quarry workers can be used as a baseline data for the quarry company since there is no study done yet regarding the personal employee exposure to particulate matter (PM<sub>10</sub>) and respiratory health among quarry workers at this company.

The lung function test is important in indicating the respiratory disease such as asthma and also chronic restrictive or obstructive lung disease (Murray *et al.*, 1979., Hetzel *et al.*, 1979). From the result of lung function, preventive and control measures can be taken in minimizing the exposure to respirable particles and also respiratory symptoms.

According to Factories and Machinery (Mineral Dust) Regulations 1989, it is the duty of the employer to carry out exposure monitoring and medical surveillance among employees. In proportion to the regulations, the data obtained will help the employer to have clear view on the PM<sub>10</sub> exposure to the employees and enables the company to develop suitable and effective control measures in order to minimize worker's exposure to the PM<sub>10</sub>.

#### 1.4 Conceptual Framework

Figure 1.1 shows the conceptual framework of the  $PM_{10}$  exposure in quarry industry and related respiratory symptoms. The quarry activities may contribute to the air pollution, water pollution, soil pollution and also noise pollution. However, this study only focuses on employee's exposure to indoor air pollution at the workplace through inhalation of  $PM_{10}$ . How far these particles can get into the respiratory tract depends on the volume of air inhaled, size, density, its form and aerodynamic nature.

There are five ways of deposition of  $PM_{10}$  in respiratory tract namely by deposition, precipitation via gravity, interception, electrostatic deposition, and also diffusion. The lung function test can be used to determine the lung function status and to determine any abnormalities or existence of respiratory symptoms such as chronic cough, chronic phlegm, chest tightness and wheezing among the quarry workers.

There are several factors that influence the lung function test result such as age, gender, smoking habit, previous history of disease and also health status which can indicate whether the lung is in normal condition or not.

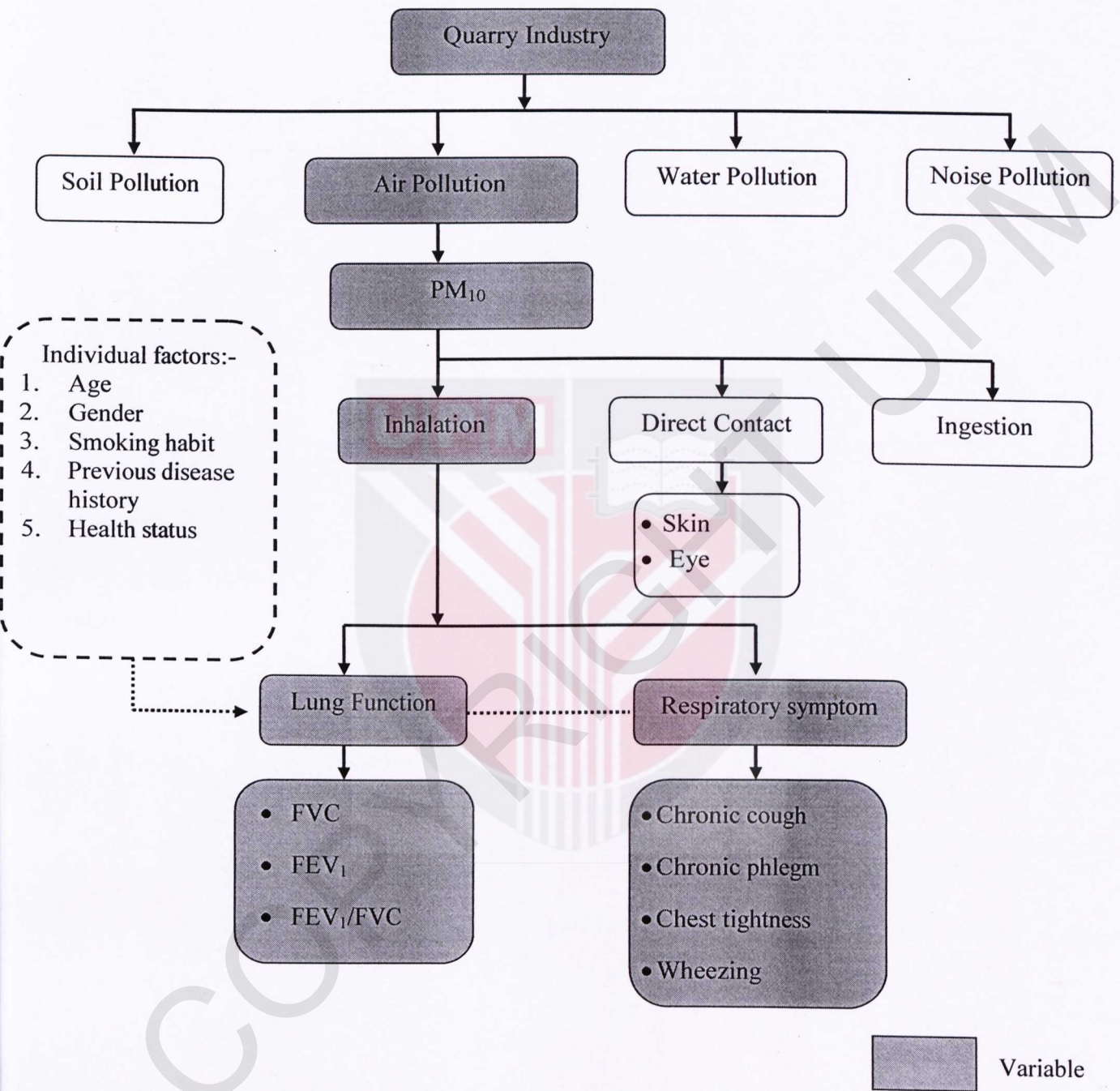


Figure 1.1: Conceptual framework of PM<sub>10</sub> exposure and respiratory health among quarry workers

## **1.5 Definition of Variables**

### **1.5.1 Conceptual Definition**

#### **1.5.1.1 PM<sub>10</sub>**

PM<sub>10</sub> refer to particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair) (EPA, 2010).

#### **1.5.1.2 Respiratory symptoms**

Respiratory tract symptoms can be defined as conditions that resulted from a disturbed respiratory system by various factors either internal or external factors. The examples of respiratory symptoms are cough, phlegm, episodes of cough and phlegm, wheezing, breathlessness, chest cold and chest illness.

### **1.5.1.3 Cough**

Cough is a reaction or reflex which helps to keep things out of lungs and clears things that are not supposed to be in the lungs (ATS Patient Health Series, 2011).

### **1.5.1.4 Phlegm**

Phlegm or known as sputum production is the mucus coming from the lungs with the function to keep the breathing pathways moist (ATS, 2011).

### **1.5.1.5 Wheezing**

A raspy whistle sound during breathing. Having wheezing or whistling sound in breathing associated with breathlessness on most days or nights (ATS, 1978).

### **1.5.1.6 Breathlessness**

Breathlessness refer to a feeling occurring when the lung changes from working in the way it was normally designed to work, to working differently. If the lung senses that it takes more work or effort to move air in and out of the lungs, a feeling of breathlessness will be experienced.

### **1.5.1.7 Chest cold**

Most common signs and symptoms of a cold start gradually and can include a runny nose, watery eyes, sneezing and/or a sore throat (ATS, 2004).

### **1.5.1.8 Chest illness**

Symptom is varying among individual. It can be severe pain, crushing, squeezing and pressure in chest.

### **1.5.1.9 Forced Vital Capacity (FVC)**

The maximum volume of air exhaled with maximally forced effort from a maximal inspiration (ATS, 2005).

### **1.5.1.10 Force Expiratory Volume in One Second (FEV<sub>1</sub>)**

The maximum volume of air exhaled in the first second of a forced expiration from a position of full inspiration (ATS, 2005).

## **1.5.2 Operational Definition**

### **1.5.2.1 PM<sub>10</sub>**

The exposure level of PM<sub>10</sub> is measured by personal air sampling pump for 8 hours work duration. The instrument is attached to respondents.

### **1.5.2.2 Respiratory symptoms**

The occurrence and intensity of respiratory symptoms is evaluated using a modified questionnaire which developed from American Thoracic Society (ATS-DLD-78-A Adult Questionnaire). Symptoms evaluated are cough, phlegm, episodes of cough and phlegm, wheezing, breathlessness, chest cold and chest illness.

### **1.5.2.3 Cough**

Cough symptoms are determine from the study questionnaire modified from ATS (1978).

### **1.5.2.4 Phlegm**

Phlegm symptoms are determine from the study questionnaire modified from ATS (1978).

#### **1.5.2.5 Wheezing**

Wheezing symptoms are determined from the study questionnaire modified from ATS (1978).

#### **1.5.2.6 Breathlessness**

Breathlessness symptoms are determined from the study questionnaire modified from ATS (1978).

#### **1.5.2.7 Chest cold**

Chest cold symptoms are determined from the study questionnaire modified from ATS (1978).

#### **1.5.2.8 Chest illness**

Chest illness symptoms are determined from the study questionnaire modified from ATS (1978).

### **1.5.2.9 Forced Vital Capacity (FVC)**

The FVC is measured using the spirometer (Chestgraph HI-101 Model) and expressed in litres.

### **1.5.2.10 FEV<sub>1</sub>**

The FEV<sub>1</sub> is measured for the volume of air exhaled during the first second with spirometer (Chestgraph HI-101 Model) and expresses litres.

### **1.5.2.11 FEV<sub>1</sub> % Predicted**

Percentage value of measured FEV<sub>1</sub> divided with FEV<sub>1</sub> predicted of a respondent.  $FEV_1 \% \text{ Predicted} = (FEV_1 \text{ Measured} / FEV_1 \text{ Predicted}) \times 100$

### **1.5.2.12 FVC % Predicted**

Percentage value of measured FVC divided with FVC predicted of a respondent.  $FVC \% \text{ Predicted} = (FVC \text{ Measured} / FVC \text{ Predicted}) \times 100$

## 1.6 Research Objective

### 1.6.1 General Objective

To determine the association between the exposures to particulate matter ( $PM_{10}$ ) and respiratory health among quarry workers in Ipoh, Perak.

### 1.6.2 Specific Objectives

1. To determine socio-demographic data of exposed and comparative group.
2. To compare personal  $PM_{10}$  exposure level among exposed and comparative group.
3. To compare lung function level among exposed and comparative group.
4. To compare the respiratory symptoms among exposed and comparative group.
5. To determine the association between personal  $PM_{10}$  exposure level and lung function level among exposed group.
6. To determine the association between working duration and lung function level among exposed group.

### 1.6.3 Study Hypothesis

1. The personal PM<sub>10</sub> exposure level is significantly higher among exposed group compared to comparative group.
2. The lung function levels are significantly reduced in exposed group compared to comparative group.
3. The respiratory symptoms are significantly higher among exposed group compared to comparative group.
4. There is a significant association between personal PM<sub>10</sub> exposure level and lung function level in exposed group.
5. There is a significant association between working duration and lung function level among exposed group.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Particulate matter (PM<sub>10</sub>)

Particulate matter (PM) is the term used for a mixture of solid particles and liquid droplets suspended in the air. These particles originate from a variety of sources, such as power plants, industrial processes, diesel trucks and they are formed in the atmosphere by transformation of gaseous emissions. Particulate matter composed of both coarse and fine particles. As defined by U.S Environmental Protection Agency (USEPA), the PM<sub>10</sub> standard includes particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair). The chemical and physical compositions of these particulates are depending on location, time of year, and weather (EPA, 2004). EPA's health-based national air quality standard for PM<sub>10</sub> is 50  $\mu\text{g}/\text{m}^3$  (measured as an annual mean) and 150  $\mu\text{g}/\text{m}^3$  (measured as a daily concentration).

Coarse particles ( $PM_{10}$ ) are formed by mechanical disruption such as crushing, grinding and abrasion of surfaces, evaporation of sprays, and suspension of dust.  $PM_{10}$  can be composed of aluminosilicate and other oxides of crustal elements, and major sources including fugitive dust from roads, industry, agriculture, construction and demolition, and fly ash from fossil fuel combustion. The lifetime of  $PM_{10}$  is from minutes to hours, and its travel distance varies from  $< 1$  km to 10 km (Fierro, 2000).

## 2.2 Particulate Matter ( $PM_{10}$ ) and its Deposition in Respiratory System

Particulate matter air pollution (PM) is a complex mixture of substances, including carbon-based particles, dust and acid aerosols formed in the atmosphere from byproducts of gaseous combustion, such as volatile organic compounds (VOCs), sulfur dioxide and nitrogen oxides.

The particles vary in size where the largest are more easily trapped in the nose or throat, while smaller particles can be drawn into the smaller air passages. Those of special concern have a diameter of 10 microns or less, or less than one-seventh the

diameter of a human hair. Those measuring 2.5 to 10 microns are called coarse particles.

Figure 2.1 shows the comparison of particle matter size.

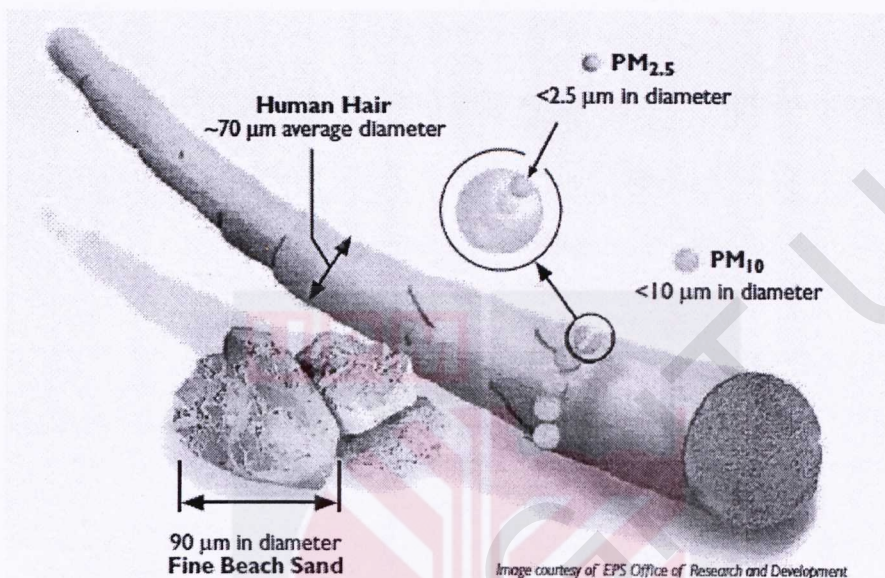


Figure 2.1 : Particle Matter Size Comparison ( U.S.E.P.A, 2007)

Particle aerodynamic diameters will determine if and for how long dusts remain airborne, their likelihood of being inhaled, and their site of deposition in the respiratory system. Dust concentration in the air and the aerodynamic diameter of the particles will determine the amount of material deposited, hence the dose received at the critical site.

Very soluble substances can be absorbed from all parts of the respiratory tract, so for soluble particles the site of deposition (and hence aerodynamic diameter) is of less importance. For insoluble particles, the site of deposition in the respiratory system is of

fundamental importance, which means that the aerodynamic properties of the particle, shape (fibres), dimensions of the airways and breathing patterns are relevant.

These particles can accumulate in the respiratory system and are associated with numerous health effects (Dockery and Pope 1994). Once particles of varying chemical compositions are inhaled, they will lead to lung damages and respiratory problems as they lodge in human lungs (Olusegun *et al.*, 2009).

### 2.3 PM<sub>10</sub> and Health Effects

The health risk associated with a dusty job depends on the type of dust (physical, chemical and mineralogical characteristics), which will determine its toxicological properties, and hence the resulting health effect; and the exposure, which determines the dose. Exposure depends on the air (usually mass) concentration and particle aerodynamic diameter of the dust in question, and exposure time (duration). The dose actually received is further influenced by conditions that affect the uptake, for example, breathing rate and volume.

Health effects resulting from exposure to dust may become obvious only after long-term exposure; this is often the case with pneumoconioses. It may happen that effects appear even after exposure has ceased, thus being more easily overlooked or mistakenly attributed to non-occupational conditions. For example, mesothelioma resulting from exposure to crocidolite has appeared after latency periods of 40 years or more after beginning of exposure. Therefore, the fact that workers do not have any symptoms, or that symptoms appear after a long time, should be no excuse for inactivity concerning avoidance of exposure to known hazards.

However, many dusts have effects that result from shorter exposures to higher concentrations. Even when dealing with pneumoconioses-producing dusts, there are cases of acute effects. Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions, such as asthma (Halek *et al.*, 2004). Health effects, which may result from exposure to different types of dust, include pneumoconioses, cancer, systemic poisoning, hard metal disease, irritation and inflammatory lung injuries, allergic responses (including asthma and extrinsic allergic alveolitis), infection, and effects on the skin. The same agent can cause a variety of adverse health effects, for example, certain wood dusts have been known to cause such impairment as eye and skin irritation, allergy, reduced lung function, asthma, and nasal cancer.

According to Richard (2002), suspended particulate matter may be affecting more people globally than any other pollutant on a continuous basis. Going by epidemiological studies, a dose-response relationship between exposure to PM<sub>10</sub> and respiratory morbidity and mortality are established (Dockery and Pope, 1994; Pope *et al.*, 1995). Likewise, it is the role of PM<sub>10</sub> in the causation of asthma, lung cancer, cardiovascular issues and premature death. Inhalable particulate matters (PM<sub>10</sub>) have adverse effects on human health even at relatively low concentration (not exceeding standard guideline of 150µg/m<sup>3</sup> for 24 hours).

## 2.4 Lung Function Test

Spirometry or also known as lung function test is the most common of the Pulmonary Function Tests (PFTs), measuring lung function, specifically the measurement of the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled. Spirometry is an important tool used for generating pneumotachographs which are helpful in assessing conditions such as asthma, pulmonary fibrosis, cystic fibrosis and chronic obstructive pulmonary disease (COPD).

Table 2.1 shows the abnormalities of lung function which consist of obstructive and restrictive disease, based on the value of FVC % predicted and FEV<sub>1</sub> % predicted. The measurement of lung volume can detect restrictive lung disease where a person cannot inhale normal volume of air. This disease may have been caused by bleeding or scratch in lung tissue or muscle tissue abnormal or bone in chest wall.

**Table 2.1: Abnormality of Lung Function**

<b>Obstructive Disease</b>	<b>FEV<sub>1</sub>% Predicted</b>
Normal	≥80
Mild	79-70
Moderate	70-60
Severe	<60
<b>Restrictive Disease</b>	<b>FVC % Predicted</b>
Normal	≥80
Mild	79-70
Moderate	70-60
Severe	<60

(Source: *ATS*, 1991)

Lung function test evaluate the amount of volume of air that can be retained by lung, how fast the movement of air going in and out through lung, and how good efficient the lung can exchange the oxygen from the lung into the blood and remove carbon dioxide from the blood. This test can assist to detect early respiratory disease and

measure the severity of lung problems that caused abnormal respiratory problems (Spengler *et al.*, 2003).

## **2.5 Studies Related to the Effect of PM<sub>10</sub> Exposure on Lung Function of the Workers**

Singh *et al.* (1993) in his study on spirometry among Malaysian age between 13-69 years old describe that the measurement of lung function parameter is higher in males compared to females. This is due to the anthropometric measurement such as height and weight of males is relatively higher than females. This study also has found that age is one of the factors that influence the lung function especially among elders with age 40 and above.

Furthermore, according to Noor *et al.* (2000), the effect of cement dust exposure which is in the form of PM<sub>10</sub> on the lung function of cement workers also involved the controlling of associated factors like age and smoking habit. This study also have found that the workers who have significant exposure to cement dust (PM<sub>10</sub>) showed significantly lower FEV<sub>1</sub>% and FEF<sub>25-75</sub>% and higher FMFT with the increasing level of

dust exposure. Yang *et al.*, (1993) has also reported the lower value of FVC,  $FEV_1 < FEF_{50}$  and  $FEF_{75}$  among the workers which exposed to cement dust in Portland.

Murugan (2000) in his study on 146 quarry workers stated that the value of FVC% predicted,  $FEV_1$ % predicted and  $FEV_1/FVC$ % predicted are lower among exposed group compared to non exposed group. His study has also reported that the lower FVC% predicted value has indicated the occurrence of restrictive disease among quarry workers. This clearly showed that the exposure of quarry dust ( $PM_{10}$ ) can affect the lung function of exposed workers.

## CHAPTER 3

### METHODOLOGY

#### 3.1 Study location

This study was conducted at a quarry factory in Ipoh, Perak for exposed group (refer Appendix 3) and at Faculty of Veterinar, Universiti Putra Malaysia for the comparative group. The quarry company was selected as it fulfilled the study criteria in which the work processes in this quarry involved high exposure of particulate matter (PM<sub>10</sub>) to the workers.

### **3.2 Study Design**

This was a cross sectional-comparative study design with the aims to determine the association between the exposure to  $PM_{10}$  and respiratory health among exposed group and comparative group in a quarry company in Ipoh, Perak. In this study, the study populations were the exposed and comparative group. The exposed group referred to the quarry workers who exposed to particulate matter ( $PM_{10}$ ) while the comparative group referred to the UPM staffs.

### **3.3 Study population**

The target population for this study was male workers, age range between 20 to 55 years old, no past history of chronic lung disease and at least one year experienced working at the quarry for the exposed group. The same inclusion criteria was used to choose the target population for the comparative group (male workers, age range between 20 to 55 years old, no past history of chronic lung disease and at least one year experienced working as office workers) (refer to Appendix 2).

### **3.4 Sampling frame**

The name list of workers which fulfilled the inclusive criteria was obtained from the quarry company and the Faculty of Veterinar, Universiti Putra Malaysia. A total of 33 quarry workers and 43 office workers have fulfilled the inclusion criteria needed.

### **3.5 Sampling Method**

Parkes (1994), stated that age and smoking habit are important issues which need to be considered in the selection of sample. The lung function can be affected due to the increased of age and also exposure to the cigarette smoke. Other than that, ethnicity and history of respiratory symptoms also have to be considered as they can influence the lung function level. If these factors cannot be avoided in the selection of sample, hence matching process was done to prevent these confounding factors from interrupting the study result. Purposive sampling method has been used to choose 76 respondents.

### 3.6 Sample Size

The sample size for this study was based on Rubinson and Nuetens (1987). The formula used is as follows:

$$n = (z/e)^2 (p) (1 - p)$$

Where:

n = sample size

p= prevalence

e= standard error (0.10)

z= 1.96

Based on (Rastogi *et.al*, 2003) the prevalence of pulmonary abnormalities is 22.3%.

$$\begin{aligned} n &= (1.96/0.10)^2 (0.223) (1 - 0.223) \\ &= 66.56 \\ &= 67 \end{aligned}$$

To account for any missing data during data collection, rounded it up to 20% of n, thus the total sample size was 80 for both exposed and comparative group. 33 respondents from exposed group and 43 respondents from comparative group were selected to join this study. However, the total number of exposed group and comparative

group were smaller compared to the sample size that has been calculated before starting the data collection. Time constraint for data collection was the main reason for smaller sample size of this study.

### **3.7 Instrumentation and Data Collection Techniques**

#### **3.7.1 Questionnaire**

A set of pre-tested questionnaire modified from the American Thoracic Society Adult Questionnaires (refer to Appendix 6) was used to obtain data on socio-demography such as age, gender, ethnicity, education level, marital status, working experience, smoking habits, respiratory symptoms and history of disease (ATS, 1978).

The subjects were interviewed face to face by using a standardized questionnaire which is adapted from the American Thoracic Society (1978) respiratory symptoms. The questionnaire is pertaining to the respiratory symptoms, past medical history, smoking and occupational history. The data obtained was analyzed using Statistical Package for Social Sciences software (SPSS) (Version 19.0).

### 3.7.2 SECA Bodymeter

Figure 3.1 shows SECA Bodymeter which was used to measure the height of respondent. The respondent was asked to take off his shoe and stand right on a wall where this equipment will be set up on it. Then the height of the respondent was recorded by the assessor.



Figure 3.1: SECA Bodymeter

(Source: SECA Website, 2011)

### 3.7.3 SECA Weighing Scale

SECA weighing machine (refer Figure 3.2) was used to measure the weight of the respondent in kilogram unit. The respondent was asked to take off their shoes during the weighing process to avoid any bias in the measurement.



Figure 3.2: SECA Weighing Scale

(Source: SECA Website, 2011)

### 3.7.4 The AirCheck ® 52 Personal Sampling Pump

Figure 3.3 shows the SKC Personal Air Samplers. This pump was employed for the assessment of respirable particulate matter exposure on the workers and was worn by them, with the collection media clipped close to their collars (breathing zone). The

monitoring was carried out on 31 January 2012 until 16 February 2012 for 8 hours continuously.

Respirable dust samples were collected using Aluminium cyclones equipped with a 37mm diameter poly vinyl chloride (PVC) filter (pore size  $5\mu\text{m}$ ) at a flow rate of 2.5 L/min. The method used for monitoring of personal exposure to  $\text{PM}_{10}$  was based on NIOSH Manual of Analytical Method 0600 (refer to Appendix 7).



Figure 3.3: SKC AirChek 52 Air Sampling Pump

(Source: SKC Website, 2011)

### 3.7.4.1 Preparation before Sampling

- a) The filter cassette was washed with soap detergent; it is rinsed thoroughly under running water. After that, the filter cassette was soaked in 50% nitric acid for 24 hours and was rinsed thoroughly with distilled water. Lastly, the filter paper was left to dry.
- b) Before initial weighing, all filters were placed on a Petri dish / envelopes and were dried out in the oven at 40°C for 2 hours. The filter then was stored in a desiccant cabinet to remove any moisture.
- c) For sampling, the filter was removed from the desiccant cabinet one at a time and was weigh one at a time. A balance with a drying cylinder was used to prevent moisture error during weighing.
- d) Pre-exposed weight of the filter correlating the weight to the filter number was recorded. The filter was placed in its holder using a tweezers and the holder/cassette was sealed. Finally, the holder/cassette was labeled.
- e) The balance was zero before each weighing.
- f) The filter was handled with forceps (nylon forceps if further analyses will be done).
- g) The filter was passed over an anti-static radiation source. This step was repeated if filter did not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.

- h) The filter was assembled in the filter cassettes and was closed firmly so that leakage around the filter will not occur. A plug was placed in each opening of the filter cassette.
- i) The cyclone's grit cap was removed before use and the cyclone interior was inspected. If the inside is visibly scored, this cyclone was discarded since the dust separation characteristics of the cyclone may be altered. The interior of the cyclone was cleaned to prevent re-entrainment of large particles.
- j) The sampler head was assembled. The alignment of filter holder and cyclone in the sampling head was checked to prevent leakage.

#### **3.7.4.1.1 During Sampling**

- a) Each personal sampling pump was calibrated to the appropriate flow rate with a representative sampler in line.
- b) The sampling equipment was placed on the employee.
- c) The filter cassettes was attached to the shirt collar or as close as practical to the nose and mouth of the employees. The inlet should always be in a downward vertical position to avoid gross contamination.
- d) The sampling time was 8 hours.
- e) The pump was turned on and the starting time was recorded.
- f) The pump operation was observed for a short time after starting to make sure it was operating correctly.

### 3.7.4.2 Post Sampling

- a) Before removing the pump at the end of the sample period, the flow rate was checked to ensure that the rotameter ball is still at the calibrated mark.
- b) If the ball is no longer at the mark, the pump rotameter reading was recorded.
- c) The pump was turned off and the ending time was recorded.
- d) The collection device was removed from the pump and was sealed as soon as possible. The seal should be attached across sample inlet and outlet so that tampering was not possible.
- e) After sampling, the cover removed from the filter holder and the exposed filter was placed. Filter must be free from the backup disk before drying.
- f) After drying, the filter was removed from the drying cabinet one at a time using tweezers and was placed on the balance for weighing.
- g) The final weight was recorded.
- h) The post-exposed filter was weighed 3 consecutive times and the variations in the readings was ensured not exceeding 1 microgram.
- i) Should the readings vary, than the weighing balance was recalibrated before use.

### 3.7.4.3 Quality Control for Personal Air Sampling

The quality controls that were taken for this monitoring include Standards Operating Procedures (SOP), calibration, and weighting. Example of SOP for this monitoring was ensuring the cassette was cleaning with acid wash to get clean cassette before using it. If not, it may disturb the real suction of PM<sub>10</sub> at the particular venue of monitoring.

Other quality control involve was by ensuring the filter paper was dried in 40°C oven for 2 hours to get dry filter paper and again no possibility to scar the weighing of filter paper. Filter paper was handled with care. The sample collector needs to use forceps instead of bare hands to avoid contamination while having a contact with it. The microbalance was zero before weighting and the same microbalance was used before and after sample collection.

The filter paper was placed in the cassette and sealed with masking tape. The weight, date, sample ID was labeled on it. Before measurement, the pump was fully charged and in good condition. The calibration was focus on calibrating the pump. Since the volume of the air depends on the flow rate, calibration of the pump to the appropriate volumetric flow rate and verification of the flow rate during the sampling period was

very important. The flow rate of the pump was adjusted to achieve the desired flow rate 2.5 L/min.

Finally, the pump was recalibrated to check the flow rate and to calculate the errors after sampling. If the error was more than 10%, then the sample must be rejected. Therefore, the pump was calibrated before and after sampling. After sampling, the pumps were calibrated before being recharged. All of these steps taken were handled carefully to avoid loss of particulate from filter or the contamination of filter paper.

### **3.7.5 Spirometer and lung function test**

The spirometer (refer Figure 3.4) was used to measure lung function parameter such as FVC, FEV<sub>1</sub> and FEV<sub>1</sub>/FVC. The proper instruction to undergo lung function test was as follows; a respondent breathe into a mouthpiece on a device called a spirometer. At the same time, it makes a tracing of the rate at which the air leaves the lung. Diseases of airflow obstruction and of lung stiffening give characteristics tracings with spirometry. It measured how fast and how much total air that a person can breathe out.



Figure 3.4: Chestgraph HI-101 Spirometer

#### 3.7.5.1 Pre Sampling

The steps taken vary with the equipment in use, and first of all, the spirometer was turned on in time so that it is stable. Then, the spirometer was checked to ensure it is well-functioning. Then, the calibration was performed and fresh and clean mouthpiece was prepared for the respondent's use.

After all the equipment was ready, the respondents were given some briefing on the purpose of the test and a demonstration on how to do it was shown. After that, the respondent's age, gender, and race was recorded, and height and weight was measured before the procedure begins.

The respondents were ensured not eaten heavily within two hours of the test. Then, the respondents were instructed to wear loose-fitting clothing over the chest and abdominal area. The testing personnel explained and demonstrated the breathing maneuvers to the respondent. The respondents were given a chance to practice breathing into the mouthpiece until they were able to duplicate the maneuvers successfully on two consecutive attempts.

#### **3.7.5.2 During Sampling**

To ensure an acceptable result, the FVC maneuver was performed with maximum effort immediately following a maximum inspiration. It should have a rapid start and the spirogram and flow-volume curve should be a smooth continuous curve.

After all the respondent's data were recorded, the respondents was given 10 minutes to rest, before performing spirometry. Then, the respondents were ensured to stand in a correct posture (the most comfortable position) in order to start spirometry test. The nose clip was placed at respondent's nose to prevent air escaping through the nose. Then, the respondents were urged to:

- seal his lips around the mouthpiece
- breathe in fully (must be absolutely full)

- immediately blast air out as fast and as far as possible until the lungs are completely empty while maintaining an upright posture
- repeat instruction as necessary, coaching vigorously
- repeat the lung function test for at least three times

### **3.7.5.3 Post Sampling**

After the spirometry test completed, only the best result of lung function test for each respondents was selected. In order to ensure the validity of the test, only the respondent's spirogram with rapid start, have a smooth continuous curve and have at least four second expiration was taken as the respondents.

### **3.7.5.4 Interpretation of Lung Function Test**

Lung function test cannot be used to diagnose the respiratory illness, however it can determine the condition of the lung. Based on Jane *et al.* (2000), there was an association between lung function and two types of respiratory symptoms; obstructive lung disease and restrictive lung disease. The important indicator for obstructive lung disease is FEV<sub>1</sub> in which, the value of % FEV<sub>1</sub>/FVC is less than 75%. The value of % FEV<sub>1</sub>/FVC is inversely proportional with the magnitude level of disease, in which the lower % FEV<sub>1</sub>/FVC, the higher magnitude level of disease (Miller, 1978).

In the other hand, the restrictive disease is categorized as the abnormalities of the lung to fully expand due to various factors such as effect on the left ventricle, impairment of chest wall movement and fibrosis (Parkes, 1994). The important indicator for this type of disease is the value of vital capacity less than 80% of the predicted value (ATS, 1978). Both of these categories of respiratory symptoms are dependent on the percentage of FEV<sub>1</sub>/FVC as mentioned in Table 3.1 below:

**Table 3.1: Lung Function Test Interpretation**

	FEV <sub>1</sub> Predicted	FVC Predicted
Normal	≥ 80	≥ 80
Low	70 - 79	70 - 79
Moderate	60 - 69	60 - 69
Severe	< 60	< 60

Source: ATS (1991)

The predicted equation values based on Singh *et al.* (1993) was used in this study. This reference values was believed to reflect the Malaysian population which covering most racial and socioeconomic groups. Table 3.2 below shows the predicted equation that has been used in this study.

**Table 3.2: Predicted Equation of FVC and FEV<sub>1</sub> Values for Malaysian Male Population with Age Range between 20 – 69 Years Old**

Lung function parameter	Predicted values
FEV <sub>1</sub>	[ 0.0353 (Height in cm) – 0.0315 (Age)] – 1.784
FVC	[ 0.0407 (Height in cm) – 0.0296 (Age) – 2.343

Source: Singh *et al.* (1993)

#### 3.7.5.5 Quality Control for Lung Function Test

Quality control was done at different stages in the study especially during the collection, measurement and data analyzing to ensure reliability and validity of data. Some of the quality controls for lung function test include:

- a) demonstration on how to do the spirometry test and each subject was given a chance to try it before the real test.
- b) the subjects were observed and encouraged throughout the procedure.
- c) subject with flu or cough was excluded from doing the test.

d) the subjects was asked if they took any medications or having any medical conditions that may affect the validity of the test.

e) the subject's smoking habits and history was thoroughly documented.

### **3.7 Ethical Consideration**

While conducting this study, several aspects have been considered to obey the research ethics. Permission from the company management is obtained first before conducting the study. The participation of the respondents was based on their willing and some briefing concerning this study was given to them before starting the data collection. All of the information obtained is private and confidential.

## CHAPTER 4

### RESULT

#### 4.1 Background and selection of respondents

A study on the relationship between personal exposures to particulate matter ( $PM_{10}$ ) and respiratory health among quarry workers has been conducted in one quarry company in Ipoh, Perak. The study sample that has been chosen consisted of 33 quarry workers as the exposed group while 43 male administrative workers from Faculty of Veterinary were selected as the comparative group, those who did not expose to respirable particles ( $PM_{10}$ ) in the workplace.

The quarry workers were selected based on the purposive sampling method, which fulfilled the inclusive criteria (male, age range between 20 to 55 years, no past

history of chronic lung disease and at least one year experienced working as quarry workers). The same inclusive criteria were used for the comparative group, which was the administrative workers (male, age range between 20 to 55 years, no past history of chronic lung disease and at least one year experienced working as office workers).

#### **4.2 Response Rate**

In this study, 33 quarry workers which fulfilled the inclusive criteria were chosen as the exposed group. The comparative group had 51 initial samples but only 43 samples matched the inclusive criteria. The inclusive criteria for both groups are were restricted to age range between 20 to 55 years, no past history of chronic lung disease and at least one year experienced working at quarry or as office workers. The response rate for both exposed and comparative groups were respectively 100%.

### 4.3 Socio-Demographic Data among Study Groups

#### 4.3.1 Ethnicity and Education Level among Study Groups

Based on Table 4.1, this study involved four ethnic groups for exposed group and two ethnic groups for comparative group. Most of the quarry workers are Malays (54.5%), followed by others ethnicity (33.3%), Chinese (9.1%) and Indians (3.0%). For other ethnicity, it included the aborigines and Indonesians.

For comparative group, majority of them are Malays (86.0%) and Indians (14.0%). Both respondents have different education level. For exposed group, majority of them had SPM level (42.4%), and then followed by PMR (30.3%), others (21.2%), Degree (3.0%) and also did not have any formal education at all (3.0%). For comparative group, most of them had STPM/Diploma level (44.2%), SPM level (41.9%), Degree (11.6%) and also PMR (2.3%). Based on the marital status result shown, majority of the respondents from exposed group (60.6%) have married compared to comparative group (44.2%) where most of them are single person (53.5%).

**Table 4.1: The Distribution of Ethnicity, Education Level and Marital Status among Study Groups**

Variables	Exposed group (n = 33)	Comparative group (n = 43)
	Number (%)	Number (%)
<b>Ethnicity</b>		
Malay	18 (54.5)	37 (86.0)
Chinese	3 (9.1)	-
Indian	1 (3.0)	6 (14.0)
Others	11 (33.3)	-
<b>Education</b>		
PMR	10 (30.3)	1 (2.3)
SPM	14 (42.2)	18 (41.9)
STPM/Diploma	-	19 (44.2)
Degree	1 (3.0)	5 (11.6)
Others	7 (21.2)	-
None	1 (3.0)	-
<b>Marital Status</b>		
Single	11 (33.3)	23 (53.5)
Married	20 (60.6)	19 (44.2)
Divorce	2 (6.1)	1 (2.3)
N=76		

### 4.3.2 Anthropometric Data among Study Groups

Table 4.2 shows that the distribution of anthropometric data for exposed group and comparative group. Factors such as age, height and weight are some factors that may affect the lung function level of the respondents.

To control these confounding factors from interrupting the study result, matching process was done between exposed and comparative group by using appropriate statistical analysis. It was found that there was no significant difference between age, height and weight factors between these two groups. This shown that the distribution of age, height and weight will not interrupt the study result. No significant differences in the mean values of physical parameters were found between the two groups. The mean age for exposed group was  $34.48 \pm 9.12$  years and mean age for comparative group was  $32.23 \pm 7.79$  years.

**Table 4.2: Distribution of Anthropometric Data among Study Groups**

Variable	Exposed group (n=33)	Comparative group (n=43)	z value	p value
	Mean±SD	Mean±SD		
Age (Year)	34.48 ± 9.12	32.23 ± 7.79	-1.096	0.273
Height (cm)	164.39 ± 7.49	166.51 ± 6.50	-1.254	0.210
Weight (kg)	64.76 ± 10.02	62.53 ± 9.52	-0.894	0.371

N=76

#### 4.3.3 Smoking History among Study Groups

Smoking habit was also one of the confounding factors that may affect the lung function of the respondents. Table 4.3 reported that for smoking status, there were 93.9% smokers among exposed group compared to 90.7% smokers in the comparative group.

Based on the statistical analysis that has been done, there was no significant difference between these two groups. The result in the Table 4.3 found that most of the respondents from both groups smoking between 10 to 20 cigarettes per day (75.8% for exposed group and 60.5% for the comparative group).

**Table 4.3: The Distribution of Smoking History among Study Groups**

Variable	Exposed group	Comparative group	$\chi^2$ value	p value
	(n=33)	(n=43)		
	Number (%)	Number (%)		
<b>Smoking status</b>				
Smokers	31 (93.9)	39 (90.7)	-	<sup>a</sup> 0.692
Non-smokers	2 (6.1)	4 (9.3)		
<b>No. of cigarette per day</b>				
< 10	5 (15.2)	9 (20.9)	2.354	0.502
10 - 20	25 (75.8)	26 (60.5)		
> 20	1 (3.0)	4 (9.3)		

<sup>a</sup>Fisher's Exact Test

#### 4.3.4 Previous job employment and working history

Table 4.4 presents the distribution of previous job employment among exposed and comparative group. Majority of the respondents from exposed groups have working experience before (81.8%) compared to the comparative group (48.8 %). Most of the respondents from the comparative group (51.2%) did not have any previous job

employment compared to exposed group which was only 18.2% have no previous job employment.

**Table 4.4: The Distribution of Previous Job Employment among Study Groups**

Variable	Exposed group	Comparative group
	(n=33)	(n=43)
	Number (%)	Number (%)
Previous job employment		
Yes	27 (81.8)	21 (48.8)
No	6 (18.2)	22 (51.2)
N=76		

As illustrated in Table 4.5, the exposed group has longer number of working duration compared to the comparative group. The result shows that there was no significant different in working duration between exposed and comparative group ( $z = -1.554, p = 0.120$ ). For the income of the respondents, it was found that there was a significant difference in the income between exposed group and comparative group ( $z = -2.283, p = 0.022$ ).

**Table 4.5: Comparison of Working History between Study Groups**

Variable	Exposed group (n=33)			Comparative group (n=43)			z value	p value
	Median (IQR)	Range	Mean rank	Median (IQR)	Range	Mean rank		
	Working duration (years)	10(11)	1-29	42.98	7(7)	1-34		
Income (RM)	1690(750)	900-3000	31.94	2000(500)	900-2800	43.53	-2.283	0.022*

N=76

\* Significant at  $p < 0.05$

#### 4.4 Personal respirable particulates (PM<sub>10</sub>) exposure

Table 4.6 below shows the comparison of concentration level of PM<sub>10</sub> among exposed and comparative group by using Mann-Whitney U test. In total, 76 respirable dust samples were collected from 76 respondents. The dust concentration in the work environments varied with different occupational groups. The highest concentration of respirable dust was found in the exposed group. The inhaled dust for exposed quarry

workers was higher than that for the comparative group. The median concentration of PM<sub>10</sub> in exposed group was higher ( $498.62 \pm 610.91\mu\text{g}/\text{m}^3$ ) compared to the comparative group which was  $121.10 \pm 3.50\mu\text{g}/\text{m}^3$ .

**Table 4.6: Comparison of PM<sub>10</sub> Concentration between Study Groups**

Variable	Exposed group (n=33)			Comparative group (n=43)			z value	p value
	Median (IQR)	Range	Mean rank	Median (IQR)	Range	Mean rank		
PM <sub>10</sub> concentration ( $\mu\text{g}/\text{m}^3$ )	498.62 (610.91)	100.08- 1010.23	48.70	121.10 (3.50)	87.90- 244.60	27.35	-4.280	0.001*

N=76

\*Significant at  $p < 0.05$

According to Table 4.7, there was a significant difference in the exposure level of PM<sub>10</sub> concentration between study groups ( $p < 0.0001$ ). The PM<sub>10</sub> concentration has been categorized into two groups which were high concentration of PM<sub>10</sub> or low concentration of PM<sub>10</sub>. The high PM<sub>10</sub> concentration was defined as PM<sub>10</sub> concentration more than  $498.62\mu\text{g}/\text{m}^3$  and the low PM<sub>10</sub> concentration referred to PM<sub>10</sub> concentration less than  $498.62\mu\text{g}/\text{m}^3$ .

Based on the result obtained, 17 out of 33 respondents from the exposed group have been identified to expose to high concentration of PM<sub>10</sub> and 16 of them have been exposed to low concentration of PM<sub>10</sub> during working. However, for the comparative group, all of the respondents were exposed to low concentration of PM<sub>10</sub>. Figure 4.1 and Figure 4.2 below show the distribution of PM<sub>10</sub> concentration level among exposed and comparative group.

**Table 4.7: Comparison of Exposure Level to PM<sub>10</sub> between Study Groups**

Variable		Exposed group (n=33)	Comparative group (n=43)	z value	p value
		Number (%)	Number (%)		
PM <sub>10</sub> concentration (µg/m <sup>3</sup> )	High	17(51.5)	-	-5.306	<0.001*
	Low	16(48.5)	43(100)		

N=76

\*Significant at p < 0.05

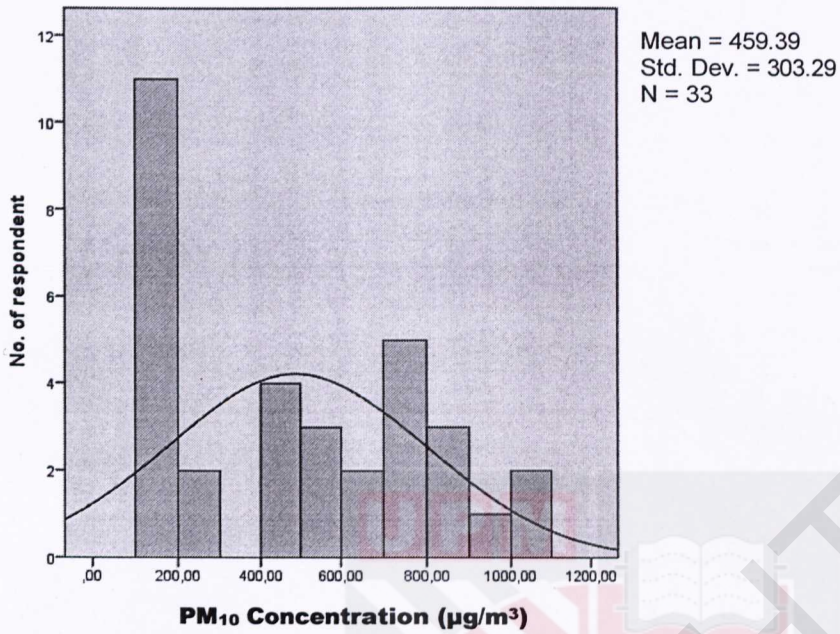


Figure 4.1: The distribution of PM<sub>10</sub> concentration level among exposed group

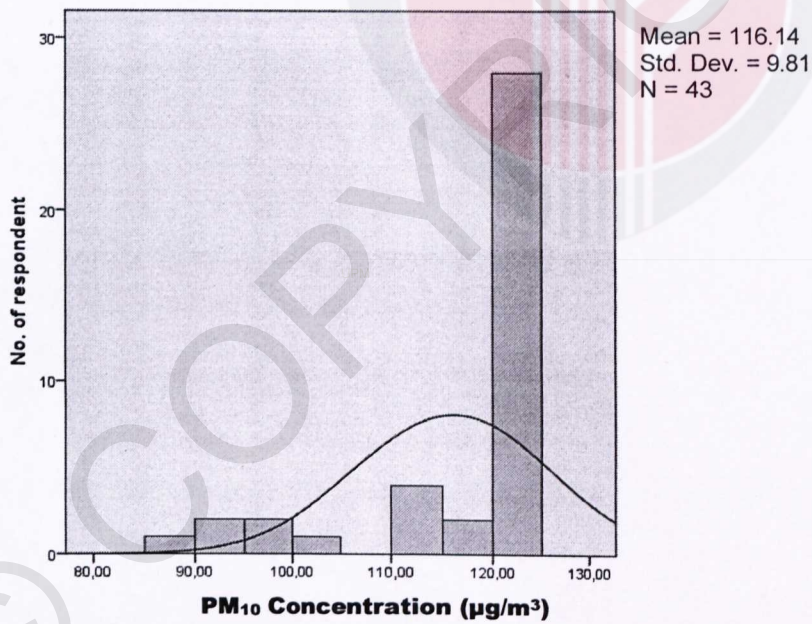


Figure 4.2: The distribution of PM<sub>10</sub> concentration level among comparative group

#### 4.5 Comparison of Lung Function among Study Groups

Lung function test were performed by the respondents to determine the lung function of the respondents and also to determine their association with  $PM_{10}$  concentration. Table 4.8 shows the lung function values among respondents. The data were analyzed using the Mann-Whitney U test. From the result, there was a significantly lower in FVC ( $2.79 \pm 0.63$ ),  $FEV_1$  ( $2.55 \pm 0.67$ ), FVC% predicted ( $80.66 \pm 11.98$ ) and  $FEV_1$ % predicted ( $84.09 \pm 14.27$ ) among exposed group compared to the comparative group.

**Table 4.8: Comparison of Lung Function (FVC%, FEV<sub>1</sub>% and FEV<sub>1</sub>/ FVC% predicted) between Study Groups**

Variables	Mean ± SD		z value	p value
	Exposed group (n = 33)	Comparative group (n = 43)		
FVC (litre)	2.79 ± 0.63	3.13 ± 0.38	-2.628	*0.009
FEV <sub>1</sub> (litre)	2.55 ± 0.67	2.95 ± 0.35	-3.160	*0.002
FVC% predicted	80.66 ± 11.98	89.75 ± 12.29	-2.871	*0.004
FEV <sub>1</sub> % predicted	84.09 ± 14.27	90.74 ± 12.21	-2.239	*0.025
FEV <sub>1</sub> /FVC% predicted	104.36 ± 8.89	101.35 ± 5.83	-1.264	0.206

\* Significant at p < 0.05

#### 4.6 Comparison of Lung Function Abnormalities between Study Groups

Table 4.9 below shows that the percentage of respondents from exposed group which have abnormalities in FVC% predicted was significantly higher (54.5%) compared to the comparative group (23.3%). About 76.7% of respondents from comparative group have normal FVC% predicted compared to the exposed group

(45.5%). For FEV<sub>1</sub> % predicted, 51.5% of the exposed group and 16.3% of the comparative group have abnormalities in FEV<sub>1</sub> % predicted, while 48.5% of the exposed group and 83.7% of the comparative group have normal value of FEV<sub>1</sub> % predicted. However, there was a significant different in FVC% predicted (p = 0.005) and FEV<sub>1</sub> % predicted (p = 0.001).

**Table 4.9: Comparison of Lung Function Abnormalities between Study Groups**

Variables		Exposed group (n = 33)	Comparative group (n = 43)	$\chi^2$	p value
		Number (%)	Number (%)		
FVC% predicted	Abnormal	18 (54.5)	10 (23.3)	7.85	*0.005
	Normal	15 (45.5)	33 (76.7)		
FEV <sub>1</sub> % predicted	Abnormal	17 (51.5)	7 (16.3)	10.72	*0.001
	Normal	16 (48.5)	36 (83.7)		
FEV <sub>1</sub> /FVC% predicted	Abnormal	-	-	-	-
	Normal	33 (100)	43 (100)		

N=76

\*Significant different at p< 0.05

#### 4.7 Comparison of Respiratory symptoms

The modified questionnaire which adapted from the American Thoracic Society-Adult Questionnaire (1978) was used to identify the prevalence of respiratory symptoms among respondents. The respiratory symptoms include cough, phlegm, wheezing and chest tightness. Table 4.10 below illustrates the prevalence of respiratory symptoms experienced by the respondents. Chronic cough, chronic phlegm and chest tightness shows a significant difference ( $p < 0.05$ ) from the statistical analysis (Chi-square test) that has been conducted. However, only wheezing symptoms did not show any significant difference between these two groups.

The number of respiratory symptoms for chronic cough (OR = 5.797, 95% CI = 1.446 – 23.238), chronic phlegm (OR = 4.239, 95% CI = 1.192– 15.078) and chest tightness (OR = 9.333, 95% CI = 1.064 – 81.867) were significantly higher among quarry workers compared to the office workers. The result also shows that the exposed group was predicted to have 9 times risk of getting chest tightness, 5 times risk of getting chronic cough, 4 times risk of getting chronic phlegm and 2 times risk of getting wheezing compared to the comparative group. Figure 4.3 below shows the distribution of respiratory symptoms among exposed and comparative group.

**Table 4.10: Comparison of Respiratory Symptom among Study Groups**

Symptoms	Exposed group (n = 33)	Comparative group (n = 43)	Odds Ratio (95% CI)	$\chi^2$ value	p value
Chronic cough	10 (30.3)	3 (7.0)	5.797 (1.446 – 23.238)	7.165	0.007*
Chronic phlegm	10 (30.3)	4 (9.3)	4.239 (1.192– 15.078)	5.480	0.019*
Chest tightness	6 (18.2)	1 (2.3)	9.333 (1.064 – 81.867)		<sup>a</sup> 0.038*
Wheezing	3 (9.1)	2 (4.7)	2.050 (0.322 – 13.039)		<sup>a</sup> 0.647

<sup>a</sup> Fisher Exact test

\*Significant at  $p < 0.05$

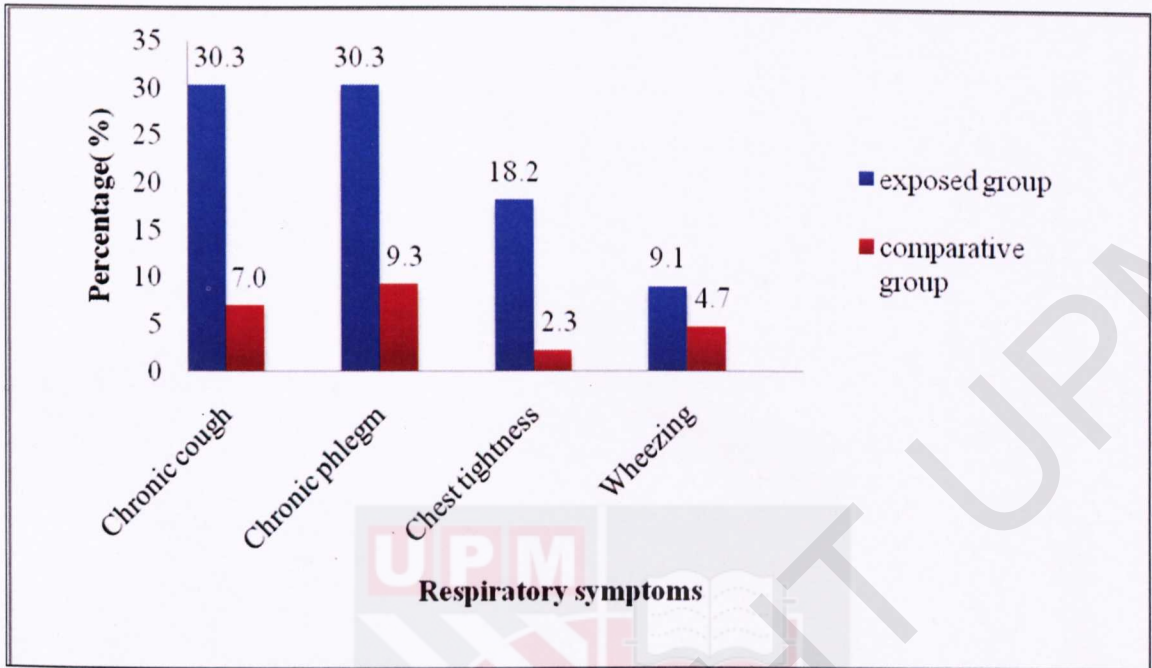


Figure 4.3: Distribution of respiratory symptoms among exposed and comparative group

#### 4.8 Association between Exposure Level to Particulate Matter ( $PM_{10}$ ) and Lung Function

To determine the association between concentrations of particulate matter ( $PM_{10}$ ) and lung function at the workplace, Spearman-rho correlation have been conducted between concentrations of particulate matter ( $PM_{10}$ ) and FVC% predicted, FEV<sub>1</sub>% predicted and FEV<sub>1</sub>/FVC% predicted. Table 4.11 shows that there was no

significant association ( $p > 0.05$ ) between concentration of  $PM_{10}$  and lung function parameters (FVC% predicted,  $FEV_1$  % predicted and  $FEV_1/FVC$ % predicted) among exposed group. However, both  $FEV_1$ % predicted and  $FEV_1/FVC$ % predicted show reverse association among exposed group.

**Table 4.11: Association between Exposure to  $PM_{10}$  and Lung Function**

PM <sub>10</sub>	Exposed group (n = 33)	
	r value	p value
FVC% predicted	0.025	0.889
$FEV_1$ % predicted	-0.054	0.767
$FEV_1/FVC$ % predicted	-0.033	0.854

#### 4.9 Association between Working Duration and Lung Function among Exposed Group

Spearman-rho correlation has been used to determine the association between working duration and lung function parameters. Based on Table 4.12, the result has found that there was no significant association between these two variables. However, only  $FEV_1/FVC$ % predicted shows reverse association among exposed group.

**Table 4.12: Association between Duration of Exposure and Lung Function**

Duration of exposure	Exposed group (n = 33)	
	r value	p value
FVC% predicted	0.015	0.900
FEV <sub>1</sub> % predicted	0.025	0.830
FEV <sub>1</sub> /FVC% predicted	-0.052	0.657

#### 4.10 Study Limitation

Besides a strict compliance on measurements and data collection techniques in the study, the main limitations of this study were as follows:

- i. This study is a cross sectional study which can only collect information on exposure and health status at the same time. The design attempt to assess exposures data retrospectively under the assumption that the concentration contrasts measured today have been constant over time (WHO, 2002).
- ii. The sample size of the study was small due to the time constraint and difficulties to get the permission from the company to conduct monitoring.

- iii. Limited studies on personal exposure to particulate matter (PM<sub>10</sub>) and respiratory health done locally. Limited local baseline data and references for quarry workers in Malaysia caused some difficulties to discuss and make comparison on the study results.



## CHAPTER 5

### DISCUSSION, CONCLUSION AND RECOMMENDATIONS

#### 5.1 Discussion

##### 5.1.1 Background and selection of respondents

This chapter reviewed and discussed the findings obtained from this cross-sectional comparative study on the exposure to particulate matter (PM<sub>10</sub>) and respiratory health among quarry workers (exposed group) and office workers (comparative group). After being granted and got approval by the Ethical Committee of Faculty Medicine and Health Sciences, the measurement on particulate matter (PM<sub>10</sub>) and respiratory health (which include respiratory symptoms and lung function test) for this study was started on 31<sup>st</sup> January 2012 and was finished on 16<sup>th</sup> February 2012.

This study was conducted among quarry workers in a quarry company with the aim to determine the relationship between personal exposure to particulate matter (PM<sub>10</sub>) and the respiratory health. Respondents were purposively sampled based on the inclusive criteria that were already being listed before conducted the study. Therefore, only 33 quarry workers were selected from the company as exposed group and 43 office workers from Faculty of Veterinary, Universiti Putra Malaysia as comparative group. The comparative group was chosen among office personnel who did not expose to particulate matter (PM<sub>10</sub>). The inclusive criteria were established to control the confounding factors that may influenced the outcome of the study.

Respondents were interviewed to gather information related to socio-demographic data, smoking habit, health status, work employment history, respiratory symptoms and family history on respiratory health by using a set of questionnaire which modified from the American Thoracic Society – Adult Questionnaire (1978). Quantitative methods such as the measurement of PM<sub>10</sub> concentration and lung function test were conducted on the respondents.

## **5.1.2 Socio-demographic data**

As stated before, the inclusive criteria were aimed to control the confounding factors which may influence the outcome of the study. Therefore, this study only involved male workers for both exposed and comparative group to control gender difference.

As mentioned earlier in Chapter 4, several socio-demographic data such as age, race, education level, smoking status, previous job employment and working duration were all compared between exposed and comparative group. Factors such as age, smoking habit and working duration were controlled during the selection of the respondents and data analysis. Based on statistical analysis being carried out, these factors were found to be equal or match between both groups and will not affect the results.

### **5.1.2.1 Ethnicity, Education Level and Marital Status of Study Groups**

Based on the findings, most of the respondents from both groups are Malays. However, for marital status, majority of the respondents from exposed group have married while for the comparative group, most of them are single person. From the distribution of education level, most of the respondents from exposed group had SPM level while in the comparative group, most of them had STPM level and a few of them had Degree level.

For marital status, majority of the respondents from exposed group have married compared to comparative group where majority of them are single person.

### 5.1.2.2 Anthropometric Data between Study Groups

Several investigators have shown that anthropometric parameter have significant relationship with lung function indices (Aderole and Oduwole, 1983; Jaja and Fagbenro, 1995). Therefore, it was necessary to ensure that the anthropometric parameters of the two groups (exposed and comparative groups) were similar as was done in this study.

During the selection of the respondents, the age of the respondents was set between 20 to 55 years old. The mean age for the exposed group was  $34.48 \pm 9.12$  years and  $32.23 \pm 7.79$  years for the comparative group. Height is one of the factors that may affect the lung function of the respondents. From the findings, the mean height for the exposed group was  $164.39 \pm 7.49$  cm while the mean height of the comparative group was  $166.51 \pm 6.50$  cm.

The mean weight of the exposed group was higher ( $64.76 \pm 10.02$  kg) compared to the comparative group ( $62.53 \pm 9.52$  kg). Although the mean of all these anthropometric data were varies between both group, but these confounding factors have

been controlled and were found to be equal or match between both groups and will not affect the results.

### **5.1.2.3 Smoking History**

The findings have shown that most of the respondents from both groups were smokers and majority of them smoking between 10 to 20 cigarettes per day. According to Hessel *et al.* (2000), smoking habit is one the important factor in the study of lung function. Based on that statement, the researcher have matched the smoking respondents between these two groups to ensure that there was equal or match between both groups. As a conclusion, the exposed group as well as the comparative group has similar characteristics in smoking status.

### **5.1.2.4 Previous Job and Working History**

The findings reported that most of the respondents from both groups have previous working history. For exposed group, a few of them worked at the quarry before but at different company. However, most of them have their previous job not related to the quarry before such as mechanic, soldier, security guard and others. The respondents for the exposed group have worked at the quarry between 1-29 years, while for the

comparative group, they have worked between 1-34 years. Based on the result, there was no significant difference in working duration between study groups.

### 5.1.3 Comparison of exposure level of PM<sub>10</sub> among Study Groups

The mean concentration of PM<sub>10</sub> in exposed group ( $459.39 \pm 303.29 \mu\text{g}/\text{m}^3$ ) was four times higher compared to the comparative group ( $116.14 \pm 9.81 \mu\text{g}/\text{m}^3$ ). The concentration of PM<sub>10</sub> in exposed group has exceeded the Malaysian Air Quality Guidelines (MAQG) of  $150 \mu\text{g}/\text{m}^3$  (Department of Environment, 1989) but still below the Permissible Exposure Limit of Factories and Machinery (Mineral Dust) Regulations 1989 of  $5 \text{ mg}/\text{m}^3$  or  $5000 \mu\text{g}/\text{m}^3$ . However, the dust concentration for the comparative group did not exceed any guidelines or regulations.

The same result by Noor *et al.* (2000) also has found that there was a significantly high concentration of dust in cement factory compared to the dust concentration in UPM offices. However, the mean concentration of PM<sub>10</sub> for exposed group in this study was much lower ( $459.39 \mu\text{g}/\text{m}^3$ ) compared to the mean PM<sub>10</sub> concentration by Noor *et al.* ( $8049 \mu\text{g}/\text{m}^3$ ).

Different work process involved in different level of exposure to particulate matter (PM<sub>10</sub>) where in quarry area, the “crushing” unit and “drilling” process involved in the release and generation of high level of dust compared to other work processes (Murugan *et al.*, 2000). Other environmental factors such as wind speed and total annual rainfall are also influencing the total particulate matter in the air (Harrison *et al.*, 1997).

Based on a study by Stern *et al.* (1984), concentration level of particulate matter (PM<sub>10</sub>) at 55 µg/m<sup>3</sup> can increase the risk for respiratory symptoms, concentration of PM<sub>10</sub> at 90 µg/m<sup>3</sup> can increase the illness at respiratory system and at 350 µg/m<sup>3</sup> can cause bronchitis. World Health Organization (WHO), 1994 indicated that an increase of particulate level to 200 mg /m<sup>3</sup> would increase 20 percent of the daily mortality rates (Oguntoke *et al.*, 2009).

#### **5.1.4 Comparison of Lung Function among Study Groups**

The lung function test was performed by using spirometer. Before performing this test, age and height factors were considered by the researcher as been suggested by Singh *et al.*, (1993). There was a significant difference in the abnormalities of the lung function among exposed and comparative group.

The findings of the study clearly showed the difference between FVC% predicted ( $z = -2.871$ ,  $p = 0.004$ ) and FEV<sub>1</sub>% predicted ( $z = -2.239$ ,  $p = 0.025$ ) of exposed group compared to the comparative group. From the Mann-Whitney U test that was used, the mean of FVC% predicted ( $80.66 \pm 11.98$ ) and FEV<sub>1</sub>% predicted ( $84.09 \pm 14.27$ ) were significantly reduced compared to the comparative group.

A study by Murugan (2000) also found that there was a reduction in lung function among quarry workers in Hulu Langat District compared to the comparative group. However, the mean of FVC% predicted and FEV<sub>1</sub>% predicted obtained from this study were significantly lower (mean of FVC% predicted =  $80.66 \pm 11.98$ , mean of FEV<sub>1</sub>% predicted =  $84.09 \pm 14.27$ ) compared to the mean of FVC% predicted and FEV<sub>1</sub>% predicted reported by Murugan (2000) study (mean of FVC% predicted =  $95.46 \pm 14.30$ , mean of FEV<sub>1</sub>% predicted =  $95.94 \pm 15.59$ ).

A study by Samsudin (2001) on particulate matter among cement workers in Perlis also found that there was a significant difference of FVC% predicted, FEV<sub>1</sub>% predicted and FEV<sub>1</sub>/FVC% predicted between two groups. Ng *et al.* (1987) in his study reported that the increased of mean particulate matter (PM<sub>10</sub>) was related to the significant reduction of FVC% predicted and FEV<sub>1</sub>% predicted.

Besides that, the reduction of FVC% predicted and FEV<sub>1</sub>% predicted value was also associated with smoking habit among the respondents. The findings showed that most of the respondents from the exposed group were smokers. However, the comparative group which also smoking did not show any reduction of lung function value.

The quarry workers were not only smokers but also exposed to the high concentration of PM<sub>10</sub> level, which may lead to the reduction of lung function value. This has been proved through a study by Soichiro *et al.* (1982), among workers in different factories which involved exposure to high diverse of dust and smoking. His study found that the reduction of FEV<sub>1</sub>/FVC % occurred among 121 respondents that have performed the lung function test from year 1978 until 1980 compared to the respondents which smoking but did not expose to the dust.

A study by Glencross *et al.* (1997) also found that the workers which exposed to the asbestos and at the same time were smokers also showed a reduction in the FVC% predicted and FEV<sub>1</sub>% predicted. However, in this study, smoking habit was not one of the factors that caused the reduction in lung function level as this confounding factor has been controlled between both groups and will not affect the results.

### 5.1.5 Comparison of Respiratory Symptoms among Study Groups

Respiratory symptoms among the respondents were obtained by using a set of pre-tested questionnaire modified from the American Thoracic Society (ATS-DLD-78-A) questionnaires. Among the respiratory symptoms being studied were chronic cough, chronic phlegm, chest tightness and wheezing. These symptoms were studied in order to identify any prevalence or complaints made by the workers regarding the respiratory problems.

The health risks associated with the exposure to the dust were largely depending on the type and composition of the dust. The toxicological properties and the health effects were determined by the physical, chemical and mineralogical characteristics of the dust.

Based on the result, there was a significant different in chronic cough ( $\chi^2 = 7.16$ ,  $p = 0.007$ ), chronic phlegm ( $\chi^2 = 5.48$ ,  $p = 0.019$ ) and chest tightness ( $p = 0.038$ ) among exposed and comparative groups. There was five times risk of developing chronic cough and 4 times risk of developing chronic phlegm in exposed group compared to the comparative group.

In this study, the most common symptoms reported by the quarry workers were chronic cough and chronic phlegm (30.3%), followed by chest tightness (18.2%) and only 9.1% reported the wheezing symptom. The respondents agreed that they always coughing and usually brought up phlegm on getting up or first thing in the morning.

Ugbogu *et al.* (2009) in his study found that the most common respiratory symptoms complained by the quarry workers were chronic cough, chronic phlegm and chest tightness. Another study by Razlan (2002) among male quarry workers in Kelantan also showed that shortness of breath, chest tightness, morning phlegm and morning cough were the most common symptoms experienced by quarry workers. This study also reported that the risk of chest tightness was found to be significantly associated with the age-group of more than 40 years (OR = 3.57) and duration of work of at least 12 years (OR = 2.80). However, the risk of shortness of breath, production of morning phlegm and morning cough was not affected by both the age-group and duration of employment.

#### **5.1.6 Association between Exposure Level to Particulate Matter (PM<sub>10</sub>) and Lung Function among Study Groups**

Based on this study, there was no significant association between the concentration of PM<sub>10</sub> and lung function parameters (FVC% predicted, FEV<sub>1</sub>% predicted and FEV<sub>1</sub>/FVC% predicted) among respondents. Most of the respondents have been working

at the quarry less than 10 years. As the result did not show any significant association, the researcher has made some suggestions. A large sample size is needed to obtain a more significant association. Time constraint and a few of the respondents were rejected for matching purposes were some of the factors that contributed to the small sample size of this study.

#### **5.1.7 Association between Working Duration and Lung Function among Study Groups**

This study found that there was no significant association between working duration and lung function (FVC% predicted, FEV<sub>1</sub>% predicted and FEV<sub>1</sub>/FVC% predicted) of the workers. The same result was obtained by Noor *et.al*, (2000) where the study also failed to show any clear association between working duration and the lung function among cement workers in Rawang.

Shahida *et al.* (2001) also found that there was no significant association between FVC% predicted and FEV<sub>1</sub>% predicted with duration of exposure to paper dust for exposed group. However, she found that there was a significant association between duration of exposure and FEV<sub>1</sub>/FVC% predicted value.

Due to the result which did not show any significant association, the researcher has made some suggestions. Most of the respondents from the exposed group are less exposed to particulate matter ( $PM_{10}$ ) and working at the quarry not more than 10 years. Short exposures to particulate matter ( $PM_{10}$ ) among these new workers have caused the insignificant association between working duration and lung function. Other than that, small sample size also contributes to this insignificant association.

## 5.2 Conclusion

The dust generated from stone quarrying and crushing activities contains a significant amount of respirable particulate matter ( $PM_{10}$ ). The high concentration of  $PM_{10}$  further suggests that the occupational environment of the workers and surrounding areas may be hazardous to human health. Air quality and the health survey conducted at the site indicate that the observed dust may be producing significant damage to respiratory health.

The lung function test showed the reduction of FVC% predicted and  $FEV_1$  % predicted among exposed group compared to the comparative group. This study was also successfully demonstrated the increased risk of respiratory symptoms like chronic

cough, chronic phlegm and chest tightness among quarry workers (exposed group) compared to the office workers (comparative group).

Exposure to high concentration of respirable particles ( $PM_{10}$ ) is commonly associated with the decreased in lung function of the workers. Based on the result, there was no significant association between personal exposure levels to particulate matter ( $PM_{10}$ ) and lung function among quarry workers. However, there was an inverse association in  $FEV_1\%$  predicted and  $FEV_1/FVC\%$  predicted among exposed group. This study also failed to show any significant association between working duration and lung function among exposed group. Only  $FEV_1/FVC\%$  predicted value showed an inverse association between working duration and lung function among exposed group.

### **5.3 Recommendation**

Work processes at the quarry involve the release of high  $PM_{10}$  concentration level. Therefore, corrective and preventive measures are important to minimize this air pollutant from affecting the lung function of the workers. Among the suggestion that can be practiced are as follows:

### **5.3.1 Engineering control**

The quarry company should be mandated to adopt modern technology of dust strapping such that a negligible quantity of dust escapes from the various operations at quarry site. The release of particulate can be controlled with scrubbers, precipitators and filters which can be retrofitted to dust-stacks for pollutants removal from emissions. The existing control measure such as water sprinkler system is good but it should be well-maintained and properly used. It should be use especially during the hot weather as at that time, the concentration of dust being produced is the highest.

### **5.3.2 Administrative control and House Keeping**

The company should educate the employees by providing training regarding the control equipment and work procedures associated with the employee's job assignments and also on the proper use of personal protective equipment (PPE). Medical examination should also be conducted routinely by the company at least once in a year especially for those who have complained on respiratory symptoms and other health problems.

Based on Factories and Machinery (Mineral Dust) Regulations 1989, the prescribed medical examination includes chest x-ray, statement of the medical, occupational and smoking history of the person examined, a clinical examination of the chest and pulmonary function test, including testing of forced vital capacity and forced

expiratory volume at one second, detailed examination for tuberculosis and any laboratory or other test which the examining registered medical practitioner deems necessary by sound medical practice. House keeping is another ways that can be done to minimize the dust at the quarry area, such as cleaning the dust at the machine controlled room or at worker's rest room regularly.

### **5.3.3 Employee Exposure Monitoring**

Monitoring of dust exposure level whether personal monitoring or ambient monitoring is important in determining the employee's exposure at the quarry site. Among the parameter that can be measured are the concentration of respirable particles and the percentage of free silica (by weight) in the dust that these quarry workers exposed to. This monitoring should be done regularly to determine whether control measures that have been taken are effective or not.

### **5.3.4 Personal Protective Equipment (PPE)**

Personal protective equipment such as face mask N95 should be provided and distributed by the company to all the exposed workers. The company authority should ensure all the employees wear face masks while working. It is also the responsibility of the company to ensure these equipments are well-maintained and replace with the new one if necessary.

## REFERENCES

- Aderele W.I. & Oduwole O. (1983) Peak expiratory flow rate in healthy school children. *Nig. J. Paed.* 10: 45-55.
- American Thoracic Society. (1978). Lung Function Testing: Selection of Reference Values and Interpretive Strategies. *American Review of Respiratory Disease*. Vol. 85: pp 762 – 768.
- American Thoracic Society. (1987). Standardization of Spirometry 1987 update. *American Journal of Respiratory and Critical Care Medicine*. pp 1285 –1298.
- American Thoracic Society. (1991). Lung Function Testing: Selection of Reference Values and Interpretive Strategies. *American Review of Respiratory Disease*. Vol. 144: pp 1202 – 1218.
- American Thoracic Society.(1987).Standardization of Spirometry 1994 update.*American Journal of Respiratory and Critical Care Medicine*.Vol 152: pp 1107 – 1136.
- Bart, O. (1993). The Association of air Pollution and Mortality: Examining the case for inference. *Archives of Environmental Health*. 48(5): 336.
- Deborah, S. (1996). Breathtaking: premature Mortality due to Particulate air pollution in 239 America Cities. Natural Resources Defence Council, New York. pp 14 – 15.
- Dockery D.W. & Pope C.A. (1994). Acute respiratory effect of particulate air pollution. *Ann Rev Public Health*: 15: 107-32.
- Erkki K. & Nancy B. (1997). Prevention of hazards. *Asian-Pasific Newsletter*. 4(2): 36-38.
- Factories and Machinery (Mineral Dust) Regulation, 1989.
- Glenncross P.M., Weinberg J.M., Ibrahim J.G. & Christiani D.C. (1997). Loss of lung function among sheet metal workers : Ten year study. *Ame.J.Ind.Med.* 32: 460-466.

Harrison R.M., Deacon A.R., Jones M.R. & Appleby R.S. (1997). Sources and processes affecting concentrations of  $PM_{10}$  and  $PM_{2.5}$  particulate matter in Birmingham (U.K). *Atmospheric Env.* 31 (24): 4103-4117.

Health Effects Institute – HEI (1995). Particulate Air Pollution and Daily Mortality: Replication and Validation of selected studies HEI Cambridge, MA. P 4.

Hessel A.P., Gamble F.J., Gee B.J., Green H.Y.F., C. Morgan K.W. & Mossman T.B. (2000). Silica, silicosis and lung cancer : A response to a recent working group report. *Journal of Occupational and Environmental Medicine.* 42(7): 704-718.

Jaja, S. I. and Fagbenro, A. O. (1995). Expiratory flow rate in Nigerians school children. *African Journal Med. Med.Science.* 24: 379-384.

Jane Q. Koenig (2000). Health effects of ambient air pollution. How safe the air we breath?. Kluwer Academic Publishers. 17-26.

Krishnendu M., Ayyappan R., Raghunathan R., Venkatesan D., Arulselvan S., Pramod K., Shyam N.P., Sankar S. & Kalpana B. (2011). Exposure to respirable particulates and silica in and around the stone crushing units in central India. *Industrial Health.* 49: 221-227.

Last, J.M. (1998). Public Health and Human Ecology (2nd Edition) McGraw-Hill Medical Publishing Prentice-Hall Int. Edition Canada. pp153-200.

Miller W.F., Scacci R. & Gast L.R. (1978). Laboratory evaluation pulmonary function. J.B. Uppincott Company. Philadelphia.

Murugan S. (2000). Partikel ternafas ( $PM_{10}$ ) dan kaitannya dengan fungsi paru-paru pekerja di kuari Daerah Hulu Langat, Selangor. B.S. (Kesehatan Persekitaran dan Pekerjaan). Serdang: Universiti Putra Malaysia.

National Industrial Sand Association (1997). Respiratory Health Effects of Crystalline Silica. As available at [www.riccisand.com/health](http://www.riccisand.com/health).

Ng T.P., Chan S.L. & Lam K.P. (1987). Radiological progression and lung function in silicosis : ten year follow-up study. *Br.Med.J.* 295:164-168.

NIOSH Manual of Analytical Methods (1997). NIOSH 0600.

Noor H., Yap C.L., Zolkepli O. & Faridah M. (2000). Effect of exposure to dust on lung function of cement factory workers. *Med. Journal Malaysia.* 55: 51- 57.

- Oguntoke O., Aboaba A. & Gbadebo T.A. (2009). Impact of granite quarrying on the health of workers and nearby residents in Abeokuta Ogun State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*. 2 (1): 1-11.
- Parkes W.R. (1994). Occupational lung disorders. Third ed. Butterworth Heinemann pub. 111-114, 295-304.
- Pless-Mulloli T., Howel D., King A., Stone., Merefiefield J., Bessell. & Darnell R. (2000). Living near opencast coal mining sites and children's respiratory health. *Occupational and Environmental Med*. 57: 145-151.
- Pope C.A., Thun M.J. & Namboodiri M.M. (1995). Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. *Am J Respir Crit Care Med*.;151(pt 1):669-674.
- Priemus H. & Schutte-Postma E. (2009). "Notes on the particulate matter standards in the European Union and the Netherlands", *Int J Environ Res Public Health*. 6(3): 1155-1173.
- Rastogi S.K., Ahmad I., Pangtey B.S. & Mathur N. (2003). Effects of occupational exposure on respiratory system in carpet workers. *Indian Journal of Occupational and Environmental Medicine*.7(1):19-26.
- Razlan M., Lin N., Zulkifli A. & Rusli N. (2002). Respiratory symptoms and pulmonary function among male quarry workers in Kelantan, Malaysia. *Malaysian Journal of Public Health Medicine*. 2(1): 54-57.
- Richard T., Michael J., Eugenia E., Daniel K., Kazuhiko I. & George D. (2002). Lung cancer, Cardiovascular mortality and lung-term exposure to fine particulate air pollution. *Journal of American Medical Association*. 287(9).
- Rubinson L. & Neutens J.J. (1987). Research Techniques for the Health Sciences. Macmillon Pub. New York. 93pp.
- Samsudin Z. (2001). Pendedahan debu simen (PM<sub>10</sub>) terhadap fungsi paru-paru pekerja kilang simen, Bukit Keteri, Perlis, B.S. (Kesihatan Persekitaran dan Pekerjaan). Serdang: Universiti Putra Malaysia.
- Shahida A.M. (2000). Pendedahan debu kapas (PM<sub>10</sub>) dan kaitannya dengan fungsi paru-paru pekerja di kilang kertas kitar semula, Mentakab, Pahang. B.S. (Kesihatan Persekitaran dan Pekerjaan). Serdang: Universiti Putra Malaysia.

Singh, R., Singh, H.J., and Sirisinghe, R.G. (1993). Spirometric Studies in Malaysian between 13 and 69 years of age. *Medical Journal of Malaysia*. 48(2): pp 175 – 184.

Soichiro I., Yasuhiko B., Yasushi K. (1982). Pulmonary function of dust workers. Proceedings of the Tenth Asian Conference on Occupational Health, 5<sup>th</sup>-10<sup>th</sup> September 1982, Singapore. 2: 670-676.

Stern A.C. (1982). History of Air Pollutants Legislation in the United States. *J.APCA*. 32:44-61.

Ugbogu OC, Ohakwe J. & Foltescu V. (2009). Occurrence of respiratory and skin problems among manual stone-quarrying workers. *Mera: African Journal of Respiratory Medicine*. 23-26.

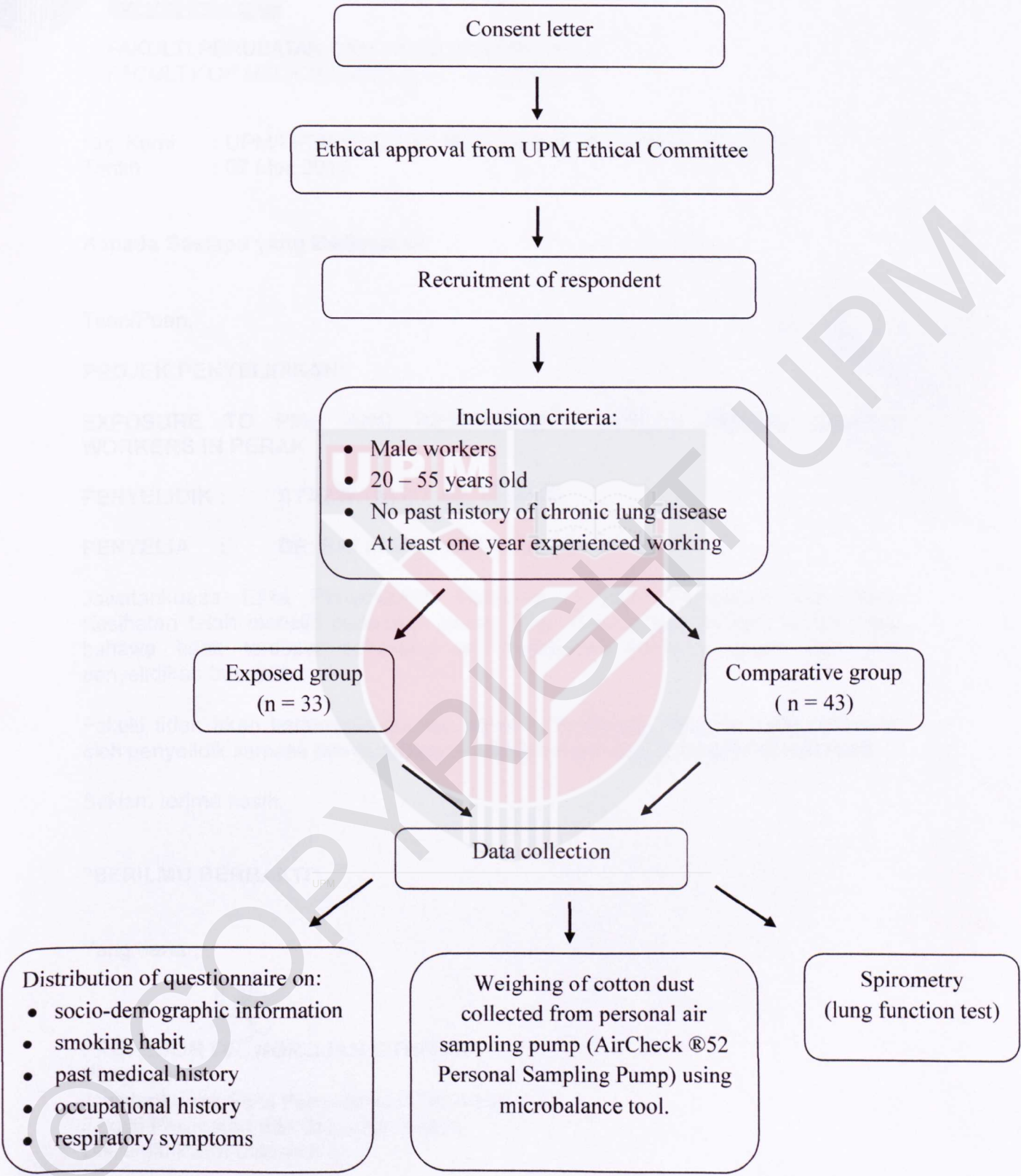
UNEP (1991). Urban Air Pollution. In: Environment Library, No. 4, Nairobi: UNEP.

USEPA (2008). Region 4: Laboratory and Field operations – PM<sub>2.5</sub>: Objectives and History. As available at [en.wikipedia.org/wiki/particulate](http://en.wikipedia.org/wiki/particulate).

[www.gulflink.osd.ml/particulate](http://www.gulflink.osd.ml/particulate)

Yang C.Y., Huang C.C., Chang I.C., Lee C.H., Tsai J.T. & Ko Y.C. (1993). Pulmonary function and respiratory symptoms of Portland cement workers in southern Taiwan. *Journal of Toxicology and Environmental Health*. 9: 186-92.





Flow chart for data collection



## **PENERANGAN KEPADA PESERTA**

### **TAJUK KAJIAN : PENILAIAN TAHAP KESIHATAN TERHADAP PEKERJA KILANG KUARI YANG TERDEDDAH KEPADA PM<sub>10</sub> PENYELIDIK : SYAZWANI BINTI AB. KHALID**

Terima kasih kerana membantu kami di dalam kajian ini.

#### **Apakah kajian ini?**

Industri kuari merupakan salah satu industri yang berkembang pesat di negara ini. Industri ini merupakan salah satu industri yang menyumbang kepada pencemaran udara terutamanya partikel ternafas (PM<sub>10</sub>). Selain daripada komuniti yang tinggal di kawasan berhampiran tapak kuari, pekerja kuari merupakan individu yang paling terdedah kepada partikel ternafas (PM<sub>10</sub>) ini. Situasi pencemaran udara yang berpunca daripada tapak kuari adalah satu masalah pencemaran yang tidak boleh dielakkan tetapi ianya dapat dikawal dengan beberapa kaedah.

Justeru itu, ia perlu dititikberatkan bersama dan memerlukan kerjasama dari semua pihak, baik pihak kilang mahupun pekerja itu sendiri untuk memastikan kualiti udara di kawasan kilang kuari adalah terkawal dan langkah-langkah keselamatan berkaitannya dipraktikkan. Pendedahan kepada partikel ternafas (PM<sub>10</sub>) berhubungkait dengan fungsi paru-paru di mana ia dapat menghalang paru-paru daripada beroperasi dengan baik. Berdasarkan maklumat yang diperolehi dari kajian ini, beberapa usaha boleh dijalankan bagi mengawal pencemaran udara di kilang kuari daripada terus berleluasa. Antaranya adalah kawalan pencemaran udara melalui penguatkuasaan undang-undang di tempat kerja dan pendidikan kesihatan.

#### **Apakah tujuan kajian ini?**

Kajian ini dijalankan adalah bertujuan untuk mengenalpasti hubungan di antara pendedahan kepada partikel ternafas (PM<sub>10</sub>) dengan peningkatan masalah fungsi paru-paru di kalangan pekerja kilang kuari.

### **Berapa ramai responden yang terpilih?**

Responden akan dipilih dari kalangan pekerja kilang kuari yang terdedah dan yang tidak terdedah kepada partikel ternafas ( $PM_{10}$ ). Seramai 80 orang untuk kumpulan yang terdedah dan 80 orang untuk kumpulan tidak terdedah kepada partikel ternafas ( $PM_{10}$ ) dipilih. Jumlah keseluruhan responden adalah 160 orang.

### **Apakah jenis ujian yang akan dilakukan?**

Semua responden akan diberi borang soal selidik oleh pengkaji. Selain itu, bagi pekerja di kawasan kilang kuari, kualiti udara yang disedut oleh setiap individu akan diukur menggunakan *personal air sampling pump*. Bagi mengukur tahap fungsi paru-paru bagi semua responden, mereka dikehendaki melakukan ujian respirator dengan menggunakan spirometer.

### **Adakah bayaran dikenakan?**

Pengkaji akan menanggung segala pembiayaan ujian yang akan dijalankan dan tiada sebarang bayaran dikenakan terhadap setiap responden.

### **Adakah maklumat dijamin sulit?**

Semua maklumat yang diberikan oleh responden di dalam borang kaji selidik adalah dijamin sulit. Tiada huraian individu akan dibuat pada mana-mana bahagian di dalam kajian atau penerbitan.

### **Apakah hak anda?**

Kajian ini melibatkan anda secara sukarela. Oleh itu, peserta mempunyai hak untuk menarik diri dari penyertaan dalam kajian ini pada bila-bila masa sekiranya peserta merasa tidak selesa untuk memberikan maklumat kepada pengkaji.



### **Apakah yang anda akan dapati?**

Kajian ini akan menjelaskan sama ada pendedahan kepada partikel ternafas ( $PM_{10}$ ) boleh mengakibatkan masalah kepada fungsi paru-paru atau tidak kepada pekerja kilang kuari yang terdedah. Jika tahap partikel ternafas ( $PM_{10}$ ) adalah tinggi dan memberi kesan kepada responden, maklumat kajian ini berguna untuk tindakan selanjutnya. Melalui hasil kajian tersebut, beberapa polisi boleh digubal atau dilaksanakan oleh pihak kilang untuk meningkatkan taraf kesihatan pekerja. Melalui kajian ini juga, anda dapat menentukan samada anda mengalami masalah sistem pernafasan atau tidak tanpa dikenakan sebarang bayaran dan ianya berfaedah untuk anda.

### **Apakah yang harus anda lakukan?**

Anda dikehendaki menandatangani borang penyertaan responden yang menyatakan minat anda untuk menyertai kajian ini. Ianya boleh dilakukan setelah anda membaca dan memahami isi kandungan penerangan ini. Borang penyertaan responden boleh dikembalikan kepada pengkaji sebelum temubual dan ujian yang akan dijalankan. Sekiranya anda mempunyai sebarang kemusykilan, pengkaji akan membantu untuk memberi maklumat yang selanjutnya.

Terima kasih atas kerjasama dan bantuan anda.

**SYAZWANI BINTI AB. KHALID**

Penyelidik

B. Sc. Kesihatan Persekitaran dan Pekerjaan

Jabatan Kesihatan Persekitaran dan Pekerjaan

Fakulti Perubatan dan Sains Kesihatan

Universiti Putra Malaysia.

017 - 4076084

syazwaniabdulkhalid@gmail.com



**BORANG PERSETUJUAN RESPONDEN**

**TAJUK KAJIAN: PENILAIAN TAHAP KESIHATAN TERHADAP PEKERJA KILANG KUARI YANG TERDEDAH KEPADA PM<sub>10</sub>**

**PENYELIDIK : SYAZWANI BINTI AB. KHALID**

Saya ..... No.K/P: .....  
alamat.....

.....dengan ini secara sukarela bersetuju untuk mengambil bahagian dalam penyelidikan yang dinyatakan di atas. Saya telah dimaklumkan mengenai latar belakang penyelidikan ini dari segi kaedah, kemungkinan kesan buruk dan komplikasi( rujuk kepada risalah maklumat). Saya faham bahawa saya mempunyai hak untuk menarik diri dari kajian ini pada bila-bila masa tanpa memberikan apa jua sebab. Saya juga faham bahawa kajian ini adalah sulit dan semua maklumat yang diberikan mengenai identiti saya adalah sulit dan persendirian.

Saya ingin \*tahu/tidak ingin mengetahui keputusan ujian yang dijalankan ke atas sampel saya.

\* potong mana yang tidak berkaitan

Tandatangan ..... Tandatangan.....  
(Responden) (Saksi)

Tarikh : ..... Nama : .....

No. K/P : .....

Saya mengesahkan bahawa saya telah menjelaskan kepada responden latar belakang dan tujuan penyelidikan di atas.

Tarikh ..... Tandatangan.....  
(Penyelidik)



## PENILAIAN TAHAP KESIHATAN TERHADAP PEKERJA KUARI YANG TERDEDAH KEPADA PARTIKEL TERNAFAS (PM<sub>10</sub>)

Dengan ini, sukacita dimaklumkan bahawa pihak tuan telah disenaraikan sebagai salah seorang responden dalam satu kajian penyelidikan yang mengkaji hubungan antara pendedahan kepada partikel ternafas (PM<sub>10</sub>) dan hubungannya dengan fungsi paru-paru. Oleh yang demikian, saya memohon jasa baik pihak tuan untuk menjawab soalan-soalan yang terdapat dalam borang soal selidik ini secara tepat dan jujur. Segala maklumat kajian yang diterima akan dirahsiakan. Kerjasama dari pihak tuan amatlah dihargai.

No Responden:

--	--	--	--	--	--	--	--	--	--

Tarikh:

--	--	--	--	--	--	--	--	--	--

No Telefon:

					-														
--	--	--	--	--	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Tandatangan:

---

**SULIT**



**A. LATAR BELAKANG RESPONDEN**

1. Nama: \_\_\_\_\_

2. Alamat: \_\_\_\_\_  
\_\_\_\_\_

3. No. telefon: \_\_\_\_\_

4. Pekerjaan: \_\_\_\_\_

5. Umur: \_\_\_\_\_ tahun Tarikh Lahir: \_\_\_\_\_

6. No kad pengenalan: \_\_\_\_\_

7. Jantina: lelaki / perempuan

8. Tinggi: \_\_\_\_\_ cm Berat: \_\_\_\_\_ kg

9. Bangsa:

Melayu

Cina

India

Lain-lain:

(Nyatakan)

\_\_\_\_\_

10. Warganegara: \_\_\_\_\_

11. Tahap pendidikan:

PMR/ Tingkatan 3

SPM/ Tingkatan 5

STPM/ Diploma

Ijazah

Lain-lain

Tiada

12. Status perkahwinan:

Bujang

Berkahwin

Duda/Janda

13. Jumlah pendapatan: RM \_\_\_\_\_



**B. SEJARAH PERUBATAN**

14. Adakah anda mengalami masalah paru-paru sebelum masuk bekerja?

Ya

Tidak

15. Pernahkah anda mengalami sebarang penyakit berikut?

Bronkitis kronik

Pneumonia (radang paru-paru)

Asma / lelah

TB

Tiada

JIKA YA PADA SOALAN 15,

16. Adakah penyakit yang tersebut di atas disahkan oleh doktor?

Ya

Tidak

**C. BUTIR-BUTIR PEKERJAAN**

17. Pekerjaan sekarang: \_\_\_\_\_ Tempoh bekerja: \_\_\_\_\_ tahun

18. Pekerjaan dahulu: \_\_\_\_\_ Tempoh bekerja: \_\_\_\_\_ tahun

19. Di bahagian mana anda bekerja:

Pentadbiran

Pengeluaran

20. Adakah anda terdedah kepada debu/habuk semasa bekerja?

Ya

Tidak

JIKA YA PADA SOALAN 20,

21. Berapa lama anda terdedah dalam sehari? \_\_\_\_\_ Jam

22. Apakah tahap pendedahan kepada habuk di tempat kerja anda?

Kurang

Sederhana

Teruk

23. Adakah anda selesa bekerja di tempat ini?

Ya

Tidak



**D. SEJARAH PENYAKIT**

24. Pernahkah mengalami masalah pernafasan?

Ya

Tidak

JIKA YA PADA SOALAN 24 DI ATAS, SILA JAWAB SOALAN DI BAWAH:

25. Apakah penyakit berkenaan?

Asma (lelah)

Emfisema (pengembangan paru-paru)

Barah paru-paru

Pleurisy (peradangan dari lapisan sekeliling paru-paru)

26. Masih menghidap penyakit tersebut?

Ya

Tidak

27. Adakah penyakit anda disahkan oleh doktor?

Ya

Tidak

28. Adakah mendapat rawatan untuk penyakit tersebut?

Ya

Tidak

**E. BATUK**

29. Adakah anda selalu mengalami batuk?

Ya

Tidak

30. Adakah anda mengalami batuk semasa bangun daripada tidur?

Ya

Tidak

31. Adakah anda mengalami batuk pada waktu pagi?

Ya

Tidak



JIKA **YA** PADA SALAH SATU SOALAN DI ATAS, SILA JAWAB SOALAN DI BAWAH:  
JIKA **TIDAK** PADA SEMUA SOALAN, SILA JAWAB SOALAN DI BAHAGIAN SETERUSNYA.

32. Adakah anda mengalami batuk hampir setiap bulan?  
Ya  Tidak
33. Adakah anda mengalami batuk untuk 3 bulan berturut-turut dalam setahun?  
Ya  Tidak
34. Berapa lamakah anda mengalami masalah sebegini? \_\_\_\_\_ bulan/tahun
35. Adakah anda mengikuti sebarang rawatan?  
Ya  Tidak

#### **F. KAHAK**

36. Adakah anda selalu mengeluarkan kahak daripada dada anda?  
Ya  Tidak
37. Adakah anda selalu mengeluarkan kahak seperti ini 2 kali sehari?  
Ya  Tidak
38. Adakah anda selalu mengeluarkan kahak seperti ini 4 kali seminggu?  
Ya  Tidak
39. Adakah anda selalu mengeluarkan kahak seperti ini lebih dari 4 kali seminggu?  
Ya  Tidak
40. Adakah anda selalu mengeluarkan kahak seperti ini selepas bangun daripada tidur?  
Ya  Tidak
41. Adakah anda selalu mengeluarkan kahak seperti ini pada waktu pagi?  
Ya  Tidak
42. Adakah anda selalu mengeluarkan kahak seperti ini pada waktu malam?  
Ya  Tidak



JIKA **YA** PADA SALAH SATU SOALAN DI ATAS, SILA JAWAB SOALAN DI BAWAH:

JIKA **TIDAK** PADA SEMUA SOALAN, SILA JAWAB SOALAN DI BAHAGIAN SETERUSNYA.

43. Adakah anda selalu mengeluarkan kahak seperti ini untuk 3 bulan berturut-turut?

Ya

Tidak

44. Adakah anda selalu mengeluarkan kahak seperti ini lebih dari 3 bulan berturut-turut?

Ya

Tidak

45. Berapa lamakah anda mengalami masalah berkahak? \_\_\_\_\_ bulan/tahun

### G. NAFAS BERBUNYI (WHEEZING)

46. Pernahkah anda terasa nafas anda berbunyi seperti wisel?

Ya

Tidak

47. Berapa lamakah dada berbunyi ini berterusan? \_\_\_\_\_ bulan/tahun

48. Adakah anda mendapat rawatan doktor untuk masalah ini?

Ya

Tidak

### H. KESESAKAN NAFAS

49. Adakah anda selalu mengalami kesesakan nafas atau dada apabila batuk?

Ya

Tidak

50. Adakah anda mengalami masalah ini ketika bekerja?

Ya

Tidak

51. Adakah anda mendapat rawatan doktor?

Ya

Tidak

52. Adakah anda telah menjalani ujian X-ray?

Ya

Tidak



**I: SEJARAH PENYAKIT KELUARGA**

53. Sejarah penyakit ahli keluarga seperti ibu bapa, adik beradik atau keluarga.

Bronkitis kronik

Barah paru-paru

Asma (lelah)

Emfisema (pengembangan paru-paru)

Lain-lain penyakit (Nyatakan) : \_\_\_\_\_

**J. TABIAT MEROKOK**

54. Adakah anda menghisap rokok?

Ya

Tidak

55. Berapa batang rokok anda hisap dalam sehari?

\_\_\_\_\_ batang

**SEKIAN, TERIMA KASIH**

**PARTICULATES NOT OTHERWISE REGULATED, RESPIRABLE**

**0600**

**DEFINITION:** aerosol collected by sampler with 4- $\mu$ m median cut point

**CAS:** None

**RTECS:** None

**METHOD:** 0600, Issue 3

**EVALUATION:** FULL

**Issue 1:** 15 February 1984

**Issue 3:** 15 January 1998

**OSHA :** 5 mg/m<sup>3</sup>  
**NIOSH:** no REL  
**ACGIH:** 3 mg/m<sup>3</sup>

**PROPERTIES:** contains no asbestos and quartz less than 1%; penetrates non-ciliated portions of respiratory system

**SYNONYMS:** nuisance dusts; particulates not otherwise classified

SAMPLING		MEASUREMENT	
<b>SAMPLER:</b>	CYCLONE + FILTER (10-mm nylon cyclone, Higgins-Dewell [HD] cyclone, or Aluminum cyclone + tared 5- $\mu$ m PVC membrane)	<b>TECHNIQUE:</b>	GRAVIMETRIC (FILTER WEIGHT)
<b>FLOW RATE:</b>	nylon cyclone: 1.7 L/min HD cyclone: 2.2 L/min Al cyclone: 2.5 L/min	<b>ANALYTE:</b>	mass of respirable dust fraction
<b>VOL-MIN:</b>	20 L @ 5 mg/m <sup>3</sup>	<b>BALANCE:</b>	0.001 mg sensitivity; use same balance before and after sample collection
<b>-MAX:</b>	400 L	<b>CALIBRATION:</b>	National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights
<b>SHIPMENT:</b>	routine	<b>RANGE:</b>	0.1 to 2 mg per sample
<b>SAMPLE STABILITY:</b>	stable	<b>ESTIMATED LOD:</b>	0.03 mg per sample
<b>BLANKS:</b>	2 to 10 field blanks per set	<b>PRECISION:</b>	<10 $\mu$ g with 0.001 mg sensitivity balance; <70 $\mu$ g with 0.01 mg sensitivity balance [3]
<b>ACCURACY</b>			
<b>RANGE STUDIED:</b>	0.5 to 10 mg/m <sup>3</sup> (lab and field)		
<b>BIAS:</b>	dependent on dust size distribution [1]		
<b>OVERALL PRECISION (<math>\hat{S}_{r,r}</math>):</b>	dependent on size distribution [1,2]		
<b>ACCURACY:</b>	dependent on size distribution [1]		

**APPLICABILITY:** The working range is 0.5 to 10 mg/m<sup>3</sup> for a 200-L air sample. The method measures the mass concentration of any non-volatile respirable dust. In addition to inert dusts [4], the method has been recommended for respirable coal dust. The method is biased in light of the recently adopted international definition of respirable dust, e.g., = +7% bias for non-diesel, coal mine dust [5].

**INTERFERENCES:** Larger than respirable particles (over 10  $\mu$ m) have been found in some cases by microscopic analysis of cyclone filters. Over-sized particles in samples are known to be caused by inverting the cyclone assembly. Heavy dust loadings, fibers, and water-saturated dusts also interfere with the cyclone's size-selective properties. The use of conductive samplers is recommended to minimize particle charge effects.

**OTHER METHODS:** This method is based on and replaces Sampling Data Sheet #29.02 [6].

**EQUIPMENT:**

1. Sampler:
  - a. Filter: 5.0- $\mu$ m pore size, polyvinyl chloride filter or equivalent hydrophobic membrane filter supported by a cassette filter holder (preferably conductive).
  - b. Cyclone: 10-mm nylon (Mine Safety Appliance Co., Instrument Division, P. O. Box 427, Pittsburgh, PA 15230), Higgins-Dewell (BGI Inc., 58 Guinan St., Waltham, MA 02154) [7], aluminum cyclone (SKC Inc., 863 Valley View Road, Eighty Four, PA 15330), or equivalent.
2. Personal sampling pump, 1.7 L/min  $\pm$  5% for nylon cyclone, 2.2 L/min  $\pm$  5% for HD cyclone, or 2.5 L/min  $\pm$  5% for the Al cyclone with flexible connecting tubing.  
NOTE: Pulsation in the pump flow must be within  $\pm$  20% of the mean flow.
3. Balance, analytical, with sensitivity of 0.001 mg.
4. Weights, NIST Class S-1.1, or ASTM Class 1.
5. Static neutralizer, e.g., Po-210; replace nine months after the production date.
6. Forceps (preferably nylon).
7. Environmental chamber or room for balance, e.g., 20 °C  $\pm$  1 °C and 50%  $\pm$  5% RH.

---

**SPECIAL PRECAUTIONS:** None.

---

**PREPARATION OF SAMPLERS BEFORE SAMPLING:**

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h.
2. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight,  $W_1$  (mg).
  - a. Zero the balance before each weighing.
  - b. Handle the filter with forceps (nylon forceps if further analyses will be done).
  - c. Pass the filter over an anti-static radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.
3. Assemble the filters in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette.
4. Remove the cyclone's grit cap before use and inspect the cyclone interior. If the inside is visibly scored, discard this cyclone since the dust separation characteristics of the cyclone may be altered. Clean the interior of the cyclone to prevent reentrainment of large particles.
5. Assemble the sampler head. Check alignment of filter holder and cyclone in the sampling head to prevent leakage.

**SAMPLING:**

6. Calibrate each personal sampling pump to the appropriate flow rate with a representative sampler in line.  
NOTE 1: Because of their inlet designs, nylon and aluminum cyclones are calibrated within a large vessel with inlet and outlet ports. The inlet is connected to a calibrator (e.g., a bubble meter). The cyclone outlet is connected to the outlet port within the vessel, and the vessel outlet is attached to the pump. See APPENDIX for alternate calibration procedure. (The calibrator can be connected directly to the HD cyclone.)  
NOTE 2: Even if the flowrate shifts by a known amount between calibration and use, the nominal flowrates are used for concentration calculation because of a self-correction feature of the cyclones.
7. Sample 45 min to 8 h. Do not exceed 2 mg dust loading on the filter. Take 2 to 4 replicate samples for each batch of field samples for quality assurance on the sampling procedure (see Step 10).  
NOTE: Do not allow the sampler assembly to be inverted at any time. Turning the cyclone to anything more than a horizontal orientation may deposit oversized material from the cyclone body onto the filter.

**SAMPLE PREPARATION:**

8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in an environmentally controlled area or chamber.

**CALIBRATION AND QUALITY CONTROL:**

9. Zero the microbalance before all weighings. Use the same microbalance for weighing filters before and after sample collection. Calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
10. The set of replicate field samples should be exposed to the same dust environment, either in a laboratory dust chamber [8] or in the field [9]. The quality control samples must be taken with the same equipment, procedures, and personnel used in the routine field samples. Calculate precision from these replicates and record relative standard deviation ( $S_r$ ) on control charts. Take corrective action when the precision is out of control [8].

**MEASUREMENT:**

11. Weigh each filter, including field blanks. Record this post-sampling weight,  $W_2$  (mg), beside its corresponding tare weight. Record anything remarkable about a filter (e.g., visible particles, overloading, leakage, wet, torn, etc.).

**CALCULATIONS:**

12. Calculate the concentration of respirable particulate,  $C$  ( $\text{mg}/\text{m}^3$ ), in the air volume sampled,  $V$  (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \cdot 10^3, \text{ mg}/\text{m}^3$$

where:  $W_1$  = tare weight of filter before sampling (mg)  
 $W_2$  = post-sampling weight of sample-containing filter (mg)  
 $B_1$  = mean tare weight of blank filters (mg).  
 $B_2$  = mean post-sampling weight of blank filters (mg)  
 $V$  = volume as sampled at the nominal flowrate (i.e., 1.7 L/min or 2.2 L/min)

**EVALUATION OF METHOD:**

1. Bias: In respirable dust measurements, the bias in a sample is calculated relative to the appropriate respirable dust convention. The theory for calculating bias was developed by Bartley and Breuer [10]. For this method, the bias, therefore, depends on the international convention for respirable dust, the cyclones' penetration curves, and the size distribution of the ambient dust. Based on measured penetration curves for non-pulsating flow [1], the bias in this method is shown in Figure 1.

For dust size distributions in the shaded region, the bias in this method lies within the  $\pm 0.10$  criterion established by NIOSH for method validation. Bias larger than  $\pm 0.10$  would, therefore, be expected for some workplace aerosols. However, bias within  $\pm 0.20$  would be expected for dusts with geometric standard deviations greater than 2.0, which is the case in most workplaces.

Bias can also be caused in a cyclone by the pulsation of the personal sampling pump. Bartley, et al. [12] showed that cyclone samples with pulsating flow can have negative bias as large as  $-0.22$  relative to samples with steady flow. The magnitude of the bias depends on the amplitude of the pulsation at the

cyclone aperture and the dust size distribution. For pumps with instantaneous flow rates within 20% of the mean, the pulsation bias magnitude is less than 0.02 for most dust size distributions encountered in the workplace.

Electric charges on the dust and the cyclone will also cause bias. Briant and Moss [13] have found electrostatic biases as large as -50%, and show that cyclones made with graphite-filled nylon eliminate the problem. Use of conductive samplers and filter cassettes (Omega Specialty Instrument Co., 4 Kidder Road, Chelmsford, MA 01824) is recommended.

2. Precision: The figure 0.068 mg quoted above for the precision is based on a study [3] of weighing procedures employed in the past by the Mine Safety and Health Administration (MSHA) in which filters are pre-weighed by the filter manufacturer and post-weighed by MSHA using balances readable to 0.010 mg. MSHA [14] has recently completed a study using a 0.001 mg balance for the post-weighing, indicating imprecision equal to 0.006 mg.

Imprecision equal to 0.010 mg was used for estimating the LOD and is based on specific suggestions [8] regarding filter weighing using a single 0.001 mg balance. This value is consistent with another study [15] of repeat filter weighings, although the actual attainable precision may depend strongly on the specific environment to which the filters are exposed between the two weighings.

#### REFERENCES:

- [1] Bartley DL, Chen CC, Song R, Fischbach TJ [1994]. Respirable aerosol sampler performance testing. *Am. Ind. Hyg. Assoc. J.*, 55(11): 1036-1046.
- [2] Bowman JD, Bartley DL, Breuer GM, Shulman SA [1985]. The precision of coal mine dust sampling. Cincinnati, OH: National Institute for Occupational Safety and Health, DHEW (NIOSH) Pub. No. 85-220721.
- [3] Parobeck P, Tomb TF, Ku H, Cameron J [1981]. Measurement assurance program for the weighings of respirable coal mine dust samples. *J Qual Tech* 13:157.
- [4] ACGIH [1996]. 1996 Threshold limit values (TLVs™) for chemical substances and physical agents and biological exposure indices (BEIs™). Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
- [5] American Conference of Governmental Industrial Hygienists [1991]. Notice of intended change - appendix D - particle size-selective sampling criteria for airborne particulate matter. *Appl Occup Env Hyg* 6(9): 817-818.
- [6] NIOSH [1977]. NIOSH Manual of sampling data sheets. Cincinnati, OH: National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-159.
- [7] Higgins RI, Dewell P [1967]. A gravimetric size selecting personal dust sampler. In: Davies CN, Ed. *Inhaled particles and vapors II*. Oxford: Pergamon Press, pp. 575-586.
- [8] Bowman JD, Bartley DL, Breuer GM, Doemeny LJ, Murdock DJ [1984]. Accuracy criteria recommended for the certification of gravimetric coal mine dust personal samplers. NTIS Pub. No. PB 85-222446 (1984).
- [9] Breslin, JA, Page SJ, Jankowski RA [1983]. Precision of personal sampling of respirable dust in coal mines. U.S. Bureau of Mines Report of Investigations #8740.
- [10] Bartley DL, Breuer GM [1982]. Analysis and optimization of the performance of the 10-mm cyclone. *Am Ind Hyg Assoc J* 43: 520-528.
- [11] Caplan KJ, Doemeny LJ, Sorenson S [1973]. Evaluation of coal mine dust personal sampler performance, Final Report. NIOSH Contract No. PH CPE-r-70-0036.
- [12] Bartley DL, Breuer GM, Baron PA, Bowman JD [1984]. Pump fluctuations and their effect on cyclone performance. *Am Ind Hyg Assoc J* 45(1): 10-18.
- [13] Briant JK, Moss OR [1983]. The influence of electrostatic charge on the performance of 10-mm nylon cyclones. Unpublished paper presented at the American Industrial Hygiene Conference, Philadelphia, PA, May 1983.
- [14] Koqut J [1994]. Private Communication from MSHA, May 12, 1994.

[15] Vaughn NP, Chalmers CP, Botham [1990]. Field comparison of personal samplers for inhalable dust. *Ann Occup Hyg* 34: 553-573.

**METHOD REVISED BY:** David L. Bartley, Ph.D., NIOSH/DPSE/ARDB and Ray Feldman, OSHA.

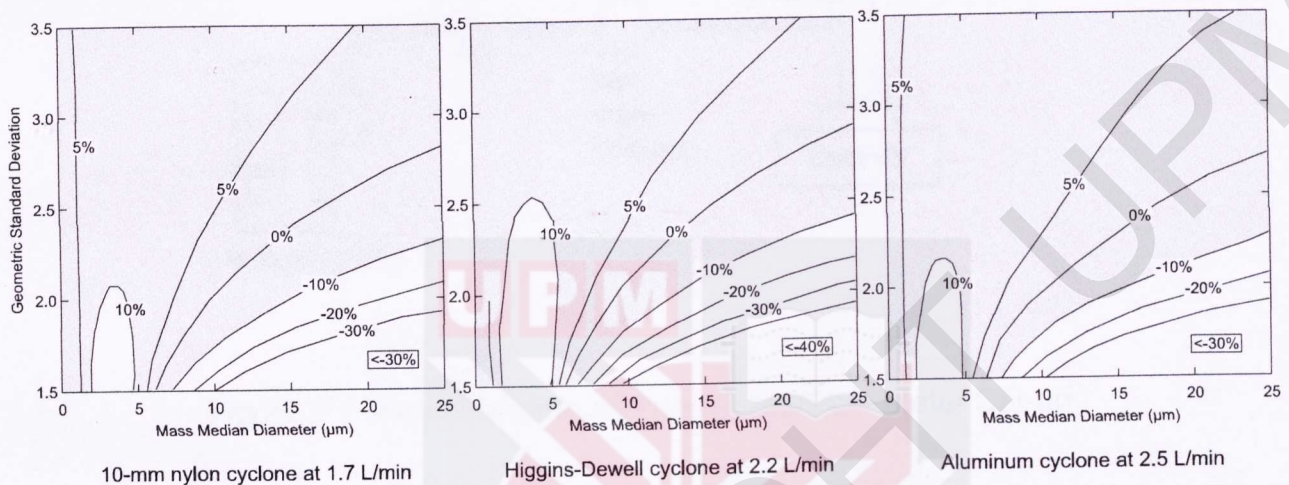


Figure 1. Bias of three cyclone types relative to the international respirable dust sampling convention.

#### APPENDIX: Jarless Method for Calibration of Cyclone Assemblies

This procedure may be used in the field to calibrate an air sampling pump and a cyclone assembly without using the one-liter "calibration jar".

- (1) Connect the pump to a pressure gauge or water manometer and a light load (adjustable valve or 5- $\mu$ m filter) equal to 2" to 5" H<sub>2</sub>O with a "TEE" connector and flexible tubing. Connect other end of valve to an electronic bubble meter or standard bubble tube with flexible tubing (See Fig. 2.1).  
NOTE: A light load can be a 5- $\mu$ m filter and/or an adjustable valve. A heavy load can be several 0.8- $\mu$ m filters and/or adjustable valve.
- (2) Adjust the pump to 1.7 L/min, as indicated on the bubble meter/tube, under the light load conditions (2" to 5" H<sub>2</sub>O) as indicated on the pressure gauge or manometer.
- (3) Increase the load until the pressure gauge or water manometer indicates between 25" and 35" H<sub>2</sub>O. Check the flow rate of the pump again. The flow rate should remain at 1.7 L/min  $\pm$  5%.
- (4) Replace the pressure gauge or water manometer and the electronic bubble meter or standard bubble tube with the cyclone having a clean filter installed (Fig. 2.2). If the loading caused by the cyclone assembly is between 2" and 5" H<sub>2</sub>O, the calibration is complete and the pump and cyclone are ready for sampling.

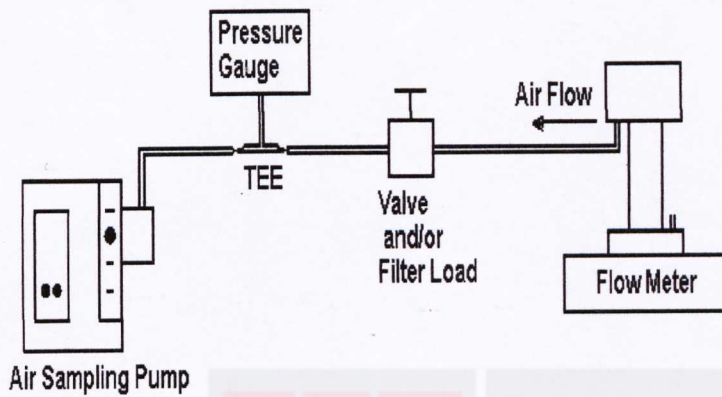


Figure 2.1 Block Diagram of Pump/Load/Flow Meter Set-up.

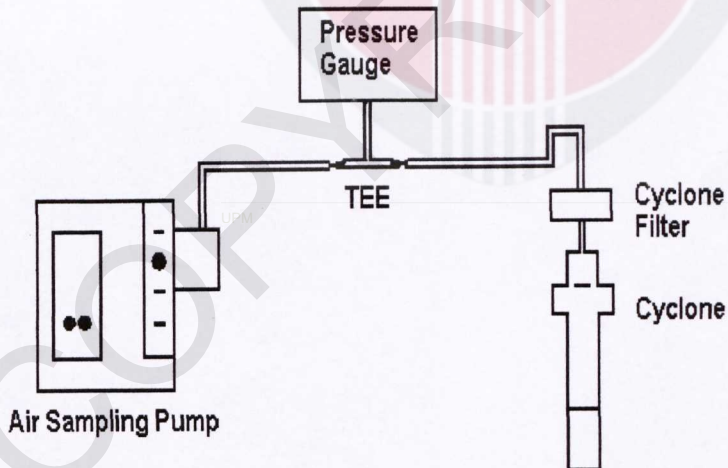


Figure 2.2. Block Diagram with Cyclone as the Test Load.