KNOWLEDGE, PRACTICES AND RESPIRATORY SYMPTOMS AMONG SELECTED FACTORY WORKERS IN REGARDS TO DUST EXPOSURE

by

NUR AFIQAH BT RUSLAN

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LIST OF ABBREVIATIONS AND SYMBOLS

CIMA	Cement Industries of Malaysia Berhad
HIRARC	Hazard Identification, Risk Assessment and Risk Control
MSDS	Material Safety Data Sheets
NSCI	Negeri Sembilan Cement Industry
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Act
PEL	Permissible Exposure Limit
PMR	Penilaian Menengah Rendah
PPBLT	Pusat Pengajian Bahasa, Literasi dan Terjemahan
PPE	Personal Protective Equipment
PRPE	Personal Respiratory Protective Equipment
SOP	Standard Operating Procedures
SPM	Sijil Pelajaran Malaysia
SPSS	Statistical Package for Social Science
TLV	Threshold Limit Value
TWA	Time Weight Average
USECHH	Use and Standard Exposure of Chemical Hazardous to Health
eg	Example
et al	And others (Latin: *et aliae*)
&	And
N	Frequency
%	Percentage
cm	Centimeter
mm	Millimeter

μ	Micro
μm	Micrometer
$\mu g/m^3$	Micrometer per meter cube
mg/m^3	Milligram per meter cube
g/cm^3	Gram per centimeter cube
$>$	More than
$<$	Less than
^oC	Degree celcius
Bhd	Berhad

PENGETAHUAN, AMALAN DAN SIMPTOM PERNAFASAN DALAM KALANGAN PEKERJA DI KILANG TERPILIH BERHUBUNG DENGAN PENDEDAHAN HABUK

ABSTRAK

Cement Industries of Malaysia Berhad (Kumpulan CIMA) terlibat dalam pengeluaran dan pengedaran simen serta aktiviti seumpamanya. Habuk merupakan pencemar perindustrian yang utama dalam penghasilan simen terhadap persekitaran tempat kerja. Habuk terhasil melalui proses pemindahan dan penghancuran. Kajian ini dijalankan untuk menentukan perkaitan antara pengetahuan, amalan dan simptom pernafasan dalam kalangan pekerja industri simen. Satu kajian keratan rentas telah dijalankan dalam kalangan 56 pekerja di bahagian pemprosesan akhir di Negeri Sembilan Cement Industry (NSCI). Pengumpulan data melalui senarai semak dan soal selidik telah digunakan dan data telah dianalisis menggunakan SPSS versi 22. Pekerja yang ditugaskan di kawasan pemprosesan akhir terdedah kepada persekitaran yang berdebu pada penarafan risiko yang tinggi. Sebahagian besar pekerja tidak pernah bekerja di tempat kerja berdebu selain daripada NSCI (71.4%, n=40). Kebanyakan pekerja lebih suka menggunakan topeng habuk di tempat kerja (80.4%, n=45). Separuh daripada pekerja batuk berkahak (50%, n=28). Terdapat perkaitan signifikan antara pengetahuan mengenai alat pelindung pernafasan boleh mengelakkan dari masalah pernafasan dengan kekerapan memakai pelindung pernafasan di tempat kerja (p=0.001). Hubungan antara pengetahuan mengenai kecekapan sistem kawalan debu dengan gejala pernafasan seperti batuk pada awal pagi dan batuk berkahak menunjukkan perkaitan signifikan ($p<0.05$). Terdapat perkaitan antara amalan pemakaian alat pernafasan dengan gejala pernafasan dalam kalangan pekerja ($p<0.05$). Sebagai kesimpulan, terdapat perkaitan secara purata antara pengetahuan mengenai pendedahan habuk, amalan memakai pelindung pernafasan dan gejala pernafasan di kalangan pekerja di NSCI. Pelaksanaan langkah-langkah yang mencukupi harus menjadi langkah pertama untuk meningkatkan prestasi kesihatan dan keselamatan dalam industri simen.

KNOWLEDGE, PRACTICES AND RESPIRATORY SYMPTOMS AMONG SELECTED FACTORY WORKERS IN REGARDS TO DUST EXPOSURE

ABSTRACT

Cement Industries of Malaysia Berhad (CIMA Group) has been involved in the manufacturing and distribution of cement and related activities. Regardless of the cement manufacturing, dust is the major industrial pollutant towards the workplace environment. Dust is emitted throughout all these processes especially during the transferring processes and the crushing processes. This study was conducted to determine the association between knowledge, practices and respiratory symptoms among workers in cement industry. A cross sectional study was conducted, recruiting 56 cements workers at the final processing section at Negeri Sembilan Cement Industry (NSCI). A walk through checklist and questionnaire were applied for data collection and data was analysed using SPSS version 22. The workers that stationed at final processing area were exposed to the dusty environment at high risk rating. Majority of the workers never worked at dusty workplace other than NSCI (71.4%, n=40). Most of the workers preferred to used dust mask at the workplace (80.4%, n=45). Half of the workers coughed with sputum (50%, n=28). There was a significant association between knowledge that respiratory protector can prevent from respiratory problem with the frequency of wearing respiratory protector at the workplace (p=0.001). The association between the knowledge regarding to well-functioned of dust control system with respiratory symptoms such as coughing early in the morning and cough with sputum showed significant association with (p<0.05). There was an association on respirator wearing with the respiratory symptoms among the workers (p<0.05). As a conclusion, there is quite an average association between knowledge on dust exposure, practices in wearing respiratory protector and respiratory symptoms among the workers at NSCI. Implementation of sufficient measures should be the first step to improve health and safety performance in the cement industry.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Cement Industries of Malaysia Berhad (CIMA Group) has been involved in the manufacturing and distribution of cement and related activities since 1975 (Cement Industries of Malaysia Berhad, 2014). CIMA has become the third largest cement manufacturer in Malaysia with the other competitor such as YTL Cement, Lafarge Malayan Cement and Tasek Cement (Adnan, 2014). Negeri Sembilan Cement Industry (NSCI) is the company of CIMA Group that located at Jelai, Negeri Sembilan and has been built since 1999. The Group has ventured into the international markets included Singapore, Indonesia and Myanmar (Cement Industries of Malaysia Berhad, 2014).

Cement industry and dust exposure are interrelated to each other as dusts are produced in each process involved in cement manufacturing such as blasting, crushing, transferring, milling and packaging (Abdul-Wahab, 2006). Review by Mwaiselage *et al.* (2005) stated that the amount of dust exposure is vary in each of production processes. Despite different amount of dust exposure to the factory workers, Ahmed and Newson-Smith (2009) reported that exposure to dust can lead to respiratory problems such as wheezing, asthmatic problems, chronic bronchitis and adversely alter the pulmonary function indices.

The workers are mostly exposed to dust every day during their routine or non-routine jobs especially at the high dust areas. A study done by Ahmed and Newson-Smith (2009) found that the workers in their study were not aware of the long term effect of dust hazard exposure, thus result in poor safety practices toward dust exposure. In addition, according to supervisor of Safety Department in NSCI (unpublished data), there were several cases of respiratory problems reported among workers who worked at the cement mill and packing plant areas of NSCI.

Hence, the control measures at source, path and persons exposed to the hazards such as dusts, together with education in occupational health and safety are the ideal means of preventing occupational diseases and injuries from the manufacture of cement. Workers' knowledge about the hazards associated with their jobs and workers education especially instructions on control and use of personal protective measures will reduce and may even eliminate some occupational health risks.

1.2 Rationale of study

As dust dispersed through the air, the probability of the dust to enter the respiratory systems is high and will cause respiratory problems to the workers. The aerodynamic diameter of the cement dust ranges from 0.05 μm to 20.00 μm targeting the whole respiratory tract for cement deposition (Mwaiselage *et al.*, 2006). Hence, the workers who work at plant area are highly exposed to dust exposures. According to Department of Occupational Safety and Health (2000), Use and Standard Exposure Chemical Hazardous to Health (USECHH) Permissible Exposure Limit (PEL)/Time Weight Average (TWA) for respirable dust is 5.0 mg/m^3 while for inhalable dust is 10.0 mg/m^3.

There are two kinds of dust exist within the cement manufacturing work site including NSCI which are respirable dust and inhalable dust. Inhalable dust is approximates to the fraction of airborne material which can enter the nose and mouth during breathing and is therefore available for deposition in the respiratory tract

(United State Department of Labor, 2014). In the other hand, respirable dust approximates to that fraction which can penetrate to the gas exchange region of the lung (United State Department of Labor, 2014).

The cement mill and packing plant section of NSCI were selected in this study due to the highest rate of dust emission compared to other processing area (~~Arshad, 2012; Arshad, 2013;~~ Nizam, 2014). These results were based on the previous dust and chemical monitoring in 2012 and 2013 conducted by a consultation agency, SHE Strategic Sdn. Bhd. The report recorded that both respirable dust and inhalable dust exceeded the USECHH PEL/TWA for most of the area and personal monitoring (~~Arshad, 2012; Arshad, 2013;~~ Nizam, 2014).

Dust can cause respiratory problem by entering primary respiratory organ which is nose, then travelled to the next respiratory organ which is the lung. Dust can cause harm either locally or subsequently elsewhere in the body (Ugbogu *et al.*, 2009). Particles that remain for a long time have increased potential to cause disease. As to prevent the respiratory problem from occurring, a preventive action is taken in order to minimise the dispersion of dust to the air including elimination, isolation, and substitution, engineering control, administration control and providing personal protective equipment (PPE) to the workers (Department of Occupational Safety and Health, 2008).

Personal protective equipment (PPE) is the last option as in the hierarchy of preventive measure. Thus most of the workers might consider wearing respiratory protectors such as dust mask and respirator as their last resort. Respiratory protectors may only be worn whenever dusts accumulated at the highest level or whenever preferred. In addition, workers might wear the PPE without proper instructions.

Therefore, this study was conducted to determine and understand the occupational hazards specifically on dust exposure at the workplace, their safety practices and reported respiratory symptoms among the workers in the cement industry. Hence, further recommendations can be suggested to achieve work safety during working at the cement industry.

1.3 Research questions

1. What is the workers' perspectives that influence the knowledge and practices of workers towards dust exposure?

2. What is the knowledge and practices on using respiratory protector such as dust mask or respirator among workers at cement industry?

3. What is the effect of dust exposure on respiratory health among workers at cement industry?

1.4 Objectives

General objective:

1. To determine the association between the knowledge on dust exposure, safety practices and respiratory symptoms among workers in cement factory.

Specific objectives:

1. To investigate the condition of the workplace that influence the knowledge and practices of workers towards dust exposure.
2. To determine the association of knowledge on dust exposure with practices on wearing respiratory protector.
3. To determine the association of knowledge on dust exposure with respiratory symptoms among workers at NSCI.
4. To determine the association of safety practices with respiratory symptoms among workers at NSCI.

1.5 Hypothesis

1. The knowledge on dust exposure is significantly associated with safety practices and respiratory symptoms among workers at NSCI.

2. Safety practices are significantly associated with respiratory symptoms among workers at NSCI.

CHAPTER 2

LITERATURE REVIEW

2.1 Definitions

2.1.1 Dust definition

Dust is a small, dry, solid particles which can be projected into the air by either natural forces, such as wind, volcanic eruption; by mechanical or man-made processes such as crushing, grinding, milling, drilling, demolition, shovelling, conveying, screening, bagging, and sweeping. Dust particles are usually in the size range from about 1 μm to 100 μm in diameter, and they settle slowly under the influence of gravity (Calvert, 1990).

2.1.2 Mineral dust definition

Mineral dust is defined as dust of mineral such as Portland cement, limestone and gypsum which include those containing free crystalline silica, coal and cement dusts (Department of Occupational Safety and Health, 1989).

2.1.3 Cement dust definition

Cement dust are powdery substances made by calcining lime and clay, mixed with water to form mortar or mixed with sand, gravel, and water to make concrete (Oxford University Press, 2014).

Cement dust can also be defined as a greyish powder that mixed with water and sand to make mortar or with water, sand, and small stones to make concrete (Cambridge University Press, 2014).

2.2 General process of cement making

There are a few steps in the process of cement manufactures (adapted from Cement Industries of Malaysia Berhad (2014)). Based on figure 2.1, the process start from the mining of the limestone from quarries by the setting off explosives with a negligible impact on the environment, by using the modern technology employed.

Next, the fragmented limestone are transported to the crusher via specialised trucks to be crushing to chunks which approximately less than 25 mm in sizes. The limestone is then delivered through conveyer belt to the Storage area. This process is known as crushing.

After that, the proportional mix of required materials such as limestone, shale, laterite and other required materials are added to form the right combination for cement. Each of the raw materials stored in storage station for future use. This process is known as pehomogenisation step.

The fourth process is grinding the materials and pneumatic transportation simultaneously using a vertical steel mill machine.

After that, the materials are placed in silos equipped for obtaining a homogenous mix of material and followed by calcination process. Calcination is the process of heating a substance to a high temperature, but below its melting point, to bring about thermal decomposition (Oxford University Press, 2015a). A huge rotary kiln take place for the calcinations process by transforming raw materials into clinker at 1400 ^{o}C; small and dark nodules 3 cm to 4 cm in diameter.

The next process is cement milling in which the clinker is ground by different size steel balls while it works its way through the mills 2 chambers, with gypsum being added to extend cement setting times. The clinker is the incombustible residue, fused into an irregular lump, which remains after the combustion of coal (Oxford University Press, 2015b).

The final process is the cement packing and shipping. The cement is then housed in storage silos, to be hydraulically or mechanically extracted and transported to package in bags or supplies in bulk. The shipping can be either by freighter truck or bulk cargo.

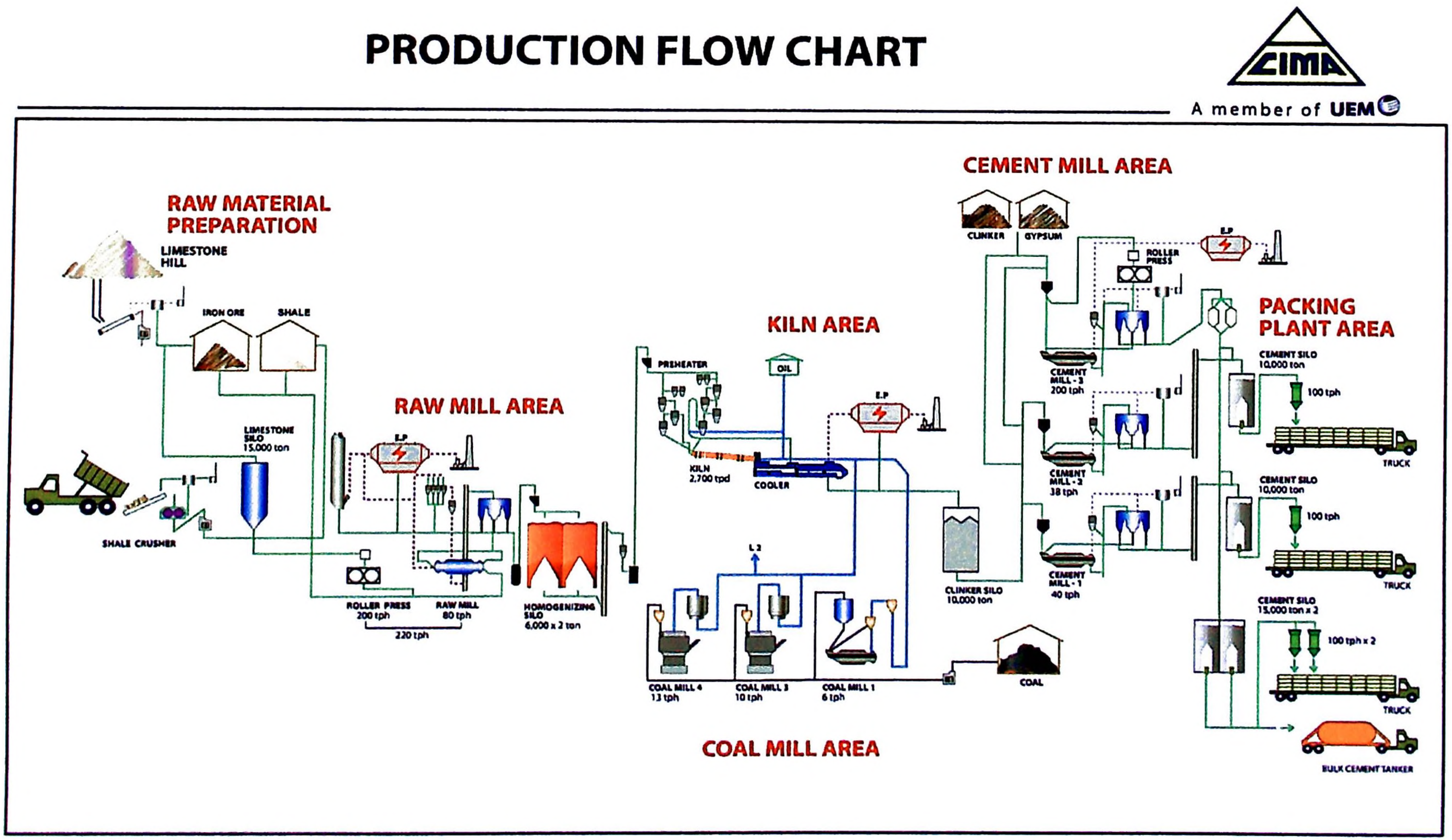

Figure 2.1 Production Flow Chart

Source: Cement Industries of Malaysia Berhad (2014).

2.3 Workplace conditions

A study done by Zeleke *et al.* (2010) found that there is an association between cement dust exposure and acute lung function. The result showed high total dust exposure of 38.6 mg/m^3 and 18.5 mg/m^3 among the exposed workers in the crusher and packing area respectively. They mentioned that cement dust may occur at most stages of the manufacturing process and higher dust concentrations such as at the Crusher and Packing Sections (Zeleke *et al.*, 2010).

In addition, a study done by Kakooei *et al.* (2012) found that the workers of crushing and packing area at selected cement factory had higher respirable dust exposure than the cement mill, kiln, maintenance and administration area. They found that the threshold limit value (TLV) of personal respirable dust in the crushing (30.18 mg/m^3), in the packing (27 mg/m^3), in the cement mill (5.4 mg/m^3), in the kiln (5.9 mg/m^3) and in the maintenance (5.48 mg/m^3) in selected factory were exceeding the TLV in the American Conference of Governmental Industrial Hygienists (ACGIH) which is 5 mg/m^3 (Kakooei *et al.*, 2012).

Besides that, a study by Mwaiselage *et al.* (2005) stated that cement dust exposure were the highest at the cranes, packing and crusher areas. The fractions of samples that exceeded the occupational exposure limit (OEL) were in the crane (91.7%), crusher (84.6%) and packing (76.5%). In regards to workers activities, workers who performed cleaning and housekeeping had higher prevalence in dust levels compared to other workers in the production sections (Zeleke *et al.*, 2010).

In addition, Noor *et al.* (2000) performed a study to evaluate the impairment of pulmonary function and respiratory symptoms of Malaysian cement factory workers after exposure to dust in their occupational environment. Their study found that dust concentrations measured at the factory ranged from 328.10 $\mu g/m^3$ total dust to 10,180.25 $\mu g/m^3$. They concluded that the highest dust exposure area in the factory in terms of both total and fine dust was packing plant, while the least exposed was in the kiln section (Noor *et al.*, 2000).

2.4 Workplace investigation and inspection

To ensure a safe working condition with a proper corrective action, a fundamental of Hazard Identification, Risk Assessment and Risk Control (HIRARC) are implemented in planning, management and the operation of a business (Department of Occupational Safety and Health, 2008). As part of investigation at the workplace, a safety checklist which comprise of several elements such as personal protective equipment (PPE), environment, building plan and others is used to identify the risk of the workplace. The inspection checklist do not specify to any format, in fact can be developed according to the specific need of the workplace (Canadian Centre for Occupational Health & Safety, 2014).

According to Tomar (2014), risks assessment is important to preserve workers health and safety and to maintain a qualified labour at the workplace. The inspection estimates the risk in the workplace and allows any hazard to be identified and analysed. It can be done by the qualitative and semi quantitative method. The details and description for the 2D matrix semi quantitative are as listed in Table 2.1, 2.2, 2.3 and 2.4.

Table 2.1 Severity of hazards

Severity (S)	Example	Rating
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	**5**
Fatal	Approximately one single fatality major property damage if hazard is realized	**4**
Serious	Non-fatal injury, permanent disability	**3**
Minor	Disabling but not permanent injury	**2**
Negligible	Minor abrasions, bruises, cuts, first aid type injury	**1**

Source: Department of Occupational Safety and Health (2008).

Table 2.2 Likelihood of an occurrence

Likelihood (L)	Example	Rating
Most likely	The most likely result of the hazard/ event being realised	**5**
Possible	Has a good chance of occurring and is not unusual	**4**
Conceivable	Might be occur at some time in future	**3**
Remote	Has not been known to occur after many years	**2**
Inconceivable	Is practically impossible and has never occurred	**1**

Source: Department of Occupational Safety and Health (2008).

Table 2.3 Risk matrix table

Likelihood (L)	**5**	M	M	H	H	H
	4	L	M	M	H	H
	3	L	M	M	M	H
	2	L	L	M	M	M
	1	L	L	L	L	M
SCALE		**1**	**2**	**3**	**4**	**5**
		Severity (S)				

Source: Department of Occupational Safety and Health (2008).

Table 2.4 Risk description

RISK DESCRIPTION	ACTION
HIGH (H) (15 – 25)	A HIGH risk requires immediate action to control the hazard as detailed in the hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion.
MEDIUM (M) (5 – 14)	A MEDIUM risk requires a planned approach to controlling the hazard and applies temporary measure if required. Actions taken must be documented on the if required. Actions taken must be documented on the risk assessment form including date for completion.
LOW (L) (1 – 4)	A risk identified as LOW may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

Source: Department of Occupational Safety and Health (2008).

2.5 Respiratory protector

In the Factories and Machinery (Mineral Dust) Regulations 1989 (part five regarding the personal protective equipment in regulation eighteen); generally the employee shall be provided with a suitable protective clothing or any other protective equipment respective to the type of work and also an approved respiratory protective equipment to be used for mineral process, cleaning or any other work (Department of Occupational Safety and Health, 1989). In selecting the right respiratory protector, the forms of hazardous materials need to be known so that the selected respiratory protectors are appropriate and suitable with the condition at the workplace. Table 2.5 shows the forms of hazardous materials available in the environment.

Table 2.5 Forms of hazardous materials

Form	Properties	Examples
Solid particles	Particles of solid material, including aerosols, dusts, fibres, smokes and fume	Asbestos dust, engine exhaust particles and fume, lead dust and fume, stone dust, welding fume, wood dust, smoke, fungal spores and parasites, bacteria and viruses, flour
Liquid particles	Fine sprays, mists and aerosols made up of small droplets of liquid	Sprayed liquids: Paints, pesticides, powder coating mix, liquid jetting Mists: Chrome acid, cutting fluids, oil mist
Vapour	Gaseous forms of a solid or liquid	Solvent vapour, mercury vapour
Gas	Not indicated	Carbon monoxide, engine exhaust gases, sewer gas, chlorine

Source: Health and Safety Executive (2013).

With regards to the variable forms of hazardous materials in the environment surrounding us, there are various types of respiratory protector design in accordance with the needs in protecting workers at the workplace. The standard respiratory protector used in the cement industry should be a P-, N- or R-95 respirator to minimise inhalation of cement dust (Occupational Safety and Health Administration, 2015). Table 2.6 listed the filter media selection for dust, mist or fumes contaminants.

Table 2.6 Filter media selection

Contaminants	Filter media
Dust, mist, fumes	<u>Particulates filter:</u> **N95, R95, P95, N99, R99, P99, N100, R100, P100** •*N-Series: Not for oil* –Approved for non-oil particulate contaminants. –Examples: dusts, fumes, mists not containing oil. •*R-Series: Resistant to oil* –Approved for all particulate contaminants. –Examples: dusts, fumes, mists (including those containing oils). –Time restriction of 8 hours when oils are present. •*P-Series: Oil Proof* –Approved for all particulate contaminants. –Examples: dusts, fumes, mists (including those containing oils). •*Efficiency Level: 95%, 99%, 99.97%* eg. N95 means the filter media has at least 95% efficiency tested at 0.3 micrometer and it can only be used in non-oil environment.

Source: Department of Occupational Safety and Health (2005).

Table 2.7 summarises the type of respiratory protector with the requirement of the form of the hazardous materials. Disposable half mask and reusable half mask are both effective for both particles and available in APF4, APF10 and APF20. APF is assign protective factors with efficiency level of 95%, 99% and 99.97%. For example, N95 means the filter media has at least 95% efficiency tested at 0.3 micrometer and it can only be used in non-oil environment.

Table 2.7 Types of respiratory protector

Adequacy/suitability	Respirators						
RPE type	 Disposable half mask – particle filter*	 Reusable half mask – particle filter	 Reusable half mask – gas/ vapour filter	 Full face mask – particle filter	 Full face mask – gas/vapour filter	 Powered mask	 Powered hoods/helmets
Effective for particles	✔	✔	✘	✔	✘	✔ **	✔ **
Effective for gas/vapour	✘	✘	✔	✘	✔	✔ **	✔ **
Continuous wear time	Less than 1 hr	Less than 1 hr	Less than 1 hr	Less than 1 hr	Less than 1 hr	More than 1 hr	More than 1 hr
APF4 types	✔	✔	✘	✔	✘	✘	✘
APF10 types	✔	✔	✔	✔	✘	✔	✔
APF20 types	✔	✔	✘	✘	✔	✔	✔
APF40 types	✘	✘	✘	✔	✘	✔	✔
APF200 types	✘	✘	✘	✘	✘	✘	✘
APF2000 types	✘	✘	✘	✘	✘	✘	✘

Source: Health and Safety Executive (2013).

2.6 Work practices in cement industry

According to Ahmed and Newson-Smith (2009), many workers especially in the industrial sectors are exposed to significant occupational health hazards and contributed to high risk of work-related diseases which vary either from minor irritations, injuries or cancers. Occupational Health Division received a total of 1,426 cases of occupational disease and poisoning in 2010 as compared with 791 cases reported in the previous year. The occupational lung diseases score 43 from the total of cases (6.5%) (Department of Occupational Safety and Health, 2013).

A study done by Musa *et al.* (2012) on the occupational hazard awareness and safety practices among cement factory workers at Obajana found that a majority of the respondents (98.2%); did aware of hazards associated with their jobs, and 96.7% of the respondents accepted that their occupation was hazardous. The condition of the workplace with the most commonly known hazard by the respondents was dust with 77.4%, and 31.2% was noise. Regarding the usage of the personal protective equipment, 97.8% were using them and about 98.9% from the respondents were interested in updating their knowledge about hazards prevention.

Tam and Fung (2008) quoted that the awareness of wearing respiratory protector is quite low when compared to other personal protective equipment (PPE) such as safety helmets or safety shoes. The action of not wearing safety helmets or safety shoes and respirator may cause an immediate accident and health hazards respectively. Moreover, the usage of personal respiratory protective equipment (PRPE) under hot, humid, confined and poor ventilated area is inconvenience and uncomfortable for workers (Tam and Fung, 2008). Tam and Fung (2008) further reported that 86.6% among the management team and 48.6% of the construction workers do not use respirators while working.

According to Durocher (1998), the majority of workers had poor knowledge and negative attitude about the preventive measures. The lack of awareness on various potential hazards presents in their working environment may introduce them to unexpected to injury.

In a cross-sectional study done by Ahmed and Newson-Smith (2009), the most common hazards mentioned in the cement industry are dust, heat, machines such as milling machine and falling materials, chemicals, fire, and smoke. 108 of 114 respondents mentioned they have respiratory problem such as coughing with sputum, allergy, and eye problem as dust-related health problems. While the remaining 6 subjects mentioned other health effect problems such as stomach, liver and heart problems which related to dust.

In addition, according to Mousa *et al.* (2014), workers may suffer acute or adverse health effects when they are exposed with potential or actual hazard in their working environment continuously. For example, they may develop several symptoms such as shortness of breath, coughing and declining lung function.

2.7 Dust routes of entry

Penetration and deposition of particles in the human respiratory tract begin via nasal route (nose) or oral route (mouth) (Lippmann *et al.*, 1980). The probability of inhalation of the particle depends on its aerodynamic diameter, air movement entering the body, and breathing rate. The inhaled particles may then either be deposited or exhaled out from the body, depending on a whole range of physiological and particle-related factors.

The five deposition mechanisms include sedimentation, inertial impaction, and diffusion for very small particles which is less than 0.5 μm, interception, and electrostatic deposition (World Health Organisation, 1999). Sedimentation and impaction are the most important mechanisms in relation to inhaled airborne dust in accordance with particle aerodynamic diameter. The largest inhaled particles, with the aerodynamic diameter greater than about 30 μm, are deposited in the airways with the point of entry from the lips or nostril and the larynx. During nasal breathing, particles are deposited in the nose due to the filtration occur by the nasal hairs and impaction occur with the airflow changes direction. Retention happens after deposition by the mucus that lines the nose.

Nasal route is a more efficient particle filter as to compare with the oral, especially at low and moderate flow rates. The people that breathe through the mouth may be expected to have more particles reaching the lung and depositing than those who breathe entirely through the nose. During exertion, the flow resistance of the nasal passages causes a shift to mouth breathing in almost all people. Other factor influencing the deposition and retention of particles include cigarette smoking (World Health Organisation, 1999).

The harmful dust such as asbestos and silica, the potential for an adverse health effect might even greater, which may range from some minor impairment to irreversible disease and even life-threatening conditions (Herrick, 2000). While the health risk is associated with the type of dust including the physical, chemical and mineralogical characteristics; their factor also will determine its toxicological properties.

Exposure of dust depends on the air mass concentration and particle aerodynamic diameter of the dust and exposure time duration. The dose received is further influenced by conditions that affect the uptake like breathing rate and volume. Dust concentration in the air and the aerodynamic diameter of the particles will determine the amount of material deposited. Health effects resulting from exposure to dust might become obvious after long-term exposure such as pneumoconiosis. It may happen that effects may appear even after exposure has halt, thus being more easily overlooked or mistakenly attributed to non-occupational conditions. The fact that workers who do not have any symptoms, or only appear after a long time, might be exposed to known hazards (World Health Organisation, 1999).

However, many dusts have effects that result from shorter exposures to higher concentrations. Even when dealing with pneumoconiosis-producing dusts, there are cases of acute health effects, which may result from exposure to different types of dust, include pneumoconiosis, 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 an array 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.

Particulate fraction in terms of aerodynamic equivalent diameter (AED) is the diameter of a hypothetical sphere of density 1 g/cm^3 having the same terminal settling velocity in calm air as the particle in question, regardless of its geometric size, shape and true density (World Health Organisation, 1999). Inhalable particulate fraction is the fraction of a dust cloud that can be breathed into the nose or mouth. Thoracic particulate fraction is the fraction that can penetrate the head airways and enter the airways of the lung. Respirable particulate fraction is the fraction of inhaled airborne particles that can penetrate beyond the terminal bronchioles into the gas-exchange region of the lungs (Brown *et al.*, 2013). Dust such as quartz and other dust containing free crystalline silica is one of a kind that counts the respirable fraction (Occupational Safety Health Administration, 2013).

2.8 Effect of dust towards respiratory system

As stated in the Department of Occupational Safety and Health (1989), Regulation 6 refers to the permissible exposure limit. No employee shall be exposed to mineral dust containing free silica 1% in weight, at a concentration greater than 5 milligram per meter cube of respirable dust or 10 milligram per meter cube of total dust averaged over an eight-hour period.

Meo (2004) found that there were 14 cases of respiratory cancer observed among men with more than 20 years of exposure to cement dust. Table 2.8 summarises the effect of cement dust to the respiratory system and also to the other systems.

Table 2.8 Effect of cement dust

Systems	Organs	Effects of cement dust
Respiratory system	Lungs	Cough and phlegm production, chest tightness, impairment of lung function, obstructive and restrictive lung disease, pleural thickening, fibrosis, emphysema, lung nodulation, pneumoconiosis and carcinoma of lung
Gastrointestinal system	Oral cavity	Mechanical trauma, mucosal inflammation, loss of tooth surface, periodontal disease, dental abrasion and dental caries
	Liver	Diffuse swelling and proliferation of sinusoidal (hepatic) lining cells, sarcoid type granulomas, perisinusoidal and portal fibrosis and hepatic lesions
	Stomach	Stomach ache and cancer of stomach
Central nervous system	Brain	Headache and fatigue
Lymphatic system	Spleen	Diminished lymphatic tissue and splenic lesions
Miscellaneous	Eye, skin and bone	Irritation of eyes, runny eyes and conjunctivitis, skin irritation, itching, skin boil and burn, osteonecrosis, lesion of the humerus, thinning of the cortex and reduction of epiphyseal cartilage

Source: Meo (2004).

Exposure to dust gives high risk towards prevalence of chronic respiratory symptoms and reduction in lung capacity. Inhalation of airborne dust irritates the respiratory epithelium (Winder *et al.*, 2004). Besides that, free silica content in raw materials may lead to silicosis. Moreover, other indications such as high ambient temperatures, radiant heat and high noise levels in cement industry environment may result in development of disease of respiratory system, digestive disorders, skin diseases, rheumatic and nervous conditions, hearing and visual disorders (Neghab and Choobineh, 2007).

The final product of cement processing usually contains 60 to 70% calcium oxide, 19 to 24% silicon dioxide (including about 5% free), 4 to 7% aluminium trioxide, 2 to 6% ferric oxide and less than 5% magnesium oxide (Kakooei *et al.*, 2012). According to the clinical and epidemiological studies by Kakooei *et al.* (2012), an increased in respiratory impairment among cement production workers were due to exposure to Portland cement dust. The support for a causal association of cancer with Portland cement exposure is likely due to the strength of association, consistency, the presence of a dose-response relationship and biological plausibility (Health and Safety Executive, 1994).

Exposure of cement dust through skin and eye contact, or inhalation may cause adverse health effect. Obuekwe and Okoh (2005) stated that risk of injury depends on duration and level of exposure and individual sensitivity. Cement dust causes lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and carcinoma of the lung, stomach and colon (Meo, 2004). Statistical analysis of the data revealed that symptom like regular cough, phlegm, wheezing and shortness of breath were significantly more prevalent among exposed workers (Neghab and Choobineh, 2007).

Respiratory tract disorders are the most important group of occupational diseases in the cement industry, as the result of inhalation of airborne dust. Silicosis and mixed dust pneumoconiosis have been claimed to be the greatest risks for the cement workers. Therefore, the need in wearing proper personal protective equipment while